



शिक्षा विभाग
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Education in Emergency

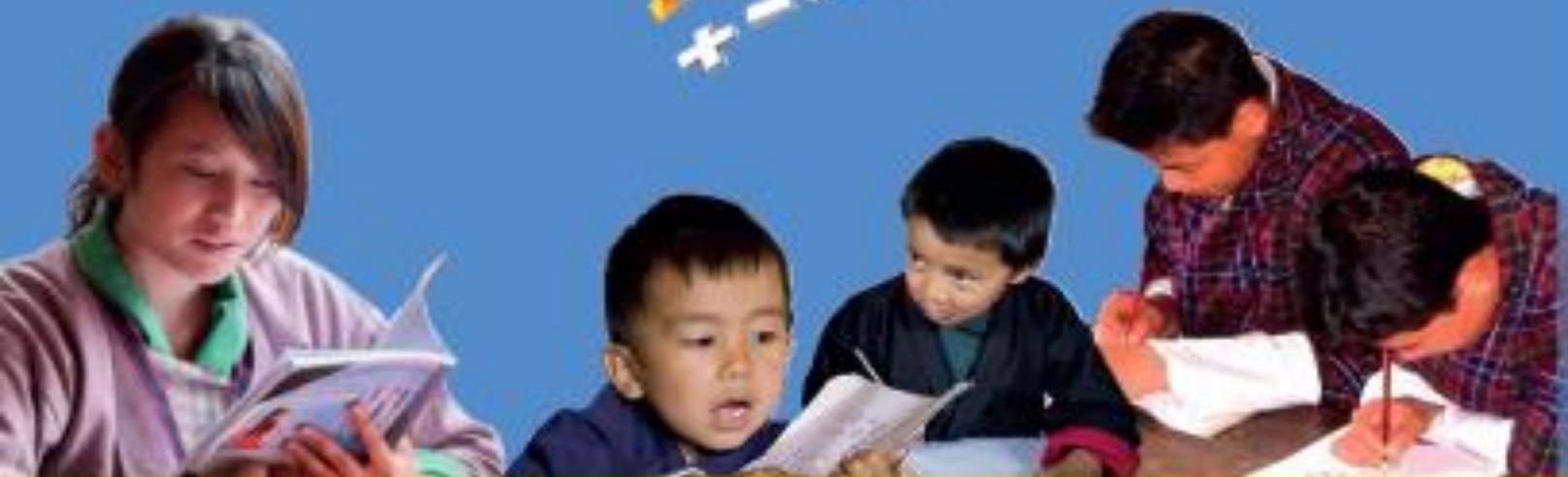
Self - Instructional Materials

शिक्षा विभाग



ABC

Math



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Key Stage 5 CI - XI - XII
Vol. III

Self-Instructional Materials

Key-stage V
(Classes XI and XII)

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TABLE OF CONTENTS

Information for students..... vi

ENGLISH1

 1.1. ARGUMENTATIVE ESSAY.....1

 1.2. NATURE OF LANGUAGE.....6

 1.3. SUMMARY WRITING.....10

ཚོང་ལ།.....14

 ༡- ལྷན་ཚུལ། སློབ་ཚུལ་དང་ དབྱེ་གཏུལ།.....14

 ༢- ཡི་གུའི་སློབ་བཤུན་ མིང་ཚིག་བརྗོད་པའི་རྣམ་གཞག།.....18

 ༣- འབྲི་ཚུལ། སྤྱིར་བཏང་འབྲི་ཚུལ་དང་ ཚུད་སྐྱེང་འབྲི་ཚུལ།.....24

 ༤- ཡི་གུའི་སློབ་བཤུན་ རྣམ་དབྱེ་བརྒྱུད།.....27

 ༥- ལྷན་ཡིག། ལྷན་ཡིག་གི་འབྲུང་ཁུངས།.....36

 ༦- ཡི་གུའི་སློབ་བཤུན་ སློབ་ཚུལ་ཚིག་མཚན་གྱི་འཇུག་པ།.....40

 ༧- ཡི་གུའི་སློབ་བཤུན་ རྒྱན་སྤྱད་དང་ ལྷག་བཅས།.....47

MATHEMATICS51

 1. TRIGONOMETRIC FUNCTION.....51

 2. TRIGONOMETRIC EQUATIONS.....59

 3. INVERSE TRIGONOMETRIC FUNCTIONS.....63

 4. ALGEBRA: APPLICATION OF DETERMINANTS.....67

 5. ALGEBRA: PROPERTIES OF DETERMINANTS.....74

SCIENCE STREAM.....78

1. BIOLOGY78

 1.1. PHOTOSYNTHESIS78

 1.2. DNA FINGER PRINTING85

 1.3. DNA REPLICATION92

 1.4. EVOLUTION.....98

 1.5. SPECIES AND SPECIATION104

 1.6. MUSCLES111

 1.7. TRANSMISSION OF NERVE IMPULSES119

2. CHEMISTRY.....125

 2.1. ELECTRONEGATIVITY125

 2.2. ISOMERISM.....128

2.3.	HOMOLOGOUS SERIES AND NOMENCLATURE OF ORGANIC COMPOUNDS.....	136
2.4.	AMINES	148
2.5.	ACID BASE EQUILIBRIA.....	155
2.6.	HYBRIDISATION AND SHAPES OF MOLECULES.....	167
2.7.	RADIO ACTIVITY	173
3.	PHYSICS.....	179
3.1.	RESOLUTION OF VECTORS.....	179
3.2.	KINEMATIC EQUATION.....	184
3.3.	COULOMB'S LAW.....	188
3.4.	SIMPLE HARMONIC MOTION (SHM).....	193
	COMMERCE STREAM.....	201
	1.COMMERCE.....	201
1.1.	MANAGEMENT.....	201
1.2.	COMMUNICATION AND ITS IMPORTANCE	206
1.3.	PRINCIPLES OF EFFECTIVE COMMUNICATION	209
	2.ECONOMICS.....	213
2.1.	MEASUREMENT OF PRICE ELASTICITY OF DEMAND.....	213
2.2.	SUPPLY, ITS DETERMINANTS AND LAW OF SUPPLY	218
2.3.	MOVEMENT AND SHIFT OF THE SUPPLY CURVE	222
2.4.	DETERMINATION OF MARKET PRICE.....	227
2.5.	MARKET STRUCTURE.....	232
	3.ACCOUNTANCY.....	237
3.1.	ACCOUNTING THEORY.....	237
3.2.	JOURNAL LEDGER AND TRIAL BALANCE	248
3.3.	REVENUE RECOGNITION	284
3.4.	ACCOUNTING PROPERTY, PLANTS AND EQUIPMENT.....	290
3.5.	ACCOUNTING EQUATION AND FINANCIAL STATEMENT.....	302
	ARTS STREAM.....	318
	1.MEDIA STUDIES.....	318
1.1.	NATURE OF MEDIA MESSAGES AND ANALYSING MEDIA REPRESENTATION	318
	2.GEOGRAPHY	326
2.1.	SETTLEMENT: RURAL SETTLEMENT.....	326
2.2.	URBAN SETTLEMENT.....	333
	3.ENVIRONMENTAL SCIENCE.....	340
3.1.	BIOMES AND ECOSYSTEM	340

3.2. ENERGY FLOW IN THE ENVIRONMENT	345
3.3. RICH BIODIVERSITY AND ECOSYSTEM SERVICES	349
3.4. BIOGEOCHEMICAL CYCLE.....	353
3.5. DISTURBANCE AND ECOLOGICAL SUCCESSION	359
ANSWERS	363
MATHEMATICS.....	363
BIOLOGY.....	365
CHEMISTRY.....	368
PHYSICS.....	373
ECONOMICS.....	373
ACCOUNTANCY.....	375



INFORMATION FOR STUDENTS

- i. The lessons on English, Dzongkha, and Mathematics subjects are meant for all the students of classes XI and XII, regardless of their stream.
- ii. The lessons for *Science, Arts, and Commerce* streams are provided in separate sections for students to choose depending on their areas of study.
- iii. The answers to questions that students need to solve in each activity are provided in the last section on 'Answers'.
- iv. Each lesson is designed for fifty-five minutes.

ENGLISH

1.1. ARGUMENTATIVE ESSAY

Learning Objectives



- Differentiate between a persuasive and an argumentative essay.
- List down the features of an argumentative essay.
- Explain the skills of writing the introduction, body and conclusion parts of an argumentative essay.
- Write an essay employing the argumentative features.

Introduction

You have learned narrative, descriptive, expository and persuasive essay writing in your earlier classes.

In this lesson, you will learn about the argumentative essay. You will read and understand the definition, purpose and features of an argumentative essay. Besides, you will find out the differences between a persuasive essay and an argumentative essay.

**ACTIVITY 1**

Instruction: Read the definition of an argumentative essay (AE) given below.

A genre of writing that requires the writers to investigate a topic, collect, generate and evaluate evidence, and establish a position in a concise manner on the topic. Not only does it provide information, but it also presents arguments with the PROs and CONs of an argumentative issue.

It is important to know that, unlike in other essays, in an argumentative essay we not only present the information but also take our stand on the issue of discussion.

Do you know the purpose of an argumentative essay? When would you choose to write it?

The ultimate purpose of an argumentative essay is to convince or persuade the readers to understand the other side of the argument that you desire to present. Writing such essays, thus, helps to both evaluate and enhance in-depth knowledge on the topic and critical thinking skills of the writer. These skills also help in resolving critical real-life issues.



ACTIVITY 2

Instruction: Let us now study the features of an argumentative essay.

Features of an Argumentative Essay

- The topic must be a well defined controversial issue. There is no need to write an argumentative essay if everyone thinks in the same line. Everyone does not think in the same way. Therefore, the topic should be debatable for the essay to be argumentative.
- It should be based on thorough research evidence.
- It studies both sides of the issues carefully and finds loopholes that may harm or benefit our views. This enables us to address our weaknesses and focus on the weak points of our opponent.
- It presents reliable facts and figures.
- There is comprehensive proof that can give more creditability to our arguments. It serves as critical evidence to prove our point of view.
- It should be written objectively, logically and respectfully with evidence.
- The essay is not personalized but respects the opponent's views. For example, we avoid using disrespectful phrases like...*some fools are of the view*..Emotional language should be avoided.
- We touch the head of the audience, so poor emotional language cannot justify our purpose.

Hope the features are clear to you. Please keep a note of the points in the box.

Those points that support our stand are known as PROs and those that oppose our stand are called CONs. In argumentative essay, we usually present both PROs and CONs.

The key terms like PROs and CONs are crucial in learning how to write an argumentative essay. With the issue at hand, a writer takes a stand.

Note: Unlike other essays, in an argumentative essay we not only present the information but also take our stand on the issue of discussion. Now, let us look at the differences between an argumentative and a persuasive essay. The key points provided in the table will help you write the two types of essays.

Persuasive Essay	Argumentative essay
<ul style="list-style-type: none"> ● It presents one side of the arguments. ● It touches the emotional aspect of the audience. ● Personalization is not prohibited. 	<ul style="list-style-type: none"> ● It presents both /two sides of the arguments. ● It touches the logical aspect of the audience through logical argument. ● It is formal and academic, therefore, no personalization.
<p style="text-align: center;">Sample of an Argumentative Essay</p> <p style="text-align: center;">Winter Tuition Class: A Drain out Bustle <i>Tshering Yangden, Drukgyel Central School</i></p> <p>‘I need not have to concentrate in the class as I have learned this and that concepts in the tuition classes ’ is a common maxim spelt out by the students today. Winter tuition classes or commonly known as coaching classes have become widespread in recent years and it will continue to flourish in the years to come. The emphasis on high academic achievements fuelled by the ranking of schools and awarding of testimony further add to the increasing popularity of winter coaching classes in Bhutan. Unlike the winter breaks in the past decades, winter vacation is no longer a break for the majority of the Bhutanese students. Winter break is now used as an opportunity to learn the curriculum ahead by the teachers and students. With winter coaching classes gaining popularity, people tend to develop mixed feelings about this so-called tuition class. <i>Notwithstanding the assumption that coaching class assists the students to move ahead in their curriculum, enhance academic achievements and provide continuous learning, it must be noted that it has certain glitches such as wastage of parents’ hard-earned money and a no brain break activity for the weary students. (Thesis Statement)</i></p> <p><i>Winter tuition classes have the hardest blow on the financial status of the students and their families. Apart from the tuition fees which almost sums up to 12000 in a month, the students also have to take pocket money and at times do separate shopping that may again eat up some portion of the family’s income. The majority of the students, while attending coaching classes also plan trips, get-togethers, catching up with friends and outings. Can all these happen without money? No. it cannot. Hence, winter coaching classes are but synonymous with monetary draining activity. (PRO Idea)</i></p> <p><i>Sceptics are of the view that winter tuition classes facilitate before-hand learning. They intend to claim that it will assist the students to move ahead in their curriculum. They have a point in saying that as the students are introduced to the topics before they actually learn in the schools. (CON argument). Conversely, one must not forget that classes are squeezed into less than the quarter the time and course offerings are very limited in selection. The syllabus designed for 180 instructional days cannot be covered in 26 instructional days. Dorji, a tuition recipient for three consecutive years claims,</i></p>	

‘most tutors at the coaching classes taught us the simplest topics and what they have covered during the tuition classes is not even one-fourth of the intended syllabus we have had’. Subsequently, being ahead in the curriculum is not given full justice.

(Refutation)

Opponents are of the view that tuition classes bridge the gap in students’ learning thereby promoting continuous learning. (CON argument) For such critics, it is undeniable that they have overlooked the fact that the brain needs rest to function well. How long is the winter break? It is just two months and almost nine months are spent in the school. The students have a taxing schedule in the school and what an agony to further tax the burdened brain. As stated by ‘QuickBooks’ in the article titled, ‘Five Reasons You Need to Take a Break’, it is emphasized that the best ideas come to the people when they are relaxed and the brain needs to recover after a workout to strengthen the brain. Further, the article also revealed the capacity of the brain to review the experiences it had and turn them into permanent long term memories. Therefore, it is confirmed that continuous learning makes no sense if the learner is too exhausted to grab in the information. (Refutation)

In all, attending tuition class is not as captivating as people see it. Much has to be foregone and much has to be endured. If a person intends to seek ways to exhaust the hard-earned money, tuition class is the answer. If one looks for ways to saddle the already burdened brain, coaching class is the choice. It must be noted that tuition classes are not boon, but doom to students’ life. Be wise, save the hard-earned money and give break to the brain for only a relaxed brain can give in the best thought.



ACTIVITY 3

Instruction: Read the given issue, Take your stand on the issue and jot down the PROs and CONs in the table below.

Issue: Social media is a Boon, not a Bane.	
PRO	CON
i.	i.
ii.	ii.
iii.	iii.

These points could be for your THESIS statement.



ACTIVITY 4

Instruction: Read the information on the parts of an essay given in the table below.

Parts of the Essay		
Introduction	Body	Conclusion
<ul style="list-style-type: none"> ● Hook ● Background information ● Situational analysis ● Definition ● Thesis ● Give an overview of TWO sides and make your stand explicit. 	<ul style="list-style-type: none"> ● Point: Opposing views/topic sentence ● Elaborate the opposing view ● Explain the refutation/examples/evidences ● Link to the topic sentence and thesis statement 	<ul style="list-style-type: none"> ● A strong solid conclusion is appreciated ● Give the gist of the main ideas (restating the thesis) ● No new ideas



Summary

- Argumentative is a genre of writing that requires the students to investigate a topic, collect, generate and evaluate evidence, and establish a position on the topic in a concise manner.
- Features of an argumentative essay include: choosing a debatable topic, supporting outstand with facts and figures, examples and evidence.
- An essay comprises three main parts: an introduction, a body, and a conclusion.



Self-check for Learning

We have studied the features and definitions of an argumentative essay. We have also looked at a sample essay. It is time to test things you have learned in this lesson.

Instruction: You can write an argumentative essay using one of the following topics or on the topic of your choice.

- Should Bhutan ban regional tourism?
- COVID-19 is a blessing in disguise for the human society.
- E-learning should remain as part of the Bhutanese education system.
- A good teacher makes a good student. Argue for or against.

1.2. NATURE OF LANGUAGE

Learning Objectives



- Explain at least nine features of language.
- Name and explain the level of language analysis.
- Explain TWO theories of language acquisition.

Introduction

Let us reflect!

What is the purpose of a language?
Why do people use a language?

It is simple:

- People use language to communicate.
- The basic human urge is to communicate.

Do you know that human language is very special and unique? What makes our language special and unique? How do people acquire this special gift of communication? Let us find it out.



ACTIVITY 1

Instruction: Read the information on the features of language given below and complete activity number 2.

1. The Communication Model

Encoding → Transmission → Reception → Decoding

Communication happens when the decoder receives, decodes and understands the meaning of the encoder.

2. The Features of Language

An American Linguist Charles Hockett enumerated the features of the language, then known as key characteristics of language. Some of the features are modified and some combined. Let us look at the nine features given below.

- Duality of Pattern or structure:** human language is organized at two levels:
 - Individual level: n, p, t, b, k
 - Combinatorial level: cat/nap/bin

At an individual level like n/p/t/ do not have any meaning in themselves. Their meaning comes from a meaningful combination to produce words.

Example: when c/a/t is combined, we get the word /cat/.

- Displacement:** Human language can be used to refer to any dimension of space and time. As language users, we can refer to the past, present, and future. It can also be

used to refer to any place here or elsewhere and in neither case the language users have to move from his/her place to refer to any time or space.

Example: Sitting in the corner of a class at Drukgyel, I can talk about the US. I don't have to move to the US to talk about the US.

- iii. **Open-ended System:** The words, sounds, and sentences in a language may be limited but the combinations and constructions are unlimited.

Example: If you were asked to frame a sentence using the word 'apple', would everyone say, "I like apples". Well, some may say, "You are the **apple** of my eye", others may say, "**Apples** grow in cold places like Paro" or "An **apple** a day keeps the doctor away" and the list can go on.

Simply using a single word 'apple', we could construct unlimited sentences. This implies that human language is an open-ended system.

- iv. **Arbitrariness:** Human language is arbitrary. It implies that there is no natural connection between the word and its meaning. The signifier and the signified are brought together arbitrarily.

Example: Is there a logical reason why a table is called a table or an orange is called an orange? Perhaps "**NO**". The word 'table' and the meaning attached to the table has no preceding connections. They are brought together arbitrarily.

- v. **Cultural Transmission:** Human language is culturally transmitted. Human beings may be born with an innate predisposition to acquire language but they are not born with the ability to produce utterances in a specific language.

Example: Sonam was born to a Bhutanese family in Bhutan. Right after his birth, he was taken to China and was raised by a Chinese family. What language will Sonam speak? Will he speak Dzongkha? Perhaps not. Instead he would most probably speak Mandarin because language is culturally transmitted.

- vi. **Meta Linguistic System:** This means that human language can be used to talk about itself, its features, levels and varieties. We can talk about talking and of course, think about thinking too.

Example: I am using language to talk about language to you all. Can you remember the Teacher on Duty commenting on the speech in the morning assembly? This implies that human language has the metalinguistic feature.

- vii. **System of System:** Language is not a collection of sounds and forms at random, but a highly organized system in which each unit has its own place and value.

Example: The / comedian / is / seriously / funny. Each word has its place and value. We cannot place the words randomly like; Is the seriously comedian funny?

Individual and Social Phenomenon

Language is an individual and social phenomenon. Language serves to express individual needs and urges. It also brings an individual into a relationship with the external world.

Example: When you are thirsty, you ask for a glass of water. How do you do that? You use language to get a glass of water to quench your thirst.

i. Species-specific and Species Uniform

The biological set up of different species is different. The biological set up of a monkey is such that it can learn only a monkey’s language and the species born under the human category has the biological setup that can help them learn human languages. The ability to understand language is inherited genetically but the particular language that children speak is culturally and environmentally transmitted to them. Children all over the world acquire their native tongue without tutoring.



ACTIVITY 2

Instruction: Fill in the blanks. Do not use more than four words.

1. An Indian expatriate serving in Trashigang district for ten years begins to speak Sharchopkha. This is because language is.....
2. Sonam shared her childhood experience with her students of grade 12 and told them about her plans. This feature is related to
3. A teacher wrote some alphabets on the board and asked her students to use those letters to form words. The students came up with different words using those letters. It signals that language is.....
4. The unnatural connection between the word and its meaning indicates that language is.....
5. The use of the language to talk about itself depictsfeature of language.



ACTIVITY 3

Instruction: Read the information on two theories of language acquisition and levels of language analysis given below.

1. Theories on Language Acquisition

- a. *Behaviourist theory*
- b. *Rationalist theory*

Behaviourist	Rationalist
Main proponent: B.F Skinner	Main Proponent: Noam Chomsky
Environmental influence brings about language development.	Biological influence brings about language development.
Language is learned through principles of conditioning such as imitation, association and reinforcement.	Language is acquired through means of LAD –Language Acquisition Device. LAD is an intrinsic mental capacity which enables an infant to acquire and produce language
Believes that babies are born as empty vessels and language has to be put into it.	LAD is hard-wired into the child and humans are born with innate ability to learn a language.
Nurture: language development and acquisition is a learned behaviour.	Nature: language learning is spontaneous and natural as LAD is already wired into the brain.

2. Levels of Language Analysis

- a. Phonetic or phonological level: deals with pronunciation.
- b. Morphological level: deals with the smallest parts of words that carry meaning.
- c. Syntactic level: deals with grammar and structure.
- d. Semantic level: deals with the meaning of words and sentence.



Summary

- Human language is the most special language. It is what makes us special and unique from other species.
- Our language makes us who we are.
- The nine features of the language include the duality of pattern, displacement, metalinguistic system, open-ended system, social and individual phenomenon, cultural transmission, species-specific, a system of system and arbitrariness.
- There are two schools of thought on how people acquire language: Rationalist and Behaviourist theories.
- The four-level of language analysis are phonology, semantic, syntactic and morphology.



Self-check for Learning

Answer the following questions in your notebook.

1. Explain the state of the world without language?
2. Do you believe in rationalist or behaviourist theory? Justify your stand with at least TWO reasons.

1.3. SUMMARY WRITING

Learning Objectives



- Define a summary.
- Summarize a given text incorporating the steps of summarization.

Introduction

Have you heard of a maxim that reads, ‘LESS IS MORE?’ At times we come across volumes of information. For instance, you have read the story, ‘The White Knight’ by Eric Nicol in grade 10. If I ask you to rewrite or retell that story in 200 words, the story is about 710 words long. Can you do that without losing the essence of the story?

Yes, you can. It can be done through summarization. In this lesson, let us look at how we can summarize a text.



ACTIVITY 1

Instruction: Read the following dialogue between a teacher and a student. As you go through their dialogue, try to understand the essence of summarization or summary techniques.

Student: Teacher, could you please tell me the meaning of a summary?

Teacher: That’s simple. A summary is a shortened passage, which retains the essential information of the original text. It is fairly a brief restatement in your own words of the content.

Student: Thank you. Could you tell me why I should learn how to summarize?

Teacher: Sure. Summary writing is an essential skill, not only for the students but for most people. It helps us in many ways, and the four main benefits of inculcating the art of summary writing include:

- Improvement of reading skills.
- Enhancement of vocabulary.
- Enrichment of critical thinking skills.
- Refinement of writing and editing skills.

Student: Thank you, teacher. Could you tell me when do I use summary writing skills?

Teacher: Of course. A summary can be used to sum up the information, to present information concisely and to state the main or essential points without any detailed explanation.

Student: I am very interested in learning summary writing skills now. Can you help me learn the steps to summary writing?

Teacher: It will be my pleasure. The table below will provide you with the steps involved in summary writing.

<p>1. Read</p> <ul style="list-style-type: none"> ● Read the original piece of work. ● Focus on the main idea of the piece.
<p>2. Gather the Main Idea</p> <ul style="list-style-type: none"> ● Reflect on what you have read. ● Determine the Five Ws (who, what, where, when, and why). ● Illuminate the essential elements of the text.
<p>3. Reread while Taking Notes</p> <ul style="list-style-type: none"> ● Mark the important points and underline the topic sentence, significant plot points, highlight essential quotes and major events. ● Point out the difficult areas you do not understand and reread.
<p>4. Organize Your Notes</p> <ul style="list-style-type: none"> ● Take time to organize the information. ● Elaborate on the key points.
<p>5. Create a Thesis Statement</p> <ul style="list-style-type: none"> ● Develop a thesis statement that demonstrates your understanding of the author's original work. ● Recast author's idea without including a personal opinion
<p>6. Draft a Short Paragraph</p> <ul style="list-style-type: none"> ● Use the thesis statement as the introductory sentence to your summary. ● Write in the present tense mostly. ● Include the author and the title of the work. ● Be concise – the summary should not be equal to the length of the original text. ● Cite direct quotes if you use them. ● Do not put your own opinion, ideas, or interpretations. ● Write in third person narrative.
<p>7. Revise</p> <ul style="list-style-type: none"> ● Reread your summary to make sure that you have represented the author's main idea. ● Ensure that the text does not contain any personal commentary. ● Is there sentence variety? ● Are there transitional words and phrases to connect ideas?
<p>8. Read your Summary One Last Time</p> <ul style="list-style-type: none"> ● Look for spelling, punctuation, and grammar errors and cross out the errors neatly with a single line and rewrite.

Student: That is very elaborate. I am a bit confused. Could you please show me some samples?

Teacher: I will show you some samples. Here it is:

- **Original Paragraph:** Skipping breakfast might seem like an easy way for dieters to cut calories. However, new research finds that the majority of the people who are successful at losing weight and keeping it off, eats breakfast.
- **Summarized Version:** Research shows that people who wish to lose weight do not skip breakfast.



ACTIVITY 2

Instructions: Read the text taken from a commencement address delivered by J.K Rowling, author of the best-selling Harry Potter series book. Summarize it. Follow the steps as given in the table.

Original Text

Now, I am not going to stand here and tell you that failure is fun. That period of my life was a dark one, and I had no idea that there was going to be what the press has since represented as a kind of fairy tale resolution. I had no idea then how far the tunnel extended, and for a long time, any light at the end of it was a hope rather than a reality.

So why do I talk about the benefits of failure? Simply because failure meant a stripping away of the inessential. I stopped pretending to myself that I was anything other than what I was, and began to direct all my energy into finishing the only work that mattered to me. Had I succeeded at anything else, I might never have found the determination to succeed in the one arena I believed I truly belonged. I was set free, because my greatest fear had been realized, and I was still alive, and I still had a daughter whom I adored, and I had an old typewriter and a big idea. And so rock bottom became the solid foundation on which I rebuilt my life.

You might never fail on the scale I did, but some failure in life is inevitable. It is impossible to live without failing at something unless you live so cautiously that you might as well not have lived at all – in which case, you fail by default.

Failure gave me an inner security that I had never attained by passing examinations. Failure taught me things about myself that I could have learned no other way. I discovered that I had a strong will and more discipline than I had suspected; I also found out that I had friends whose value was truly above the price of rubies.

The knowledge that you have emerged wiser and stronger from setbacks means that you are, ever after, secure in your ability to survive. You will never truly know yourself, or the strength of your relationships until both have been tested by adversity. Such knowledge is a true gift, for all that it is painfully won, and it has been worth more than any qualification I ever earned.

Source: <https://harvardmagazine.com/2008>.



Summary

As we sum up, remember the following points.

- Summary writing is a crucial skill one must master.
- It is a brief account of the main points of something.
- Remember the steps and keep in mind summary should be concise -say everything you need to say using few words as possible.
- Make sure 5 Ws and one H are covered (who? what? why? where? when? and how?)
- Summary writing remains a crucial skill throughout our academic career, it isn't easy. We should learn to master the skill through constant practice.



Self-check for Learning

Since you are now familiar with how to write a summary, do the following activities:

1. Read the story 'Open Window' by Saki from Class XI Reading and Literature Text for class XI students.
2. Read the short story 'Lamb to the Slaughter' by Roald Dahl and write a summary on it for class XII students.
3. Write a summary using the steps we learned in this lesson.

རྫོང་ལ།

༡-སློབ་ཚུལ། སློབ་ཐོན་དང་དཔྱེ་གཏམ།

ལས་དོན།



- སློབ་ཐོན་གྱི་དག་ཚུལ་ལུ་བརྟེན་ཏེ་ ཚུམ་རིག་གོང་འཕེལ་གཏང་ཚུགས།
- སློབ་རིག་ལས་བཏོན་ཏེ་ སླབ་ཚུགས་པའི་རིག་ཚུལ་ གོང་འཕེལ་གཏང་ཚུགས།
- རང་གི་སློབ་འདི་ཕར་ལོགས་མ་ལུ་ གོ་བཟུང་ལོགས་ཤོམ་འབད་སློབ་ཚུགས།
- དཔྱེ་གཏམ་ཚུ་ སློབ་ཚུགས་ནང་བཅུགས་ཏེ་ བྱི་ཚུགས།
- ལས་སློབ་ལྷན་སྦྲུང་དང་ ཉམས་སྲུང་འབད་ཚུགས།

དུ་སློབ།

སློབ་ཐོན་མི་འདི་ ར་བཅས་རའི་འབྲུག་རྒྱལ་ཁབ་ནང་ རུས་དང་ཕུག་ལས་ར་ མི་སློབ་རིག་ཚན་ ལ་མཁམས་པ་ ལྷེ་ལ་སློབ་ཚུགས་མི་ ལ་བདེ་ལྷེ་བདེ་ཚུ་གིས་ ཕར་ལོགས་མའི་སློབ་དང་བཅུག་ཏེ་ གཏམ་ལན་འདི་འབྲོལ་ལས་ར་ སློབ་ཐོན་བཅུགས་ཏེ་ སླབ་མི་གི་དག་ཚུལ་ལུ་ སླབ་ནི་ཨིན།

སློབ་ཐོན་གི་ཚིག་འབྲི་ཐངས།

སློབ་ཐོན་འདི་ མང་ཆེ་ཤོས་ ཚིག་འབྲུ་ ༤ མ་དང་ ཡང་ན་ ༧ མ་ ཡང་ན་ ༥ མའི་ནང་འོང་དགོཔ་ཨིན་རུང་ ཚིག་རྒྱ་ལ་ ཨིན་ཅི་ཨིན་ཅི་ ཚིག་འབྲུ་འབྲེལ་ཉམ་མེད་རུང་བརྟེན་ཅི་དང་། ཚིག་གཙོ་བོ་ རྫོང་ལའི་དག་གཤིས་ལུ་ གཞི་རྟེན་འབད་དེ་བྱིས་ཨིན།

སློབ་ཐོན་ ཚིག་འབྲུ་རྒྱལ་མ་ འབྲི་ཐངས་ཀྱི་དཔྱེ།

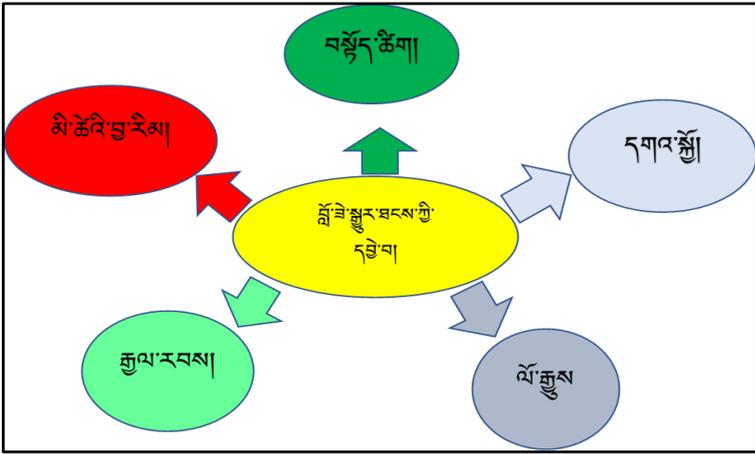
ཅ་རི་གནས་སློབ་རྒྱལ་དགོན། ཤོམ་གྱི་ལོ་རྒྱུས་མ་སླབ། རྟ་དང་སྐྱུམ་འཁོར་བཞག་སྟེ། གནས་སྐབས་ལུ་འབྲེལ་ནི། མི་ཚེ་དག་འབྲེལ་བསྐྱེད་དགོན། ཐབས་ཤེས་ལོ་རྒྱུས་མ་སླབ། འཛམ་གླིང་ཕུག་པོ་ཡང་བཀོ་སྟེ། རྣམ་ཐོས་སྐྱེས་དང་བསྐྱེས་ནི།

སློབ་ཐོན་ ཚིག་འབྲུ་བརྟེན་མ་ འབྲི་ཐངས་ཀྱི་དཔྱེ།

- གནས་ལས་ལས་གནས་ལུགས་མ་བུདན། ཁ་མས་ལས་ས་ཚུ་མི་ཐོན། །
- ཕུ་ལས་ལས་བྱུར་ཆར་མ་རྒྱབན། ཁད་འམས་ལས་ས་རུད་མི་ཆད། །
- རྒྱ་རྒྱ་ལས་རུ་མ་མ་སློབན། ཁར་ཨོམ་རྒྱ་བཙོག་པ་མི་ལུགས། །
- ཤིང་མགུ་ལས་པད་ཅ་མ་བཏོགན། མར་ཅ་བ་ར་ཉོ་མི་སྐམ།

སློབ་མོ་ ཚིག་འབྲུ་བརྒྱུད་མ་ འབྲི་བའམ་གྱི་དཔྱད།

ས་དཔལ་ལྷན་འབྲུག་པའི་རྒྱལ་ཁབ་འདི། །གཡུས་ཆགས་པའི་ཆགས་བའམ་ལྷ་ཡུལ་འདྲ། །
མི་བྱུང་པའི་བྱུང་རབས་ལྟ་དང་འདྲ། །ཚོས་ཐེག་ཚེན་གསང་སྤྲུགས་ཡོངས་ཚོགས་དར། །
ལམ་ལུགས་སློབ་བམས་ཅད་ཚོས་དང་མཐུན། །ཁྱོད་ཡིང་ཡི་ཤ་མཁས་པའི་ཚུམ་སྒྲིག་པ་གིས། །



སློབ་ལུ་ ༡ པ།

- ༡༽ སློབ་དབུ་ནང་ཡོད་པའི་ སློབ་མོའི་དཔྱད་ཚུ་ ལེགས་ཤོམ་འབད་ལྷག་ཞིན་མ་ལས་ དཔྱད་བ་དཔྱད་བཟུ།
- ༢༽ ཁྱོད་རའི་ཕམ་རྒན་ཤོས་ཚུ་ སློབ་མོ་བསྐྱུར་བཅུག་ཞིན་མ་ལས་ བཤད་པ་རྒྱབ་བཅུག།
- ༣༽ སློབ་མོ་ ལྷག་སྐྱུར་འབད་མི་ལུ་བརྟེན་ཏེ་ ཁྱོད་རའི་མི་ཚེ་ནང་ ཕན་པ་ག་ཅི་བཟུམ་འབྱུང་ནི་ཨིན་པས་ག་ དཔྱད་བ་དཔྱད།

དཔྱད་གཏམ།

དཔྱད་གཏམ་ཟེར་མི་འདི་ མི་མཁས་པ་ཚུ་གིས་ སློབ་སྐབ་པའི་སྐབས་ལུ་ སློབ་གྲོགས་དོན་དག་ཚུ་ ཕར་ལོགས་མའི་ མི་གི་སེམས་ ལུ་ དོད་རིལ་རི་འབད་ ཉ་གོ་བཅུག་ནི་དང་། སློབ་གྲོགས་ནང་དོན་ཚུ་ བཅུད་ཡོད་པ་བཟོ་ནི་དོན་ལུ་ ཡོངས་གྲགས་ཡོད་པའི་ དཔྱད་གཏམ་གྱི་ཚིག་ཚུ་ སློབ་གྲོགས་ལུ་བར་ན་བཅུགས་ཏེ་ སྐབས་མི་གི་ཚིག་ཅིག་ཨིན།

དགོས་པ།

- དཔྱད་གཏམ་འདི་ སློབ་གྲོགས་ལུ་བར་ན་བཅུགས་ཏེ་ སྐབས་དགོ་པའི་དོན་དག་འདི།
- རང་གི་སློབ་འདི་ ཕར་ལོགས་མའམ་ལུ་ གོ་བརྟེན་ལེགས་ཤོམ་འབད་ སློབ་ཚུགས།
- ཉན་མིའི་ན་བར་ ཉན་ཏོང་ཏོང་འབད་གོ་འོང།
- སློབ་ ཚིག་ཐུང་ཀྱ་ཅིག་ནང་ དོན་དག་སློབ་སློན་ཚུགས།
- ཉན་མི་ཚུ་ རང་གི་སློབ་ལུ་བཟུ་སྟེ་ ཡིད་ཚེས་བསྐྱེད་ཚུགས།

དབྱེ་གཏམ་ལུ་དབྱེ་བ་གཉིས་ཡོད།

༡༽ སློབ་གཏམ།

༢༽ སློབ་གཏམ་ ཟེར་གཉིས་ཡོད་པ་ཡིན།

༡༽ སློབ་གཏམ་ ཟེར་མི་འདི། ཚོག་ཕྱང་ཕྱང་འབད་ མ་སླབ་པར་ ཟུར་བཅུགས་ཏེ་ སླབ་ནི་དང་། ལྷགས་ཀྱིས་ཉ་གོམ་
འབད་ སླབ་མི་ལུ་གོམ་ཡིན། དཔེར་ན།

འཇམ་པ་ཤིང་གི་སྐྱེ་ལུགས། །སྟག་ཚུང་ཐེག་ཐེག་མ་འད།།

ཨོ་ལ་ནག་པོའི་འཕུར་ལུགས། །གནམ་ཁར་ལྗིང་ལྗིང་མ་འད།།

༢༽ སློབ་གཏམ་ ཟེར་མི་འདི་ སྤང་བྱེད་གི་སློབ་ལས་ བསླབ་བྱ་དང་ གོས་སྦོན་བྱིན་མི་ལུ་གོམ་ཡིན།

དཔེར་ན། དྲག་ཟེར་དཔའ་རྟགས་བསྐྱར་མ་ད། །ཞན་ཟེར་ཟུར་ཁར་སྡོད་མ་ད། །རང་མ་ཤེས་པ་རོགས་ལུ་ངྷི། ཟེར་དོ་
བཟུམ་ཡིན།

དབྱེ་གཏམ་གྱི་ ཚོག་གི་དབྱེ་བ།
དབྱེ་གཏམ་ སླབ་ཐངས་གྱི་ དབྱེ་བ།

དབྱེ་གཏམ་ཉེ་མར་དང་ རོན་གྲུལ་མར་སླབ་ནི།

དབྱེ་གཏམ་སླབ་ཐངས་གྱི་དབྱེ་བ།

རོན་ཉེ་མར་དང་ དབྱེ་གཏམ་གྲུལ་མར་སླབ་ནི།

དབྱེ་གཏམ་ གློ་ལུ་བསྐྱར་ཏེ་སླབ་ནི།

༡༽ དབྱེ་གཏམ་ཉེ་མར་དང་ རོན་དག་གྲུལ་མར་སླབ་ནིའི་དབྱེ།

དབྱེ་གཏམ།

སེམས་ཅན་སྟག་གི་རིམ་ཕྱི་ལས། །མགུ་ནག་མིའི་རིམ་ནང་ལས། །

ནང་གི་རོན་དག།

ཁ་ལས་ག་ཅི་སླབ་ཚུང་སླབ། སེམས་ཁར་ག་ཅི་མོ་དོ་ག་? ག་གིས་ཡང་མི་ཤེས། ཟེར་སླབ་དོ་བཟུམ་ཡིན་པས།

༢༽ རོན་ཉེ་མར་དང་ དབྱེ་གཏམ་གྲུལ་མར་སླབ་ནི།

ཁ་དང་ལགས་འཐབ་ད་ ཀི་ལི་ཟུར་ཁར། ཟེར་དོ་བཟུམ་ཡིན་པས།

༩༽ དཔེ་གཏང་སློབ་ལུ་བསྐྱར་ཏེ་སྐབ་ནི།



ང་ ད་ལྟོ་ཚུན་ཚོད་ གཞུགས་རང་གིས་སློབ་རུང་། ད་རེས་འབད་མ་ད་ དྲན་མ་རོགས་ཀྱིས་བཟུགས་ད་ཡི་སྐྱ་ཏེ།
ཟེར་སྐབ་དོ་བཟུམ་ཨིན་པས།

- ༡༽ དཔེ་གཏང་ཚུ་ གནས་སྤངས་དང་འབྲེལ་ཏེ་ སློ་གི་བར་ན་བཟུགས་ཏེ་ ག་དེ་སྐྱེ་སྐབ་ནི་ཨིན་ན་ དཔེ་བ་དབྱད།
- ༢༽ ལྷག་ལུ་ཡོད་མི་ དཔེ་གཏང་བཟུམ་ རྩོད་ར་གིས་ གཞན་ལས་འཚོལ་ཞིན་མ་ལས་ ལེགས་ཤོམ་འབད་ལྷག།
- ༣༽ སློ་སྐབ་ད་ དཔེ་གཏང་བཟུགས་ཏེ་ སྐབ་ནིའི་སྐྱར་བ་འབད།
- ༤༽ དེ་ལས་ སློ་སྐབ་ད་ དཔེ་གཏང་བཟུགས་ཏེ་ སློ་སྐབ་ཚུགས་པས་ག་? མི་ཚུགས་པས་ག་? དཔེ་ཞིབ་འབད།
- ༥༽ རྩོད་ར་ ད་ལྟོ་སློད་ས་ལས་ འདི་བཟུམ་གྱི་ དཔེ་གཏང་མ་འདྲམ་ ༡-༣ གང་རུང་ཅིག་ གསར་པ་བྲིས།



བཟུད་བསྐྱུལ།

- སློ་བེ་ ཟེར་མི་འདི་ ང་བཅས་རའི་འབྲུག་རྒྱལ་ཁབ་ནང་ དུས་དང་སྐྱུག་ལས་ར་ མི་སློ་རིག་ཅན་ ཁ་མཁས་པ་ ལྷེ་ལ་ སློ་ག་སྐྱར་ཚུགས་མི་ ཁ་བདེ་ལྷེ་བདེ་ཚུ་གིས་ སར་ལོགས་མའི་སློ་དང་བསྐྱར་ཏེ་ གཏང་ལན་ འདི་འཕྲོ་ལས་ར་ སློ་ ཟེ་ནང་བཟུགས་ཏེ་ སྐབ་མི་གི་ངག་རྒྱལ་ཅིག་ལུ་ སྐབ་ནི་ཨིན།
- དཔེ་གཏང་ཟེར་མི་འདི་ མི་མཁས་པ་ཚུ་གིས་ སློ་སྐབ་པའི་སྐབས་ལུ་ སློ་གི་དོན་དག་ཚུ་ སར་ལོགས་མའི་ མི་གི་ སེམས་ལུ་ དོད་རིལ་རི་འབད་ ཉ་གོ་བཟུག་ནི་དང་། སློ་གི་གནད་དོན་ཚུ་ བཟུད་ཡོད་པ་བཟོ་ནིའི་དོན་ལུ་ ཡོངས་ གྲགས་ཡོད་པའི་ དཔེ་གཏང་གི་ཚོག་ཚུ་ སློ་གི་བར་ན་བཟུགས་ཏེ་ སྐབ་མི་གི་ཚོག་ཅིག་ཨིན།



རང་ཉིད་སྐྱབ་སྐྱར་ དཔེ་ཞིབ།

- ༡༽ སྤྱིར་བཏང་ ལྷན་ཚུམ་གྱི་ཁྱད་ཚོས་མ་འདྲམ་ཅིག་ ག་ཅི་མཐོང་ཅི་གོ་?
- ༢༽ སློ་བེ་དང་ དཔེ་གཏང་ཚུ་གིས་ སློ་སྐབ་པའི་གནས་སྤངས་ནང་ལུ་ སར་ལོགས་ཉིང་དག་པ་ཅིག་ཐོ་བཀོད་དེ་ བཤད་པ་རྒྱབ།
- ༣༽ ད་ལྟོ་ བླ་ཡམས་ཀྱི་གནས་སྤངས་ལུ་གཞི་བཞག་སྟེ་ བཟོད་དོན་ལེགས་ཤོམ་ཅིག་བཏོན་ཚུགས་པའི་ སློ་བེ་ཅིག་ གསར་བཟུམ་འབད།

༡- ཡི་གུའི་སློབ་བཤེས་མིང་ཚིག་བརྗོད་པའི་རྣམ་གཞག།

ལས་དོན།



- བརྗོད་པ་རྒྱུ་ལ་ ཟེར་སྐབ་དགོ་པའི་ བྱེད་སྒྲུབ་བྱི་ཚུགས།
- བརྗོད་པ་ཆ་ཚང་བའི་གོ་དོན་ ལ་གསལ་འབད་བྱི་ཚུགས།
- བརྗོད་པ་སྐྱེ་འདུས་ ཟེར་མི་འདི་ ག་ཅི་བཟུམ་ཅིག་ལུ་ སྐབ་ཡིན་ན་སྐབ་ཚུགས།
- ཚིག་འབྲུ་ ལཱ་མའི་དཔེར་བརྗོད་ ཚིགས་བཅད་༡ རྒྱུ་ཚུགས།
- ཚིག་འབྲུ་ བདུན་མའི་ དཔེར་བརྗོད་ ཚིགས་བཅད་༡ རྒྱུ་ཚུགས།

དོ་སློབ།

རྣམ་གཞི་བརྗོད་ཚུ་ མིང་དང་དོན་ བརྗོད་པ་དང་ཚིག་ ཚིག་གི་ཚིགས་པ་རྒྱུ་ ཉ་གོ་དགོ་པ་མ་གཏོགས་ མིང་ཚིག་ལུ་མི་གོ།

མིང་གི་རྣམ་གཞག།

སློབ་འཇུག་ རྗེས་འཇུག་ ཡང་འཇུག་ མགོ་ཚན་ འདོགས་ཚན་ མིང་གཞི་དང་ དབྱེད་སྒྲུབ་ཚུ་ལས་འགྲུབ་པའི་ཚིག་ཅིག་ གིས་ བྱ་བ་དང་ བྱེད་ལས་ བྱེད་ཚོས་ལ་སོགས་པ་ ག་ཅི་གི་སློབ་ལས་ཡང་མ་སྦྱོར་པར་ དོན་གྱི་དོ་བོ་ཚམ་སློབ་མི་ལུ་མིང་ དང་ ཡང་ན་ མིང་ཚིག་ཟེར་སྐབ་ཡིན།

དཔེར་ན། མི། རྟ། འོ་ལ། སློམ། བྱིམ། ཐེམ་ལུག་ ཟེར་དོ་བཟུམ་ཡིན། དེ་སྐྱེ་འགྲུབ་པའི་ མིང་ལུ་ བྱང་གསེས་གྱི་དབྱེ་བ་ སྤྱི་མིང་། སྐྱེར་མིང་། ཚིགས་མིང་། གྲངས་མིང་། རྟགས་མིང་། ཞེས་འི་མིང་དང་བཅས་ལྷག་ཡོད།



སློབ་ལུ་ ༡ པ།

ལྷག་གི་དོན་མཚན་འདི་ ལེགས་ཤོམ་འབད་ལྷག་ཞིན་མ་ལས་ འོག་གི་དྲི་བའི་ལན་བྲིས།

- ༡ ། བཀ་ཤིས། སྤ་འོ། ལྷ། བྱི་ལི། དགུ་བཟུ། རུ་ལག། ཟེར་མི་རྒྱུ་ མིང་གི་དབྱེ་བ་ག་ཅིའི་ནང་ར་རྒྱུད་པ་ཡིན་ན་?
- ༡ ། མིང་གི་དབྱེ་བ་རྒྱུ་ དེ་དེ་བཞིན་གྱི་དཔེར་བརྗོད་ ན དེ་ བྲིས།
- ༡ ། བྱེད་རང་གིས་གོ་བ་དང་འཁྲུལ་ཏེ་ མིང་གི་རྣམ་གཞག་གི་གོ་དོན་ཅིག་འགྲེལ་བཤད་རྒྱུ།

ཚིག་གི་རྣམ་གཞག།

སྐྱེས་རྟགས་ནང་ལས་ མིང་མང་དུ་འདུས་པ་ལས་ཚིག་ ཟེར་འཐོན་ཞི་ཡོད་དོ་བཟུམ། དཔེར་ན། སློབ་གོ་སེར་ཤོ། བྱིམ་ སློམ། སློབ་གྲུའི་སློབ་དཔོན། ཟེར་སྐབ་དོ་བཟུམ་ཡིན། དེ་ལུ་ནང་གསེས་གྱི་དབྱེ་བ་

- ༡ ། མིང་གི་བྱེད་ཚིག་དང་ བྱ་བའི་བྱེད་ཚིག།
- ༡ ། བྱ་བའི་ཚིག་རྒྱུ་ཡོད་པ་ཡིན།

མིང་གི་བྱང་ཚིག་ཟེར་མི་འདི་ ཤོག་གྲངས་དཀར་པོ། ལུ་བསེལ་ཉོང་ཉོ། ཟེར་བའི་སྐབས་ དཀར་པོ་དང་ བསེལ་ཉོང་ཉོ་ཚུ་ལུ་
མིང་གི་བྱང་ཚིག་ཟེར་སྐབ་ཡིན། དེ་ལུ་དབྱེ་བ།

- ༡༽ རང་བཞིན་ནམ་འོ་བོའི་བྱང་ཚིག།
- ༢༽ གངས་ཀྱི་བྱང་ཚིག།
- ༣༽ ཏུས་ཀྱི་བྱང་ཚིག།
- ༤༽ ཡོན་ཏན་ནམ་རྣམ་པའི་བྱང་ཚིག།
- ༥༽ བྱང་ཚིག་འགྲན་སྐར་གྱི་ བྱང་ཚིག་དང་བཅས་ལྡོ་ཡོད།

བྱ་བའི་བྱང་ཚིག་ཟེར་མི་འདི། དཔེར་ན། རྒྱུ་མ་ཕྱགས་འབད་འཕྱ་དེས། སྐྱུ་མ་འཁོར་ཕྱགས་འབད་གཏང་དེས། ཟེར་དོ་
བཟུམ་ ལུ་འབད་མ་ད་ འབད་ཐངས་ཀྱི་ མཚོགས་སྟོན་དང་བྱང་པར་གྱི་རིམ་པ་ཚུ་ སྟོན་མི་ལུ་བྱ་བའི་བྱང་ཚིག་ཟེར་སྐབ་
ཡིན། བྱ་བའི་བྱང་པར་སྟོན་པའི་ཚིག་ལུ་ ལུ་འབད་ཐངས་ཀྱི་བྱང་ཚིག་དང་ ལུ་གི་བྱང་པར་སྟོན་པའི་བྱང་ཚིག་ གཉིས་
ཡོད།

བྱ་ཚིག་ལུ་ བྱེད་པ་པོ་དང་འབྲེལ་བའི་ བྱ་ཚིག། བྱེད་ཚིག། སྐྱུ་ཚིག་ཚུ་དང་། བྱེད་མེད་ལས་ཚིག་ལུ་ ཏུས་ཚིག་དང་
སྟོན་ཚིག་ཚུ་ཡང་ཡོད་པ་མ་ཚད་ དེ་ཚུ་ལུ་ འདས་མ་འོངས་ ད་ལྟ་ལ་སོགས་པ་ ཏུས་གསུམ་སྟོན་པའི་ཡིག་སྐབ་ཚུ་ཡང་
སོ་སོ་ ཡོད་པ་ཡིན།



སྟོན་ལུ་ ༡ པ།

ལྷག་གི་དོན་མཚམས་འདི་ ལེགས་ཤོམ་འབད་ལྷག་ཞིན་མ་ལས་ འོག་གི་དྲི་བའི་ལན་གྱིས།

- ༡༽ མིང་གི་བྱང་ཚིག་གི་དཔེར་བཅོལ་ ༥ བྱིས།
- ༢༽ བྱ་བའི་བྱང་ཚིག་གི་དཔེར་བཅོལ་ ༥ བྱིས།

བཅོལ་པའི་རྣམ་གཞག།

བཅོལ་དོན་ཚུ་ཚང་སྟོན་པའི་ བཅོལ་པ་དང་ ཡང་ན། མིང་ཚིག་འབྲེལ་བར་སྐྱེལ་བ་ བཅོལ་པའི་མཚན་ཉིད་ཟེར་ སྐབ་སྟོལ་
ཡོད་དོ་བཟུམ་ བཅོལ་དོན་ཚུ་ཚང་ཅིག་སྟོན་མི་ལུ་ བཅོལ་པ་ཟེར་སྐབ་ཡིན། དཔེར་ན། ས་ཁར་སྟོན་ཏུག། ཁོ་གིས་འབད་དོ།
ཟེར་དོ་བཟུམ་ཡིན། ཡིན་རུང་ བཅོལ་པའི་ནང་གསེས་ལུ་དབྱེ་བ་ཅིན་ བཅོལ་པའི་རིགས། བཅོལ་པའི་དབྱེ་བ། ཟེར་ལྷམ་པ་
གཉིས་ཡོད།

མིང་། དོན་གྱི་རོ་བོ་ཚུ་སྟོན་པའི་མིང་ ཟེར་མི་འདི་ ལྷག་ལུ་མིང་གི་རྣམ་གཞག་གི་སྐབས་ལུ་བཤད་དེ་ཡོད། ད། ལུ་ལས་
མར་ མིང་གི་རྣམ་གཞག་གི་སྟོར་ལས་ ནང་གསེས་ཀྱི་དབྱེ་བ་འདི་ཚུ་ རེ་རེ་བཞིན་གྱི་ དཔེར་བཅོལ་ཚུ་ལེགས་ཤོམ་འབད་
ལྷབ་ནི།

༡༽ ལྷི་མིང་།

ལྷི་མིང་ཟེར་མི་འདི་ གང་ཟག་དང་ དངོས་པོའི་རིགས་ག་ཅི་ར་འབད་རུང་ མིང་ག་ཅིག་གིས་ གང་ཟག་དང་ དངོས་
པོའི་སྡེ་ཚན་སྦྱར་བཏང་ལུ་ ཉ་གོ་ཚུགས་མི་འདི་ལུ་སྤྲེལ་ཨིན།
དཔེར་ན། ཤིང་། མེ་རྟོག་ མི། བྲ། ཟེར་དོ་བཟུམ་ཨིན།

༢༽ སྐར་མིང་།

སྐར་མིང་ཟེར་མི་འདི་ མིང་ག་ཅི་ར་འབད་རུང་ ཁོར་ལོ་མ་རྒྱུང་ག་ཅིག་ལུ་མ་གཏོགས་ གཞན་ལུ་མ་གོ་མི་འདི་
ལུ་སྤྲེལ་ཨིན། དཔེར་ན། བཟ་ཤིས། ཉིམ། སྤོ་ལོ། ཟེར་དོ་བཟུམ་ཨིན།

༣༽ ཚོགས་མིང་།

ཚོགས་མིང་ཟེར་མི་འདི་ མིང་ག་ཅི་ར་འབད་རུང་ དམིགས་བསལ་ག་ཅིག་ལུ་མེན་པར་ ཚོགས་པ། སྡེ་ཚན། རིགས་
མཐུན་སྦྱི་འདུས་ཀྱི་ མིང་ལུ་སྤྲེལ་ཨིན། དཔེར་ན། བྲ། རུ་ལག། ཟེར་དོ་བཟུམ་ཨིན།

༤༽ གངས་མིང་། གངས་མིང་ཟེར་མི་འདི་ གང་ཟག་དང་དངོས་པོ་ ག་ཅི་ར་འབད་རུང་ ག་ཅིག་དང་ལེ་ཤ་གི་ དབྱེ་བ་བྱེ་
མི་འདི་ལུ་ གངས་མིང་ཟེར་སྤྲེལ་ཨིན། དཔེར་ན། དག་པ་ཅིག། ཚུ། ཆ་བྲུབ། ཟེར་དོ་བཟུམ་ཨིན།

༥༽ རྟགས་མིང་།

རྟགས་མིང་ཟེར་མི་འདི་ གང་ཟག་དང་ དངོས་པོའི་ཚོས་ག་ཅི་ར་འབད་རུང་ ཤོ། མོ། མ་ནིང་གི་མིང་ མོ་མོར་ཡོད་
མི་ཚུ་ལུ་ རྟགས་མིང་ཟེར་སྤྲེལ་ཨིན།
དཔེར་ན། རྒྱལ་པོ། རྒྱལ་མོ། ཨ་པ། ཨ་འི། ཟེར་དོ་བཟུམ་ཨིན།

༦༽ ཞེ་སའི་མིང་།

ཞེ་སའི་མིང་ཟེར་མི་འདི་ དུལ་གོང་མ་ཚུ་ལུ་བརྟེན་པའི་ གང་ཟག་དང་དངོས་པོ་ ག་ཅི་ར་འབད་རུང་ རང་བཞིན་
པལ་ཚོག་མེན་པར་ ཆེ་བསྟོད་ཀྱི་ཚོག་འབད་ ལུ་མི་ལུ་སྤྲེལ་ཨིན།
དཔེར་ན། ཡབ། ཡུམ། སྐྱ་གཟུགས། སྐྱ་ཚབ། ཟེར་དོ་བཟུམ་ཨིན།

- ཚོག་གི་རྣམ་གཞག་ཟེར་མི་དེ་ཡང་ ལྷག་ལུ་ ཚོག་གི་རྣམ་གཞག་གི་སྤྲེལ་ལུ་ ཁ་གསལ་འབད་ བཤད་དེ་ཡོད་
རུང་ ད། ལཱ་མཚན་ ཚོག་གི་རྣམ་གཞག་གི་ནང་གསལ་དབྱེ་བ་དང་ དཔེར་བཞེད་འདི་ཚུ་ རེ་རེ་བཞིན་དུ་ ལྷག་
ནི་ཨིན།

ཚོག་༽ དོན་གྱི་བྱད་པར་སྦྱོར་པའི་ ཚོག་ཟེར་མི་འདི་ལུ་ རང་གསལ་གྱི་དབྱེ་བ།

- མིང་གི་བྱད་ཚོག་།
- བྱ་བའི་བྱད་ཚོག་།
- བྱ་ཚོག་ ཟེར་ནང་གསལ་གྱི་དབྱེ་བ་ ༣ ཡོད་པ་ཨིན།

དང་པ་ མིང་གི་བྱད་ཚོག་།

མིང་གི་བྱད་ཚོག་ཟེར་མི་འདི་ དཔེར་ན། རྒྱ་བསིལ་རྟོང་རྟོ། མེ་རྟོག་ལེགས་མི་ལེགས། ཁལ་བསིལ་མི་བསིལ། ཟེར་
དོ་བཟུམ་ཨིན།

གཉིས་པ་ བྱ་བའི་ཁྱད་ཚིག།

བྱ་བའི་ཁྱད་ཚིག་ཟེར་མི་འདི་ དཔེར་ན། རྒྱུང་མ་ཤུགས་འབད་འཕུ་དེས། ལྷུ་མ་འཁོར་ཤུགས་འབད་གཏང་དེས།
མི་མཚོགས་པ་མཚོགས་པ་འཕྱོ་དེས། ཟེར་དོ་བཟུམ་ཨིན།

གསུམ་པ་ བྱ་ཚིག་ལུ་ནང་གསལ་གྱི་དབྱེ་བ་ བྱེད་པ་པོ་དང་འབྲེལ་བའི་བྱ་ཚིག། བྱེད་པ་པོ་དང་མ་འབྲེལ་བའི་ལས་ཚིག།
ཟེར་དབྱེ་བ་ལྷུ་མ་པ་མ་འདྲཱ་ ༩ ཡོད།

༡༽ བྱེད་པ་པོ་དང་འབྲེལ་བའི་བྱ་ཚིག།

དཔེར་ན། ཤིང་བཏོག། ལམ་འགྲོ། ལྷུ་མ་འཁོར་གཏང། ཟེར་དོ་བཟུམ་ བྱེད་པ་པོ་ གང་ཟག་གིས་ འབྲེལ་བ་
འབྲེལ་སྟེ་ ལཱ་འབད་དགོ་མི་ཅིག་ལུ་སྒྲུབ་ཨིན།

༢༽ བྱེད་པ་པོ་དང་མ་འབྲེལ་བའི་ལས་ཚིག།

དཔེར་ན། རྩ་ཆད། མེ་ཤི། ཤིང་སྒྲེལ། ཟེར་དོ་བཟུམ་ བྱ་བ་ཅིག་བྱུང་ལུག་ དེ་འབད་མ་ད་ བྱེད་པ་པོ་ གང་
ཟག་མེད་པར་ དངོས་པོ་ཁོ་ར་གིས་ རང་བཞིན་གྱིས་སྟེ་ འབད་འཕྱོ་མི་ཅིག་ལུ་ སྒྲུབ་ཨིན།

བརྗོད་པ།

བརྗོད་པ་འདི་ལུ་ཡང་ བརྗོད་པའི་གོ་དོན་དང་ དེས་ཚིག་ཚུ་ ག་ར་གོང་ལུ་བརྗོད་པའི་ ལྷུ་མ་གཞག་གི་སྐབས་ལུ་ བཤད་
ཡོད་ནི་འདི་གིས་ ད། ལྷུ་ལས་ལས་མར་ བརྗོད་པའི་སྐོར་ལས་ དབྱེ་བ་དང་ དཔེར་བརྗོད་ཚུ་ ཁ་གསལ་འབད་སྟབ་ནི་
ཨིན།

བརྗོད་པ་ལུ་ནང་གསལ་གྱི་དབྱེ་བ།

- ༡) གསལ་བརྗོད་ཀྱི་བརྗོད་པ།
- ༢) འདྲི་བའི་བརྗོད་པ།
- ༣) སེམས་ཚོར་སྦྱོར་པའི་བརྗོད་པ།
- ༤) བཀོད་རྒྱའི་བརྗོད་པ་ ཟེར་དབྱེ་བ་ ༤ ཡོད་པ་ཨིན།

བརྗོད་པ་རང་རང་སོ་སོའི་ དཔེར་བརྗོད་ནི།

ཨང་	བརྗོད་པ།	དཔེར་བརྗོད།
༡	སྤང་ནང་མེ་ཏོག་སྐྱེས་ལུག།	གསལ་བརྗོད་ཀྱི་བརྗོད་པ།
༢	མེ་ཏོག་ག་ཏེ་སྐྱེས་ལུག་གོ་?	འདྲི་བའི་བརྗོད་པ།
༣	ལྷུ་སེམ་སེམ་འབད་སྟོན་ཤིག།	བཀོད་རྒྱའི་བརྗོད་པ།
༤	སེམས་དགའ་མི་དགའ་དབའི།	སེམས་ཚོར་སྦྱོར་པའི་བརྗོད་པ།

གཉིས་པ་བརྗོད་པའི་དབྱེ་བ།

- ༡༽ བརྗོད་པ་རྒྱུད་པ།
- ༢༽ བརྗོད་པ་ཆ་ཚང་བ།
- ༣༽ ཚིགས་བཅད་ཀྱི་བརྗོད་པ།
- ༤༽ བརྗོད་པ་སྐྱེ་འདུས་ ཟེར་ནང་གསལ་གྱི་ དབྱེ་བ་ ༤ ཡོད་པ་ཡིན།

དཔེ་བརྗོད་མི།

- ༡༽ བརྗོད་པ་རྒྱུད་པ་ཟེར་མི་འདི།
 ར་སྐྱེ་ཚིགས་སྒྲིང་ལུ་འགྲོ་མི། ཟེར་དོ་བཟུམ་ བརྗོད་དོན་གཙོ་བོ་གཅིག་དང་ བྱ་བའི་ ཡུལ་ དེ་ལས་ བྱ་ཚིག་
 གཅིག་ཡོད་མི་ལུ་སྐྱབ་ཡིན།
- ༢༽ བརྗོད་པ་ཆ་ཚང་བ་ ཟེར་མི་འདི།
 རྩོད་དེ་རིས་ སྐྱེ་ཚིགས་སྒྲིང་ལུ་ ཆ་དེར་བརྟོན་ཏེ་ ཚོང་བརྟོན་པར་སོང་། ཟེར་དོ་བཟུམ་ བརྗོད་དོན་གཙོ་བོ་
 དང་གཅིག་ཁར་ བྱ་བའི་ཡུལ། བྱ་ཚིག། དགོས་པ། རྩོད་ཚིག། དུས་དང་། བཅས་ཆ་ཚང་འབད་ཡོད་མི་ཅིག་ལུ་
 སྐྱབ་ཡིན།
- ༣༽ བརྗོད་པ་སྐྱེ་བསྐྱུས་ ཟེར་མི་འདི།
 རྩོད་ཕྱི་རྒྱལ་ལས་ ཡོག་ལྟོད་ཞིན་མ་ལས་ བད་གཞི་ཀུན་ལུ་འདྲ་ཡོད་མེད་ བརྗོད་དུང་འབད་དགོ། ཟེར་དོ་
 བཟུམ་ རྩོད་ཚིག་གཅིག་ནང་ དོན་དག་མ་ འབྲས་གཅིག་ལས་ ལྷག་སྟེ་ཡོད་མི་ལུ་སྐྱབ་ཡིན།
- ༤༽ ཚིགས་བཅད་ཀྱི་བརྗོད་པ་ ཟེར་མི་འདི།
 ཚིགས་བཅད་ཀྱི་བརྗོད་པ་ཟེར་མི་འདི་ བརྗོད་དོན་ ཚིགས་ལྷུག་པའི་ཐོག་ལས་མེན་པར་ ཚིགས་བཅད་ཀྱི་ཐོག་
 ལས་ འབྲི་མི་ལུ་སྐྱབ་ཡིན།

དཔེར་ན། ལྷོ་ཕྱོགས་འཛམ་བུའི་གླིང་ལུ། རྒྱལ་ཁབ་གྲངས་ཁ་མིན་འདུག །
 རྒྱལ་ཁབ་དེ་ཚུ་ནང་ལས། འབྲུག་གི་རྒྱལ་ཁབ་དགའ་བས། ཟེར་དོ་བཟུམ་ཡིན།

ཚིགས་བཅད་ཟེར་བའི་དེས་ཚིག་ བརྗོད་དོན་འདི་ ཚིག་རྒྱུ་ནང་ལུ་ གཅད་མཚམས་བཟོ་སྟེ་ འབྲི་མི་ཅིག་ལུ་ ཚིགས་བཅད་
 ཟེར་སྐྱབ་ཡིན།

ཚིགས་བཅད་ཀྱི་དབྱེ་བ།

ཚིགས་བཅད་ལུ་ཚིག་འབྲུ་ ༣ རེ་ འབད་མི་ལས་ འགོ་བཙུགས་ཏེ་ ཚིག་འབྲུ་ ༣༤ རེ་འབད་མི་ཚུན་ཚོད་ལུ་
 དབྱེ་བ་མ་འབྲས་ ༣༤ ཡོད། ཡིན་རུང་ ར་བཅས་ར་རྗོང་ཁའི་ནང་ མང་ཤོས་ཅིག་ ཚིག་འབྲུ་ ༡༢ ཚུན་ཚོད་མ་
 གཏོགས་ ལག་ལེན་འཐབ་ནི་མེད་ དེ་འབད་ནི་འདི་གིས་ ལཱ་ལུ་ཚིགས་བཅད་ཀྱི་ དཔེར་བརྗོད་ཀྱི་ དཔེ་དག་པ་
 ཅིག་བཀོད་དེ་ཡོད།

ཚིག་འབྲུ་ ༩ ལ།

ཚོས་ལྷན་གྱི། རྒྱལ་ཁབ་ནང། །དགའ་སྦྱིད་གྱི། །ཉི་མ་ཤར། །

ཚིག་འབྲུ་ ༧ ལ།

བཅོ་ལྷའི་རྒྱ་བ། །མཁའ་ལ་ཤར་ཚེ། །
མི་དབང་རྒྱལ་པོ། །ཞལ་རས་དྲན་སོང། །



སྦྱོར་ལྟ་ ༩ པ།

ལྷག་ལྟ་ཡོད་མི་ དོན་ཚན་རྩ་ལས་དཔེར་བརྗོད་དང་ དྲི་བའི་ལན་རྩུ་བྱིས།

- ༡༽ བརྗོད་པ་རྒྱུད་པ་ ཟེར་སྐབ་དགོ་བའི་ ལུངས་བྱིས།
- ༢༽ བརྗོད་པ་ཆ་ཚང་བ་ཟེར་ ག་ཅི་འབད་ སྐབ་ཅི་ག་? ལ་གསལ་འབད་བྱིས།
- ༣༽ བརྗོད་པ་སྐྱ་འདུས་ ཟེར་མི་འདི་ ག་ཅི་བརྩམ་ཅིག་ལུ་ སྐབ་ནི་སྟོ?
- ༤༽ ཚིག་འབྲུ་ ལྷ་མའི་དཔེར་བརྗོད་ ༩ རྒྱལ།
- ༥༽ ཚིག་འབྲུ་ བདུན་མའི་ དཔེར་བརྗོད་ ༩ རྒྱལ།



བརྗོད་བསྟུགས།

- དོན་ཚན་འདི་ནང་ལུ་གཙོ་བོ་ར་ མིང་ཚིག་བརྗོད་པ་གསུམ་གྱི་རྣམ་གཞག་དང་ བང་གསེས་གྱི་དབྱེ་བ་དང་འཁྲིལ་ ཉེ་ འཇུག་ལུ་ལྷ་ ག་དེ་སྟེར་ཡོད་པ་ཨིན་ན་ དེ་ལས་ ཚིགས་བཅད་བརྗོད་པའི་སྐབས་ལུ་ ཚིག་རྒྱུ་རྩུ་གི་ནང་ ལུ་ཚིག་འབྲུ་འཐོབ་ལམ་ ག་དེ་སྟེར་ འབྲི་སྟོལ་ཡོད་པ་ཨིན་ནའི་སྟོར་བཏོན་མ་ཨིན།



རང་ཉིད་སྦྱོར་སྦྱང་ དབྱེ་ཞིབ།

ལྷག་ལྟ་ཡོད་མི་ མིང་ཚིག་བརྗོད་པ་རྩུ་གི་ གོ་དོན་དང་ དབྱེ་བ་རྩུ་མེ་མེ་བཞིན་དུ་བཏོད།

- ༡༽ དེ་ལས་ རྩུད་ར་གིས་ཡང་ བརྗོད་པ་དབྱེ་བ་བཞི་དང་འཁྲིལ་བའི་ དཔེ་མེ་མེ་བཞིན་བྱིས།
- ༢༽ རྩུད་ཀྱིས་འབད་བ་ཅིན་ བརྗོད་པ་སྐྱ་འདུས་སྐབས་ ག་ཅི་རང་ཚང་དགོ་པ་འདུག་?
- ༣༽ མིང་ཚིག་བརྗོད་པ་གསུམ་གྱིས་ འབྲི་སྟོལ་བྱི་བའི་སྐབས་ལུ་ ལེ་པན་རྩུ་འདུག་ག་? ག་དེ་སྟེ? བྱིས།

༣- འབྲི་ཚུམ་གྱི་སྤྱིར་བཏང་འབྲི་ཚུམ་དང་ ཚུད་གྲོང་འབྲི་ཚུམ།

ལས་དོན།



- སྤྱིར་བཏང་འབྲི་ཚུམ་ཟེར་མི་འདི་ ག་བཟུམ་ཅིག་ལུ་སྒྲིབ་ཡིན་ན་ ཤེས་ཚུགས་ནི།
- ཚུད་གྲོང་འབྲི་ཚུམ་གྱི་སྤྱིར་ལས་ དེས་ཚེག་དང་ བྱད་ནམ་ དཔེ་ དེ་ལས་ མི་ ཚེད་གནས་སྤངས་ནང་ལུ་ ལག་ལེན་དངོས་འབྲེལ་གྱི་སྤྱིར་ལས་ ཤེས་ཚུགས་ནི།
- དོན་ཚན་བྱིན་ཡོད་མི་དང་འབྲི་ལ་ཉེ་ ཚུད་གྲོང་འབྲི་ཚུམ་གྱི་ཚུགས་ནི།

དོ་སློབ།

༣ འབྲི་ཚུམ་ཟེར་མི་འདི་ སྤྱིར་བཏང་གནད་དོན་ཅིག་ལུ་ གཞི་བཞག་ཞིན་མ་ལས་ དེ་ཡང་ དོན་མཚམས་སོ་སོར་བཅད་ དེ་ དོ་སློབ་དང་ བར་གྱི་གནད་དོན་ མཚུགས་བསྟུ་ཚུ་ཡོད་པའི་ འབྲི་བཀོད་ཅིག་གི་ཐོག་ལས་ ལྷག་མི་ཚུ་ ཡིད་ཆེས་བསྐྱེད་ ཚུགས་པའི་ བྱངས་དང་རྒྱ་མཚན་ དཔེ་ལུང་ཚུ་བཀོད་དེ་ བྱིད་གོ་བ་ཡིན། འབྲི་ཚུམ་འདི་ ཚུམ་རིག་གི་ནང་གསེས་ཅིག་ ཡིན་མ་ལས་ རྫོང་ཁའི་ཚུམ་རིག་གི་ ཤེས་ཡོན་ལེགས་ཤོམ་འབྲེལ་ཞིའི་དོན་ལུ་ འབྲི་ཚུམ་འདི་ སློབ་སྦྱོང་དོན་ཚན་འབད་ བཟུགས་ཉེ་ཡོད་པ་ཡིན།

- སྤྱིར་བཏང་འབྲི་ཚུམ་ནང་ལུ་ ཚང་དགོ་པའི་བྱད་ནམ།
- དོན་ཚན་དང་ སྤྱིར་བཏང་ཡི་གུའི་མགྲུ་རྒྱ།
- དོ་སློབ་ བར་གྱི་གནད་དོན་ མཚུགས་བསྟུ་གསུམ་ཚང་ཡོད་པ།
- གནད་དོན་རེ་རེ་བཞིན་ དོན་མཚམས་སོ་སོར་བཅད་དེ་བྲིས་ཡོད་པ།
- ཚེག་མཚམས་བཅད་དེ་བྲིས་ཡོད་པ།



སློབ་ལུ་ ༡ པ།

སློབ་ལུ་འབྲི་བཀོད་རྒྱ།	སློབ་ལུ་ཁ་གསལ།
ལྷག་ལུ་བཀོད་ཡོད་མི་ རྒྱབ་བྱངས་འདི་ ལེགས་ཤོམ་སྤེལ་གྱི་ལེན་ལས་ ཅི་བ་ཚུ་ གིས་ལན་ བྱི་དེ་བ་ནང་ལུ་བྲིས་དགོ།	<p>༡. འབྲི་ཚུམ་ཟེར་མི་འདི་ ག་ཅི་སློབ་?</p> <p>༢. སྤྱིར་བཏང་འབྲི་ཚུམ་འབྲི་བའི་སྐབས་ལུ་ དེས་པར་དུ་ཚང་དགོ་པའི་ བྱད་ནམ་ཚུ་ ཐོ་བཀོད་འབད།</p>

ཚུད་གྲོང་འབྲི་ཚུམ་གྱི་སྤྱིར་ལས།

ཚུད་གྲོང་འབྲི་ཚུམ་ཟེར་མི་འདི་ ཚུད་བསྐྱར་འབད་བརྟུབ་པའི་ དོན་ཚན་གཅིག་ལུ་ བྱངས་ལུན་གྱི་དགག་སྒྲིབ་གང་རུང་ཐོག་ ལས་ གཞན་ཚུ་ཡིད་ཆེས་གནས་ལུ་ བཀོད་ཚུགས་པའི་ལུང་རིག་ཚུ་བཟུགས་ཉེ་ བན་གཞན་དང་འོས་འབབ་ཡོད་མེད་ སོགས་གྱི་ར་བྱངས་དང་ བདེན་བྱངས་གཟུང་སྟེ་ བཀོད་པའི་འབྲི་ཚུམ་ཅིག་ལུ་སྒྲིབ་ཡིན། དཔེར་ན་ གོང་གསེབ་ནང་ཞིང་

ལམ་གཏོན་པ་ཅིན་ མི་སེར་ལུ་གཞོན་པ་བ་ཡང་ བན་པ་འདི་ལྷགས་ཆེ། ཟེར་ གཞོན་པ་ཡོད་ཟེར་བའི་བསམ་འཆར་ཚུ་ལུ་ གཞོན་པ་ལས་པན་པ་ར་ལྷགས་ཆེ་བའི་ཚོད་བསྟར་ སྐབ་བྱེད་དང་བདེན་ཁུངས་གཟུང་སྟེ་ འབྲི་དོ་བཟུམ་ཨིན།

ཚོད་གྲོང་འབྲི་ཚུམ་གྱི་ཁྱད་རྣམ།

- སྤྱིར་བཏང་འབྲི་ཚུམ་གྱི་ ཁྱད་ཚོས་ག་ར་ ཚང་པའི་ཐོག་ལས་ བཤད་དགོ་པའི་ གནད་དོན་འདི་ བཤད་ཐངས་ ཐང་ཁར་ ཆོག་གཙོ་བོ་ར་དོན་ཚན་འདི་ མི་སྲེའི་ནང་ལུ་ ཚོད་བསྟར་གྱི་གཞི་ཅིག་འབད་ བརྗེ་དོ་ཡོད་མི་ཅིག་ དགོ་པ།
- ལྷག་མི་ཚུ་གིས་ ཆ་བཞག་ཚུགས་ནིའི་དོན་ལུ་ ཚོད་བསྟར་འདི་ འོས་འབབ་ཡོད་པའི་ཁུངས་དང་སྐབ་བྱེད་ དང་ དཔེ་ཚུ་གོ་ཤིང་འབད་བཅུགས་ཏེ་ བཞོན་ཡོད་པ།
- གཞན་གྱིས་ བདེན་འཛིན་རེ་ཐབས་ལུ་ ཚོར་ལྷགས་ཅན་གྱི་ཆོག་ཚུ་ ཚུད་ཡོད་པ།



སློབ་ལཱ་ ༩ པ།

སློབ་ལཱི་བཞོན་ཀྱ།	སློབ་ལཱ་ཁ་གསལ།
<p>ལྷག་ལུ་བཞོན་ཡོད་མི་ རྒྱབ་ཁུངས་ འདི་ ལེགས་ཤོམ་སྟེ་ལྷག་ཞིན་ལས་ དྲི་བ་ཚུ་གི་ལན་ གི་དེ་བ་ནང་ལུ་གི་དགོ། དྲི་བ་ ༩ པའི་ལན་གི་ནིའི་དོན་ལུ་ ཐབས་ཤེས་འདི་ ཚོད་གྲོང་འབྲི་ཚུམ་ གྱི་དེས་ཆོག་ནང་ལུ་ བཞོན་ཡོད་པའི་ དཔེ་བཟུམ་གྲིས།</p>	<p>༡. ཚོད་གྲོང་འབྲི་ཚུམ་ཟེར་མི་འདི་ ག་ཅི་སྟོ་? ༢. ཚོད་གྲོང་འབྲི་ཚུམ་ འབྲི་བའི་སྐབས་ལུ་ ཚང་དགོ་པའི་ ཁྱད་རྣམ་ ཚུ་ ཐོ་བཞོན་འབད། ༣. འབྲུག་རྒྱལ་ཁབ་གྱི་ དང་སང་མི་སྲེའི་ནང་ལུ་ ཚོད་གྲོང་འབྲི་ཚུམ་འབྲི་ བཏུབ་པའི་ ཚོད་བསྟར་གྱི་གཞི་ལུ་ འབྲུར་ཡོད་པའི་གནད་དོན་ ༩ པ་ ཐོ་ བཞོན་འབད།</p>



བཅུད་བསྟུས།

- སྤྱིར་བཏང་འབྲི་ཚུམ་ཟེར་མི་འདི་ ག་བཟུམ་ལུ་སྐབ་ཨིན་ན་ ལྷག་ལུ་གིས་ཏེ་ཡོད།
- སྤྱིར་བཏང་འབྲི་ཚུམ་གྱི་དབྱེ་བ་ག་ཅི་ར་འབྲི་རུང་ ཨིན་ཅི་མེན་ཅི་ཚང་དགོ་པའི་ ཁྱད་ཚོས་ཚུ་གི་སྟོར་ལས་ལྷབ་ཅི།
- ཚོད་གྲོང་འབྲི་ཚུམ་འདི་ ག་བཟུམ་ཅིག་ལུ་སྐབ་ཨིན་ན་གི་སྟོར་ལས་ ལྷབ་ཚར་ཡི།
- ཚོད་གྲོང་འབྲི་ཚུམ་འབྲི་བའི་སྐབས་ལུ་ ཚང་དགོ་པའི་ཁྱད་རྣམ་དང་ཁྱད་ཚོས་ཚུ་ལྷབ་ཅི།
- ཚོད་གྲོང་འབྲི་ཚུམ་འབྲི་ཐངས་ དཔེ་དང་བཅས་པ་འབད་ལྷབ་ཅི།



རང་ཉིད་སློབ་སྦྱོར་ དབྱེ་ཞིབ།

འོག་ལུ་བཀོད་ཡོད་མི་ གྲི་བ་འདི་ལེགས་ཤོམ་འབད་ལྷག་ཞེན་མ་ལས་ དགག་སྐྱབ་ཀྱི་ཐོག་ལས་ ཚུད་སློང་འབྲི་ཚུམ་ ཚོག་འབྲུ་ ༤༠༠ ལས་ ༤༥༠ གི་ནང་འཁོད་ འབད་མི་ཅིག་ ཁྱོད་རའི་བྲི་དེ་བ་ནང་ལུ་བྲི་དགོ་པ་ཨིན།

- ༡༽ གྲི་བ་ཚོ་འདི་བྲི་གཉིས་ལུ་ཕན་པའི་ ཚོགས་བསགས་སློབ་སྦྱོང་གི་ཐབས་ ལྷག་དང་མཚོད་པ་སྤུལ་ནི་ལས་འདི་བསམ་པ་བཟང་པོ་བསྐྱེད་ནི་འདི་ར་དག།
- ༢༽ (དགག་སྐྱབ་ འདྲ་མཉམ་མེན་པར་ ཚོགས་བསགས་སློབ་སྦྱོང་གི་ཐབས་ ལྷག་དང་མཚོད་པ་སྤུལ་ནི་ལས་འདི་བསམ་པ་བཟང་པོ་བསྐྱེད་ནི་འདི་ར་དག་ཟེར་སྐྱབས་ཏེ་བྲི་ནི།
- ༣༽ ཚུད་སློང་འབྲི་ཚུམ་འབྲི་ཐངས་ཀྱི་དཔེ་ཅིག་འོག་ལུ་ གྲི་བ་དང་གཅིག་ཁར་བྲིས་ཡོད་པ་ཨིན།
- ༤༽ གྲི་བ་མི་ཚེ་དག་འཁྱེད་རང་ལུ་ སློང་དགོ་པ་ཅིན་ གཞུང་གཡོག་འབད་མ་ལས་འདི་ སླེར་གྱི་ལཱ་གཡོག་འབད་བ་ཅིན་ ཕན་ཐོགས་ཆེ།
- ༥༽ (དགག་སྐྱབ་ འདྲ་མཉམ་མེན་པར་ གཞུང་གཡོག་ལས་ སླེར་གཡོག་ཕན་ཐོགས་ཆེ་བའི་སློང་ལས་ སྐྱབ་སྟེ་བྲི་ནི་དཔེར་ན་ སློབ་འཛིན་ ༡༡ པའི་ ཚོ་སོག་དག་ཟེར་མི་འབྲི་ཚུམ་དང་ སློབ་འཛིན་ ༡༢ པའི་ གཞུགས་ཁམས་བདེ་བའི་ཟས་བཅུད་ཟེར་མི་ འབྲི་ཚུམ་བཟུམ་ ལྷགས་གཅིག་ལུ་གཙོ་བོ་བཟུང་སྟེ་བྲི་ནི།)

༧- ཡི་གུའི་སློབ་བཤུན་ལྟུང་བརྒྱུད།

ལས་དོན།



- རྣམ་དབྱེ་བརྒྱུད་ཀྱི་གོ་དོན་ཉ་གོ་སྟེ་ འཕྲི་ཞི་དང་ སླབ་ནི་ཚུ་འབད་ཚུགས།
- རྣམ་དབྱེ་བརྒྱུད་ རང་ར་སོ་སོའི་འཇུག་པ་ཚུ་ རྗེས་འཇུག་དང་འཁྲིལ་ཉེ་ མ་འཇོལ་བར་ ལག་ལེན་འཐབ་ཚུགས།
- རྣམ་དབྱེ་བརྒྱུད་ རང་གསེས་ཀྱི་དབྱེ་བ་ཚུ་ཕྱི་སྟེ་ དཔེར་བཅོལ་ཚུ་ རྒྱབ་ཚུགས།

ངོ་སློབ།

ཚོས་ ག་ཅི་འབད་རུང་ཅིག་གི་ མིང་ཚིག་འདི་གཞན་དང་མ་འདྲེས་པར་ རྣམ་པར་ཉེ་སོ་སོར་དབྱེ་ཞིང་འབྲེད་ཚུགས་པའི་ སྐྱའི་ཆ་ཤས་སུ་གྱུར་པའི་ ཚིག་ཕྱད་ཅིག་ལུ་ རྣམ་དབྱེ་ཟེར་སླབ་ཨིན་པས།

ཨང་	རྣམ་དབྱེ་བརྒྱུད།		
༡	ངོ་བོ་ཙམ་སྟོན་པ།	༥	འབྲུང་ཁུངས།
༢	ལས་སུ་བྱ་བ།	༦	འབྲེལ་བ་དང་།
༣	ཕྱེད་པ་པོ།	༧	གནས་གཞི།
༤	དགོས་ཆེད།	༨	པོད་སྐྱ།

རྣམ་དབྱེ་དང་པ་ ངོ་བོ་ཙམ་སྟོན་པ།

ངོ་བོ་ཙམ་སྟོན་པ། ཟེར་མི་འདི་ དོན་གྱི་ཁྱད་པར་ག་ནི་ཡང་མ་སྟོན་པར་ མིང་གི་ཐ་སྲེད་ཙམ་ཅིག་སྟོན་མི་ལུ་ ངོ་བོ་ཙམ་ སྟོན་པ་ ཟེར་སླབ་ཨིན། དཔེར་ན། ལྷ། ལྷ། མེ་ཉྱེད་ ཟེར་དོ་བཟུམ་ བཅོལ་དོན་འདི་གིས་ མིང་རྒྱུང་པ་གཅིག་མ་ གཏོགས་ བྱ་ལས་དང་ཁྱད་ཚོས་ཚུ་ ག་ནི་ཡང་མ་སྟོན་མི་འདི་ལུ་ ངོ་བོ་ཙམ་སྟོན་པ་ ཟེར་སླབ་ཨིན།

རྣམ་དབྱེ་གཉིས་པ་ ལས་སུ་བྱ་བ།

ལས་སུ་བྱ་བ། ཟེར་མི་འདི་ བྱ་བའི་ཡུལ་ངོས་བཟུང་ཞིན་མ་ལས་ དེ་ཁར་ལཱ་ཅིག་འབད་བའི་ དོན་སྟོན་མི་ལུ་སླབ་ཨིན། དེ་ལུ་ ༡༽ ལས་སུ་བྱ་བའི་རྣམ་དབྱེ་དང་། ༢༽ ཡུལ་ལས་དབྱེར་མེད་ཀྱི་རྣམ་དབྱེ་ ཟེར་དབྱེ་བ་ལྷན་པ་ ༣ པོད། རྣམ་དབྱེ་འདི་ལུ་ ཚོས་སྐད་ཀྱི་ནང་ལུ་ སུར་རུ་རུ་བྱ་བ་ལ། ཟེར་ ལ་དོན་གྱི་ཕྱད་ བདུན་ཡོད་པ་ཨིན་རུང་ རྗོང་ཁའི་ནང་ བ་ར་ལུ་གྲ་སྐྱ དང་བཅས་ ལཱ་ འཇུག་པ་ཨིན། ཕྱད་ཀྱི་འཐོབ་ཐངས་དེ་ཡང་ རྗེས་འཇུག་ ས་ གི་རྟིང་ལས་སུ་འཐོབ་ནི་ དང་། འ་ དང་ མཐའ་མེད་ ཀྱི་རྟིང་ལས་ ཕྱད་ ར་ འཐོབ་ནི། དེ་ལས་གཞན་ རྗེས་འཇུག་ཚུ་གི་ མཐའ་མར་ བ་ དང་ ལུ་ ལུ་ ཚུ་འཇུག་ནི་ཨིན། དཔེར་ན།

ལ་དོན་གྱི་ཕྱད་གཞན་ཚུ་གིས་ རྗེས་འཇུག་མཐའ་མར་འཇུག་པའི་དཔེར་བཅོམ་།	
ན	ནང་ ན་ ཤོག།
ར	གནས་ཁར་ མཚོངས།
ལྷ	ཐིམ་སྤྱག་ ལྷ་ སོང་།
གྲ	འབའ་ གྲ་ རྒྱབ།
ལྷ	དངོས་ ལྷ་ འབད།

ཟེར་དོ་བརྩམ་ཞིན། དེའི་སྐབས་ ཕྱེད་པ་པོ་དངོས་སྤྱོད་རུང་ ཕྱེད་པ་པོ་གཙོ་བོ་མ་བརྟོན་པར་ བྱ་བའི་ཡུལ་དང་ ཡུལ་གྱི་ ཐོག་ལུ་ ལྷ་ག་ཅི་འབད་དོ་ག་ གཙོ་བོ་བརྟོན་ཏེ་སྤྱབ་ཞིན།

ལས་སྤྱོད་བའི་ནང་གསེས་ ཡུལ་ལས་དབྱེར་མེད་ཀྱི་སྤྱོད་།

ནམ་དབྱེ་གཉིས་པ་ལས་སྤྱོད་བའི་ནང་གསེས་ ཡུལ་ལས་དབྱེར་མེད་ཀྱི་ནམ་དབྱེ་ ཟེར་མི་འདི་བྱ་བའི་ ཡུལ་ལས་ལས་ ཅིག་ལུ་ བྱ་བའི་ལྷ་ཅིག་འབད་མེད་ བྱ་བའི་ཡུལ་དང་ བྱ་བ་གཉིས་སོ་སོར་བྱེ་མ་ཚུགས་པར་འགྲོ་མི་ཅིག་ལུ་ སྤྱབ་ ཞིན། དཔེར་ན།

ཕྱད།	ཡུལ་ལས་དབྱེར་མེད་ཀྱི་དཔེར་བཅོམ་།
ར	མི་མཁས་པར་ ལྷུར།
ལྷ	ལྷ་ ལྷ་ ལྷུལ།
ལྷ	རང་ལྷ་ ལྷ་ བསྐྱེམ།

ཟེར་དོ་བརྩམ་ མི་དང་ མཁས་པ་ ལྷ་དང་ ལྷུལ་པ་ཚུ་སོ་སོ་མེན་པར་ གཅིག་འབད་ སྤྱབ་དོ་བརྩམ་ཞིན།

འཇུག་སྤོང་།

ཕྱད།	འཇུག་སྤོང་གི་དཔེ།	ཕྱད།	འཇུག་མེད་ཀྱི་དཔེ།
གྲ/ལྷ	ཤིང་ གྲ་ལྷ།	གྲ	ཤིང་གྲ་འཛོག་ཅི།
སྤྱ/ལྷ	ལས་འགྲོ་བའི་སྐབས་ སྤྱ་ལྷ།	སྤྱ	ལས་འགྲོ་བའི་སྐབས་སྤྱ།
ར/ལྷ	ཤིང་ཁར་ལྷ་འཛོག།	ར	ཤིང་ཁར་འཛོག།

ཟེར་དོ་བརྩམ་ ཕྱད་གཉིས་འབད་ལག་ལེན་འཐབ་སྤེ་སྤྱབ་ནི་དང་ འགྲོ་ནི་ཚུ་མ་བརྟུབ་ཞིན།

ནམ་དབྱེ་གསུམ་པ་ ཕྱེད་པ་པོ།

ཕྱེད་པ་པོའི་ནམ་དབྱེ་ཟེར་མི་དེ་ བྱ་བའི་ལྷ་ག་ཅི་འབད་རུང་ དེ་འབད་མི་གང་ཟག་དང་དངོས་པོ་ ག་ཞིན་ན་སྦྱོར་པའི་སྤྱོད་ལུ་ གོ་མ་ཞིན། འདི་ལྷ་ནང་གསེས་ཀྱི་དབྱེ་བ།

ཨང་།	བྱེད་པ་པོའི་རྣམ་དབྱེ་བ།
༡	བྱེད་པ་པོ་གཙོ་བོ།
༢	བྱེད་པ་པོ་ཕལ་པ།
༣	རང་བཞིན་གྱི་བྱེད་པ་པོ།
༤	བྱེད་སྐྱེ་རྒྱུ་མཚན་ལུ་འཇུག་པ།

རྗེས་འཇུག་དང་འཁྲིལ་ཏེ་ བྱེད་སྐྱེའི་ཕྱད་གྱི་ཐོབ་ལམ།

རྗེས་འཇུག།	ཕྱད།
༥	གྱིས།
བ	
མ	
ག	གིས།
ང་	
ན	གྱིས།
མ	
ར	
ལ	
འ་དང་ མཐའ་མེད	འིས། ཡིས།
	རྗེས་འཇུག་ལུ་གོང་གི་བཟུམ་ཡིན་མ་དང་ གིས་འདི་འ་དང་མཐའ་མེད་གྱི་མཐའ་ འཇུག་པ་ ཡིན།

སློབ་ཚིག། སློབ་རྒྱུལ་ན་མ་ར་ལ་གྱི། །ད་བ་ས་གྱི་ག་ང་གི། །འ་དང་མཐའ་མེད་འི་དང་ཡི། །རྗེས་འཇུག་ལུ་གི་འཇུག་པ་ ཡིན། །

༡༽ བྱེད་པ་པོ་གཙོ་བོ།

བྱེད་པ་པོ་ གཙོ་བོ་ ཟེར་མི་འདི་ གང་ཟག་སེམས་ཡོད་མི་ཅིག་གིས་ ལཱ་ཅིག་འབད་བའི་དོན་སྟོན་མི་ལུ་སྐྱབ་ཡིན། དཔེར་ན།

ཕྱད།	བྱེད་པ་པོ་ གཙོ་བོ་དཔེར་བརྗོད།
གིས།	སྐྱང་ གིས་ བརྒྱུད་ས།
གྱིས།	བདེ་ཆེན་ གྱིས་ ལྷག།
གྱིས།	བདེ་སྲིད་ གྱིས་ ལྷག།

༡༽ བྱེད་པ་པོ་ཕལ་པ།

བྱེད་པ་པོ་ཕལ་པ་ ཟེར་མི་འདི་ བེམ་པོའི་རང་བཞིན་ སེམས་མེད་མི་ཅིག་གིས་ ལཱ་ཅིག་འབད་བའི་དོན་སྟོན་མི་ལུ་སླབ་ ཡིན། དཔེར་ན།

ཕན།	བྱེད་པ་པོ་ཕལ་པའི་ དཔེར་བཞིན།
གིས་	གྲི་གཟུང་ གིས་ བཏོགས།
གྲིས་	རྒྱུ་གྲིས་གང་།
གྲིས་	ཁབ་ གྲིས་ བཅུམ།

༢༽ བྱེད་སྐྱེ་རང་བཞིན།

བྱེད་སྐྱེ་ལྷན་ཚུ་གིས་ བྱེད་པ་པོ་སོ་སོ་མེད་པར་ རང་བཞིན་གྲིས་སྟོན་པའི་ དོན་ལུ་ཡང་འཇུག་པ་ཡིན། དཔེར་ན།

ཕན།	བྱེད་སྐྱེ་རང་བཞིན་གྱི་ དཔེར་བཞིན།
གིས་	ཁོར་ གིས་ ར་སྐམ་སོ་ཡི།
གྲིས་	རང་བཞིན་ གྲིས་ སྐྱེས་ཡི།
གྲིས་	ངམ་ངམ་ལུགས་ གྲིས་ ཤེས་འོང།

༣༽ བྱེད་སྐྱེ་རྒྱ་མཚན་གྱི་དོན་ལུ་འཇུག་པ།

བྱེད་སྐྱེ་ལྷན་ཚུ་གིས་ རྒྱ་མཚན་བཀོད་པའི་དོན་ལུ་ཡང་འཇུག་ནི་ཡོད། དཔེར་ན།

ཕན།	བྱེད་སྐྱེ་རྒྱ་མཚན་ལུ་འཇུག་པའི་ དཔེར་བཞིན།
གིས་	ཤེས་ནི་དེ་ གིས་ མཐར་འཁྱོལ་ཡི།
	དེ་ གིས་ འབད་འཇུག་དགོཔ་བྱུང་ཡི།
	ན་ནི་དེ་ གིས་ ལུས་སོ་ཡི།

རྣམ་དབྱེ་བཞི་པ་ དགོས་ཆེད།

བྱ་བའི་ལཱ་ཅིག་འབད་མ་དུ་ ལཱ་འདི་གི་དོན་དག་དང་ ཡང་ན་ དགོས་པ་ག་ཅི་གི་དོན་ལུ་ འབད་མ་ཡིན་ན་སྟོན་མི་ཅིག་ལུ་ གོམ་ཡིན།

རྣམ་དབྱེ་འདི་ལུ་ཡང་ རྣམ་དབྱེ་ གཉིས་པ་བརྩམ་འབད་རང་ ལ་དོན་གྱི་ཕན་ ཆོས་སྐད་ཀྱི་ནང་ སྤྱི་ལཱ་ལུ་ལྷན་ དང་། རྫོང་ཁའི་ནང་ ར་ར་ལུ་གྲུ་ལུ་ ཚུ་འཇུག་པ་ཡིན། ཕན་གྱི་འཐོབ་ཐངས་ཡང་ རྣམ་དབྱེ་ གཉིས་པ་བརྩམ་འབད་རང་ ཡིན།

དཔེར་ན། སངས་རྒྱལ་ནི་གི་དོན་ ལུ་ ཆོས་འབད། དཔེ་ཆ་ལྟམ་པར་ འཇུག། ཟེར་དོ་བརྩམ་ཡིན་ནོ།

ནམ་དབྱེ་ལྷ་པ་འབྱུང་ཁྱུངས།

ལྷ་པ་འབྱུང་ཁྱུངས་ཟེར་མི་འདི་ གང་ཟག་དང་དངོས་པོ་ཚུ་ ཡུལ་ག་ལས་འབྱུང་མ་ཡིན་ན་ དེའི་ཁྱུངས་སློན་གི་འདི་གིས་ འབྱུང་ཁྱུངས་ཀྱི་ནམ་དབྱེ་ཟེར་སྲབ་ཡིན། ནམ་དབྱེ་འདི་ལྷ་ཚོས་སྐད་ཀྱི་སྐབས་ཕྱད་ ནམ་ དང་ ལས་ གཉིས་འཇུག་པ་ ཡིན། ཡིན་རུང་ རྫོང་ཁའི་ནང་ཕྱད་ ལས་ གཅིག་འཇུག་པ་ཡིན། ལས་འདི་གིས་ འབྱུང་ཁྱུངས་ལུ་ནང་གསེས་ཀྱི་དབྱེ་བ།

- ༡༽ འབྱུང་ཁྱུངས་དངོས།
- ༢༽ འབྱུང་ཁྱུངས་ཆ་འདྲ་བ།
- ༣༽ རྒྱ་མཚན་སློན་པ།
- ༤༽ འགྲན་སྲུང་གི་ཁྱུང་རིམ།
- ༥༽ སྲུང་པའི་སྲ། བཅས་ལྷ་ལུ་འཇུག་པ་ཡིན།

༡༽ འབྱུང་ཁྱུངས་དངོས།

འབྱུང་ཁྱུངས་དངོས་ཟེར་མི་འདི་ གང་ཟག་དང་དངོས་པོ་ཚུ་ ཡུལ་ག་ཞན་ལས་མེན་པར་ འབྱུང་སའི་ཡུལ་ངོ་མ་འདི་ལས་ར་ འབྱུང་དགོས་ཡིན་པའི་ཁྱུངས་དང་ ཡང་ན་འབྱུང་སའི་གཞི་ངོ་མ་སློན་མི་ལུ་གོ་ནི་ཡིན།

དཔེར་ན།

- བྱམོ་ ལས་ རྫོང་དོག།
- ཁ་ ལས་ གཏམ།
- གཟུགས་ཁ་ ལས་ ལྷག་ ཟེར་དོ་བཟུམ་ཡིན།



༢༽ འབྱུང་ཁྱུངས་ཆ་འདྲ་བ།

འབྱུང་ཁྱུངས་ཆ་འདྲ་བ་ཟེར་མི་འདི་ གང་ཟག་དང་དངོས་པོ་ཚུ་ ཡུལ་ངོ་མ་དེ་ནང་ལས་ རྒྱུང་རྒྱུང་མེན་པར་གཞན་ཁ་ལས་ འབག་འོང་སྟེ་བཞག་ཞེན་མ་ལས་ འདི་ནང་ལས་ལོག་སྟེ་འབྱུང་མི་ལུ་གོ་སྟེ་ཡིན།

དཔེར་ན།

- ཤིང་ཁ་ ལས་ སྲ།
- ཚུ་ ལས་ ཉ།
- དམ་སྲི་ནང་ ལས་ ཡོམ། ཟེར་དོ་བཟུམ།



༣༽ འགྲན་སྲུང་གི་ཁྱད་རིམ།

འགྲན་སྲུང་གི་ཁྱད་རིམ་ཟེར་མི་འདི་ གང་ཟག་དང་ དངོས་པོ་རྩུ་གི་བར་ན་ གྲག་ཞན་དང་ མཚོགས་སྟོན་ ལེགས་ཉེས་ལ་
སོགས་པའི་ ཁྱད་པར་སྟོན་མི་ལུ་སྲུབ་ཡིན།

དཔེར་ན། སྲུམ་འཁོར་ ལས་ གནམ་གྱུ་མཚོགས།

ལས་ ལྷ་ཚེ་རིང་།

རྒྱལ་ཁབ་གཞན་ ལས་ འབྲུག་རྒྱལ་ཁབ་དགའ། ཟེར་སྲུབ་དོ་བཟུམ་ཡིན་ལོ།།

༤༽ རྒྱ་མཚན་སྟོན་པ།

རྒྱ་མཚན་སྟོན་པ་ཟེར་མི་འདི་ གནད་དོན་ཅིག་ རྒྱ་རྒྱུན་དང་ རྒྱ་མཚན་ག་ཅི་ལས་བརྟེན་ཏེ་ འབྲུང་མ་ཡིན་ན་གི་དོན་སྟོན་མི་
ཅིག་ལུ་ སྲུབ་ཡིན།

དཔེར་ན། ལཱ་མ་འབདམ་ ལས་ སྲུ་མི་ཐོབ།

ཡོན་ཏན་ཡོད་པ་ ལས་ གཡོག་ཐོབ་ཅི།

གཡོག་ཚགས་ཁར་རྒྱུད་པ་ ལས་ གོ་གནས་ཐོབ།

༥༽ སྲུད་པའི་སྐྱེ།

སྲུད་པའི་སྐྱེ་ཟེར་མི་འདི་ གང་ཟག་དང་དངོས་པོ་རྩུ་ གོ་རིམ་ཚང་མ་འབད་སྲུབ་མ་དགོ་པར་ འགོ་དང་མཇུག་གི་ཚོག་གཉིས་
ཀྱིས་གོ་དོན་ ཅིལ་པོར་ སྟོན་པའི་སྐྱེ་ཅིག་ལུ་སྲུབ་ཡིན།

དཔེར་ན། རྒྱ་ཁ་ ལས་ བཀ་ཤིས་སྐྱང་རྒྱུན། ཟེར་དོ་བཟུམ་ ཡུལ་སྲུད་པ།

གསེར་ ལས་ ལྷགས་རྒྱུན། ཟེར་དོ་བཟུམ་ དངོས་པོ་སྲུད་པ།

རྩོད་ ལས་ ལྱི་རུ་རྒྱུན། ཟེར་དོ་བཟུམ་ ལུས་ཚོད་སྲུད་པ།

ནམ་དབྱེ་དྲུག་པ་འབྲེལ་སྐྱེ།

ནམ་དབྱེ་དྲུག་པ་འབྲེལ་སྐྱེ་ཟེར་མི་འདི་ བརྗོད་བྱའི་མིང་ཚིག་ གང་རུང་གཉིས་ཀྱི་བར་ན་ འབྲེལ་བ་སྟོན་པའི་ཚིག་ཅིག་ལུ་
འབྲེལ་སྐྱེ་ཟེར་སྲུབ་ཡིན། འདི་ལུ་དབྱེ་བ་ གང་ཟག་དང་གང་ཟག་ དངོས་པོ་དང་དངོས་པོ་ གང་ཟག་དང་དངོས་པོ་ དངོས་
པོ་དང་གང་ཟག་རྩུ་གི་བར་ན།

༡༽ རོ་བོ་བདག་གཅིག།

༢༽ དེ་ལས་དེ་འབྲུང་།

༣༽ ཁྱད་གཞི་དང་ཁྱད་ཚོས།

༤༽ ཡན་ལག་དང་ཡན་ལག་ཅན།

༥༽ རོར་དང་བདག་པོ།

༦༽ རྟེན་དང་བརྟེན་པ་གི་འབྲེལ་བ་རྩུ་ཡོད་པ་ཡིན།

ནམ་དབྱེ་འདི་ལུ་ཕྱད་ གི། གྱི། གྱི། འི། ཡི། ཚུ་འཇུག་པ་ཡིན། འཇུག་ལུལ་ ཚོས་སྐད་ནང་ ད་བ་ས་ གྱི། ག་ང་ གི།
ན་མ་ར་ལ་ གྱི། འ་དང་མཐའ་མེད་ འི་ དང་ ཡི། རྫོང་ཁའི་སྐབས་ལུ་གོང་གི་ནམ་དབྱེ་གསུམ་པའི་སྐབས་ལུ་བཤའ་དོ་
བཟུམ། གི་འདི་ འ་དང་མཐའ་མེད་ཀྱི་ མཐའ་མར་འཇུག་པ་ཡིན།

༡༽ རོ་བོ་བདག་གཅིག་གི་འབྲེལ་བ།

རོ་བོ་བདག་གཅིག་གི་འབྲེལ་བ་ཟེར་མི་འདི་ འབྲེལ་གཞི་དང་འབྲེལ་ཚོས་ དབྱེ་བ་མེད་པར་ རོ་བོ་གཅིག་འབད་སྟོན་མི་ལུ་
སྲབ་ཡིན། དཔེར་ན།

- ཤེལ་གྱི་དམ་སྦྲིས།
- གསེར་གྱི་ཐུར་མ།
- ཤིང་གི་རྒྱ་ལྷོ།
- སའི་རྒྱུ།

༢༽ དེ་ལས་དེ་འབྱུང་།

དེ་ལས་དེ་འབྱུང་ཟེར་མི་འདི་ འབྲེལ་ཚོས་དངོས་པོ་ཅིག་ འབྲེལ་གཞི་འབྱུང་ས་ ག་ཉེ་ལས་ཡིན་ན་འབྲེལ་བ་སྟོན་མི་ཅིག་ལུ་
སྲབ་ཡིན། དཔེར་ན།

- གངས་གྱི་ཚུ།
- བསང་གི་དུ་པ།
- ཐབ་གྱི་མེ།

༣༽ ལྷ་གཞི་དང་ ལྷ་ཚོས།

ལྷ་གཞི་དང་ ལྷ་ཚོས་འབྲེལ་གཞི་ལྷ་པར་ཅན་གྱི་གཞི་དང་ འབྲེལ་ཚོས་ ལྷ་ཚོས་གཉིས་ཀྱི་བར་ན་ འབྲེལ་བ་སྟོན་
པའི་ཚོགས་ལུ་སྲབ་ཡིན། དཔེར་ན།

- མཁས་པའི་རིག་པ།
- ཨམ་སྲུའི་རྣམ་འགྲུར།
- རྒྱལ་ཁབ་ཀྱི་ལམ་སྲོལ།
- གྲུ་རམ་གྱི་བྲོམ།

༤༽ ཡན་ལག་དང་ཡན་ལག་ཅན།

ཡན་ལག་དང་ཡན་ལག་ཅན་ཟེར་མི་འདི་ གཞི་རོ་མ་དེ་དང་ དེ་གི་ཆ་ཤས་ཚུ་གི་བར་ན་ འབྲེལ་བ་བཟོ་སྟེ་སྟོན་མི་ཚོགས་ཅིག་
ལུ་སྲབ་ཡིན། དཔེར་ན།

- ལག་པའི་སེན་མོ།
- སྐྱུ་འཁོར་གྱི་འཁོར་ལོ།
- ཁྲིམ་གྱི་སྒྲོ།
- སྐྱག་གི་མཇུག་མ།

༥༽ རོར་དང་བདག་པོ།

རོར་དང་བདག་པོ་ཟེར་མི་འདི་ མི་དང་སེམས་ཅན་རྣམས་ཀྱི་དངོས་ཚུ་གི་ བདག་པོ་ག་ཡིན་ན་གི་ འབྲེལ་བ་སྟོན་པའི་ཚིག་ཅིག་ལུ་
སྲབ་ཡིན།

དཔེར་ན། ཁོ་གི་བསྟོད་བསོ།
ཕ་མའི་རྒྱ་ལོར།
སློབ་དཔོན་གྱི་སྐུ་འཁོར།

༦༽ རྟེན་དང་བརྟེན་པ།

རྟེན་དང་བརྟེན་པ་ཟེར་མི་འདི་ རྟེན་སའི་ཡུལ་གཞི་དང་ བརྟེན་པ་གང་ཟག་དང་དངོས་པོ་རྣམས་ཀྱི་བར་ན་ འབྲེལ་བའི་སྟོན་པའི་
དོན་ཅིག་ལུ་སྲབ་ཡིན།

དཔེར་ན། སྲང་ གི་ བ་བ།
ནགས་ཚལ་ གྱི་ སེམས་ཅན།
སློབ་གྲའི་ སློབ་སྲུག།
ས་ ཡི་ ལོ་ཐོག

༧༽ གནས་གཞི།

གནས་གཞི་ཟེར་མི་འདི་ གང་ཟག་དང་དངོས་པོ་རྣམས་ཀྱི་ཚིག་ཅིག་ལུ་གནས་ཏེ་ཡོད་པ་དང་ ཡང་ན་མེད་པའི་དོན་ཅམ་ སྟོན་
པའི་ཚིག་ལུ་སྲབ་ཡིན། འདི་ལུ་ནང་གསེས་གྱི་དབྱེ་བ་ ཡུལ་གྱི་གཞི་ལ་གནས་པར་སྟོན་པའི་གནས་གཞི་དང་ ཅུས་གྱི་གཞི་
གནས་པར་སྟོན་པའི་གནས་གཞི་ཟེར་ལྷམ་པ་གཉིས་ཡོད།

༡༽ ཡུལ་གྱི་གཞི་ལ་གནས་པར་སྟོན་པའི་གནས་གཞི་ཟེར་མི་འདི།
དཔེར་ན། གཡུས་ཁ་ལུ་ཕམ་ཡོད། ཡང་ན་ ཕམ་མེད། བྱི་ཐོག་གུ་དར་ཤིང་ཡོད།

༢༽ ཅུས་གྱི་གཞི་ལ་གནས་པར་སྟོན་པའི་གནས་གཞི་ ཟེར་མི་འདི།
དཔེར་ན། གནས་དགུན་ལུ་གྲང་། ཤི་རན་ཁར་ སློ་འགྲོད་བསྐྱེད།

༨༽ བོད་སྐྱེ།

བོད་སྐྱེ་ཟེར་མི་འདི་ གང་ཟག་མཚོག་དམན་འབྲིང་གསུམ་གར་ཡིན་རུང་ དེ་རྣམས་ཀྱི་མིང་ངོ་མ་ མ་བརྟོན་པར་བྲན་པ་བཀུག་
མིའི་དོན་ལུ་ ལག་ལེན་འཐབ་པའི་ ཚིག་ཅིག་ལུ་ བོད་སྐྱེ་ཟེར་སྲབ་ཡིན།

དཔེར་ན། གྱེ། རོ་རྩེ་ ཅལ་འདི་ ལྷ་གཏང་ཞིག།
ཀྱ་ཡེ། གསོན་དང་སྤྱིང་གི་ཡིད་འོང་མ།
ཆིད་ཆིད། གཞོན་ཤོས་མ་ ལྷ་བལྟ་ཞིག།
ཁོ་རེ། བཀྲ་ཤིས་ འདི་འབག་ཤོག།
དཔའེ། ཀམ་རྒྱ་ཤོག། ཟེར་དོ་བཟུམ་ གང་ཟག་ལུ་འཐོབ་པའི་ བོད་སྐྱེ་དང་།

སྤོལ་ལེགས་པས་སྒྲུ་རེ།

ཨ་ཇའི། འདྲོག་པས་སྒྲེ།

ཨ་ཁའི། ལམས་ལོག་མི་ལོག་ ཟེར་མི་ཚུ་ སེམས་ཚེར་སྦྱོར་པའི་ བོད་སྐྱེ་ འབད་འཇུག་པ་ཨིན།

བྲན་གསལ། བོད་སྐྱེའི་ཐད་ཁར་ ཚོས་སྐད་ཀྱི་སྐབས་ གྲེ་དང་ གྲེ་ ཀྱ་ཡེ། ཟེར་མི་ཚུ་ བོད་སྐྱེའི་སྐྱེ་འབད་འཇུག་ནི་ཡོད་པ་
ད་ རྫོང་ཁའི་སྐབས་ གྲེ་ དབའེ་ ཚིད་ཚིད་ ཨའོ་ ཁོ་རེ། སྤོལ་ ཨ་ཇའི། སྤུའི། ལ་སོགས་པ་ཚུ་འབོད་སྐྱེའི་ བང་
གསེས་ སེམས་ཚེར་སྦྱོར་པའི་བོད་སྐྱེ་འབད་འཇུག་པ་ཨིན།



སྦྱོར་ལྟ་ ༡ པ།

- ༡༽ རྣམ་དབྱེ་ཟེར་བའི་གོ་དོན་བྲིས།
- ༢༽ རྣམ་དབྱེ་བརྒྱུད་ག་ཅི་ར་སྟོ་? རེ་རེ་བཞིན་དུ་བྲིས།
- ༣༽ འགྲེལ་སྒྲུ་གི་སྟོན་ཚིག་མ་འཇོལ་བར་བྲིས།
- ༤༽ ལས་སུ་བྱ་བའི་སྐབས་ཀྱི་འཇུག་སྟོང་ཚུ་ ག་ཅི་ར་ཨིན་ན? དཔེ་དག་པ་ཅིག་ཐོ་བཀོད།
- ༥༽ བོད་སྐྱེའི་ཕྱད་ཚུ་ལག་ལེན་འབབ་སྟེ་ ཚུམ་ཚིགས་བཅད་གཅིག་བྲིས།
- ༦༽ བྱད་གཞི་དང་བྱད་ཚོས་གཉིས་ཀྱི་ བྱད་པར་གྱི་ཚོས་ཚུ་ག་ཅི་ར་ཡོད་པ་སྟོ་? མ་འཇོལ་བར་བྲིས།



བཅུད་བསྟུས།

- ཚོས་ག་ཅི་འབད་རུང་ཅིག་གི་ མིང་ཚིག་འདི་གཞན་དང་མ་འདྲེས་པར་ རྣམ་པར་ཉེ་སོ་སོར་དབྱེ་ཞིང་འབྱེད་ཚུགས་
པའི་ སྐྱེའི་ཆ་ཤས་སུ་གྱུར་པའི་ ཚིག་ཕྱད་ཅིག་ལུ་ རྣམ་དབྱེ་ཟེར་སྐབས་ཨིན་པས།



རང་ཉིད་སློབ་སྦྱོར་ དབྱེ་ཞིབ།

- ༡༽ སྤྱིར་བཏང་རྣམ་དབྱེ་ཟེར་བའི་གོ་དོན་འགྲེལ་བཤད་རྒྱབ།
- ༢༽ རྣམ་དབྱེ་བརྒྱུད་ཀྱི་སྐབས་སུ་ བང་གསེས་དབྱེ་བ་ཡོད་པའི་རྣམ་དབྱེ་ ག་ཅི་ར་སྟོ་? རེ་རེ་བཞིན་དུ་བྲིས།
- ༣༽ ཉེན་དང་བཞེན་པ་དང་ གནས་གཞི་གཉིས་ཀྱི་བྱད་པར་ ག་ཅི་འདུག་ག? བྱད་པར་རོས་འཇོལ་འབད་དེ་བྲིས།

༥- རྒྱུག་ཡིག། རྒྱུག་ཡིག་གི་འབྲུང་ཁུངས།

ལས་དོན།



- རྒྱུག་ཡིག་ནང་གསལ་གྱི་དོན་ཚན་ལག་ མ་འདྲམ་ ཞུ་ ཡོད་མི་ཚུ་ ག་ར་ལེགས་ ཤོམ་སྡེ་ལྟ་བུ་ཚུགས།
- དོན་ཚན་ ཞུ་ ཚ་ར་གི་ དོན་དག་འདི་ཚུ་ ཉ་གོ་སྡེ་ སྤོ་བའི་ལན་བྲི་ཚུགས།

དོ་སློབ།

༡༽ རྒྱུག་ཡིག་གི་འབྲུང་ཁུངས། འཛམ་གླིང་ནང་ ལ་རྒྱུག་འགོ་དང་པ་འདི་ ཕྱི་སློབ་ཀྱི་འཇིག་རྟེན་འདི་ཆགས་པའི་ཤུལ་ལུ་ དང་པ་སློབ་ཆགས་ཀྱི་འགོ་བ་ཆགས། དེ་ཚུ་ལས་མིའི་འགོ་བ་བྱུང། མི་ལུ་ལ་རྒྱུག་ཀྱི་ རྒྱ་རྒྱུན་རྟེན་འབྲེལ་ ཚང་ནི་འདི་གིས་ གཅིག་གིས་གཅིག་ལུ་ བར་དོན་ སློབ་ལེན་འབད་ནིའི་ མིང་ཚེག་བརྗོད་པའི་ལ་རྒྱུག་ཚུ་ སྤོ་བའི་ལན་བྲི་ བྱུང་ཡོད་པ་ཨིན་ པས།

དེ་ཡང་ ཞིབ་འཚོལ་དང་འཁྲུལ་བ་ཅིན། དང་པ་ ལ་རྒྱུག་འདི་བྱུང་ལུག། དེ་ལས་བར་དོན་ སློབ་ནིའི་དོན་ལུ་ སྤོ་བའི་ལན་བྲི་ ཡི་གུ་དང་། སྤོ་བའི་ལན་བྲི་ཡི་གུ་ཟེར་ ལྷམ་པ་ ༡ བྱུང་ལུག།

སྤོ་བའི་ལན་བྲི་ཡི་གུ་འདི་ འཛམ་གླིང་ལུ་བ་སློབ་ལས་ ཨི་ཇིབ་ལས་བརྗོད་དེ་ རྒྱ་ནག་ལས་པར་དར་ཏེ་ ལག་ལེན་འབབ་ཨིན་ པས།

སྤོ་བའི་ལན་བྲི་ཡི་གུ་འདི་ ཡ་ལི་སི་ཐུན་ རྒྱལ་ཁབ་ལས་ འཛམ་གླིང་ཤར་ལུ་བ་རྒྱུད་དེ་ ལུ་བ་སློབ་ལུ་འོ་བ་དང་ རྒྱ་ གར། བོད་ཚུ་ལུ་དར་ལུག། ང་བཅས་རའི་ འབྲུག་གི་ ཡི་གུ་ཡང་བོད་ལས་མར་བརྗོད་དེ་ འོང་འོངམ་འབད་ནི་འདི་གིས་ སྤོ་བའི་ལན་བྲི་ཡི་གུ་ཨིན།



སློབ་ལུ་ ༡ པ།

ལྷག་གི་དོན་མཚམས་འདི་ ལྷག་ཞིན་མ་ལས་ འོག་ལུ་ཡོད་མི་ སྤོ་བའི་ལན་བྲི་ལན་བྲིས།

- ༡) ལ་རྒྱུག་དང་ འགོ་བ་མི་གཉིས་ ཉེ་མ་ག་འདི་བྱུང་ལུག་གོ་?
- ༢) མིའི་འགོ་བ་ལུ་ ལ་རྒྱུག་འདི་ག་ཅི་འབད་ ལག་ཆེས་སློ་?
- ༣) སྤོ་བའི་ལན་བྲི་ཡི་གུ་ མ་འཐོན་པའི་ཉེ་མ་ ཡི་གུ་ག་ཅི་ཟེར་མི་འདི་ བྱུང་ལུག་?

༢༽ འབྲུག་རྒྱལ་ཁབ་ཀྱི་རྒྱུག་ཡིག་ འབྲུག་རྒྱལ་ཁབ་འདི་ རྒྱུ་ཀྱ་ཅིག་ཨིན་རུང་ ལ་རྒྱུག་མ་འདྲམ་ མང་རབས་ཅིག་ ཡོད་པའི་རྒྱལ་ཁབ་ཨིན། དེ་ཡང་ མི་རིགས་མ་འདྲ་བའི་བྱུང་པར་ལུ་བརྟེན་ཏེ་དང་། ས་ཆའི་ཆགས་ཐངས་ཀྱི་འབད་ གཞུས་སློ་ཚུ་ ལ་ལུང་ཚུ་ནང་ ལ་གཏོར་ཏེ་ཆགས་ཡོད་ནི་འདི་གིས་ འབྲེལ་བ་འབབ་ནི་ལུ་ ལཱ་ལག་ཡོད་པ་ལས་བརྟེན་ཏེ་ ཨིན་མས།

༣༽ འབྲུག་རྒྱལ་ཡོངས་ཀྱི་སྐད་ཡིག་འདི། ལུ་བཟོགས་རྫོང་ལག ༥ རང་སླབ་སློབ་ཡོད་པའི་ལ་སྐད་ཅིག་ཡིན་པ་གིས་མ་
ཚད། དུས་རབས་ ༡༧ པའི་ནང་ ཞབས་དྲུང་དག་དབང་ནམ་རྒྱལ་གྱིས་ གཞུང་དབྱ་བ་སླེབ་པའི་ལུ་ལས་ ཚོས་སྲིད་
བསྟན་པའི་སློབ་ཤིང་ རྫོང་གཞི་རྒྱ་ནང་ གཞུང་འབྲེལ་གྱི་ ལ་སྐད་འབད་ལག་ལེན་འབབ་ནི་འདི་གིས་ཡིན། དེ་མ་ཚད་
འཛམ་གླིང་རྒྱལ་སྤྱིའི་ལམ་ལུགས་དང་བསྟན་ཏེ་ སྤྱི་ལོ་ ༡༩༧༡ ལོ་ལོ་ འབྲུག་རྒྱལ་ཁབ་དེ་ཡང་ འཛམ་གླིང་སྤྱི་ཚོགས་ཀྱི་
འབྲུག་མི་འབད་ འཛུལ་བཞུགས་མཛད་གནང་ཞིན་མ་ལས་རྫོང་ རྫོང་ལ་འདི་ འབྲུག་རྒྱལ་ཡོངས་ཀྱི་ ལ་སྐད་འབད་
གཞུང་འབྲེལ་དུ་ ཆ་འཛོག་མཛད་གནང་སྟེ་ཡོད་པ་ཡིན། འབྲུག་ལུ་ལ་སྐད་ཤོས་ ལྟོ་པའི་ལ། མོན་ལ་ དགུང་འདུས་པའི་ལ་
ཡིན་མ་དུ་ རྫོང་ལ་འདི་སྟོ་པའི་ལ་ལས་བྱུང་འབྱུང་མ་ཡིན་མ་འབད་སླབ་སློབ་ཡོད།



སློབ་ལྟ་ ༡ པ།

- ༡༽ ལུ་བཟོགས་རྫོང་ལག་བརྒྱུད་ནང་ སླབ་མི་ལ་སྐད་རྒྱ་ག་ར་ ཅོག་འབད་ག་? བསམ་འཆར་བཀོད།
- ༢༽ རྫོང་ལ་འདི་ རྒྱལ་ཡོངས་སྐད་ཡིག་འབད་ ཆ་བཞག་དགོ་པའི་ ལུངས་བྲིས།
- ༣༽ འབྲུག་གི་ལ་སྐད་ རྫོང་ཤོས་ར་ ག་ཅི་ར་ཡིན་ན? རོས་འཛོན་འབད་དེ་བྲིས།

༤༽ འབྲུག་ཡིག་འབྲུང་ལུངས། འབྲུག་གི་རྒྱལ་ཡོངས་ཀྱི་ཡི་གུ་འདི་ མཚོགས་ཡིག་ཡིན། མཚོགས་ཡིག་དེ་ འགོ་དང་
པ་ དུས་རབས་ ༥ པའི་ནང་གུ་རུ་རིན་པོ་ཆའི་ ཕྱག་ལུ་སྟེ་བྱོན་མི་ ལོ་རྒྱ་བ་ལྷན་མ་ཅེ་མང་གིས་ བུམ་ཐང་སྐྱ་རྗེས་ལུ་
བརྩམས་གནང་ཡོད་པ་ཡིན་མས།
དེ་ཡང་ བོད་ཀྱི་རྒྱལ་པོ་ལེ་སྲོང་ལྷེ་ལུ་བཅོན་གྱིས་ རྒྱ་ཚོས་བོད་ལུ་བསྐྱུར་མ་དང་ བུམ་ཐང་རྒྱལ་པོ་སིན་ཏུ་ར་རྫོ་གིས་ ཤོག་གུ་
ཕུལ་ཡོད་པའི་ལེགས་སྐྱོན་ལུ་ ལྷན་མང་ཅེ་མང་ གུ་རུ་རིན་པོ་ཆའི་ཕྱག་ལུ་སྟེ་ ཡི་གུ་བརྩམས་ཏེ་ གནང་ནི་འདོད་ལུ་
བཏང་བཏང་མ་ཡིན་ཟེར་ སླབ་སློབ་ཡོད། ཡི་གུ་དེ་གི་མིང་ལུ་ ཏེ་མ་སྟོ་ཡིག་ཟེར་སླབ་སློབ་ཡོད་པ་ལས་ འབྲུག་པའི་ཡི་གུ་
འགོ་དང་པ་དེ་ ལྟོ་ཡིག་ཡིན།

- འོག་གི་ཚིག་དོན་ཚན་འདི་ ལེགས་ཤོམ་འབད་ ལྷག་སྟེ་ སེམས་ཁར་དེས།
- ཡི་གུ་ཟེར་མི་འདི་ = མཚོགས་ཡིག། ལྟོ་ཡིག
- ཡི་གུ་བརྩམ་གནང་མི་= མཁས་པ་ལྷན་མ་ཅེ་མང་།
- དུས་ཚོད་འབད་བ་ཅིན་= དུས་རབས་ ༥ པའི་ནང་ལུ།

༧༽ ཡི་གུའི་ཕྱག་རྒྱ། ཡི་གུའི་རིག་ཅུལ་འདི་ ཉེ་མ་ལས་ཡོད་པའི་ མཁས་དབང་ཚུ་བརྒྱད་དེ་ དུས་རབས་༡༧ པའི་
ནང་ལས་ དགོ་འདུན་གྱི་ཚང་གི་སྐྱེ་ལོ་སྤེལ་ས་ རློང་ཡིག་རྟོ་མགོན་དབང་རྒྱལ་དང་ རྩམ་ཐངས་ཚོས་རྗེ་ རྟོ་མགོན་དབང་བཤེས་
ལམས་ཚུ་གི་ཕྱག་རྒྱའི་ལས་ འབྲུག་ཕུབ་ཕྱོགས་ལ་ཐུག་ལུ་ དར་བྱུང་སློབ་འབད་བྱུང་ཡོད་པའི་ཁར་ དུས་རབས་ཉི་ཤུ་པའི་
ནང་ འབྲུག་རྒྱལ་འཛུགས་ཚུ་གི་ བཞུགས་གནས་གཙོ་བོ་ འབྲུག་ཤར་ཕྱོག་བུམ་ཐང་ལ་ཐུག་ ཨིན་མ་ལས་བརྟེན་ སློབ་
དཔོན་གངས་ཆན་སོགས་ཀྱི་ ཕྱག་རྒྱའི་ལས་ ཡི་གུའི་རིག་པ་ལུ་ མཁས་པའི་མི་རིགས་ ས་གནས་དེ་ལ་ལས་པར་ མང་སྤུ་
དར་བྱུང་མོང་ལུག།



སློབ་ལུ་ ༣ པ།

༡༽ འབྲུག་རྒྱལ་ཁབ་འདི་ རྒྱ་ཀྲུང་གི་ཨིན་རུང་ མི་རིགས་མ་འདྲཱ་ལེ་ག་ཡོད་དགོ་པའི་རྒྱ་མཚན་ ག་ཅི་འོང་ནི་བཟུམ་
ཅིག་འདུག་གོ? བྱངས་བཀའ་ཉེ་བྱིས།



བརྒྱན་བསྐྱུལ།

- རྟོ་མགོན་གི་འབྲུང་བྱུངས། འབྲུག་རྒྱལ་ཁབ་ཀྱི་རྟོ་མགོན་ཡིག། འབྲུག་རྒྱལ་ཡོངས་ཀྱི་རྟོ་མགོན་ཡིག། འབྲུག་ཡིག་འབྲུང་
བྱུངས། རྒྱ་ལོ་ཡིག་སློབ། ཡི་གུའི་ཕྱག་རྒྱའི་ཚུ་གི་བྱུངས་དང་དགོས་པའི་སློབ།



རང་ཉིད་ལྟོ་སྦྱང་ དབྱེ་ཞིབ།

༡༽ ལྟོ་སྦྱང་གི་ཚིག་ཚུ་ ལེགས་ཤོམ་འབད་ལྟོ་སྦྱང་ཞིན་མ་ལས་ རྟོ་མགོན་གི་འབྲུང་བྱུངས་སློབ་ དབྱེ་དཔྱད་འབད་དེ་ རོན་
མཚམས་ག་ཅིག་བྱིས།

༤- ཡི་གུའི་སློབ་བཞུགས་སློབ་ཚུལ་ཚིག་མཚན་གྱི་འཇུག་པ།

ལས་དོན།



- སློབ་ཚུལ་ཚིག་མཚན་འཇུག་པའི་ བླ་མ་གསལ་དབྱེ་བ་ཚུ་ཕྱེ་ཚུགས།
- སློབ་ཚུལ་ཚིག་མཚན་གྱི་འཇུག་པ་དང་འབྲེལ་ཏེ་ དཔེར་བཞིན་རྒྱབ་ཚུགས།
- ཚོས་སྐད་དང་ རྗེས་འཇུག་ཚིག་མཚན་སློབ་ཚུལ་གཉིས་ཀྱི་ བྱེད་པར་ཕྱེ་ཚུགས།
- རྗེས་འདུག་ ཚོས་སྐད་གཉིས་ཀྱི་སློབ་ཚུ་ མ་འཇོལ་བར་དོས་འཇོལ་འབད་ཚུགས།

དོན་རྒྱུད།

སློབ་ཚུལ་ཚིག་མཚན་གྱི་འཇུག་པ་ཟེར་མི་འདི་ སློབ་དཔེ་དང་རྣམས་དབྱེ་ག་ར་ལུ་སྐབ་ཤི་ཡིན། རྣམས་དབྱེ་ཟེར་མི་འདི་ སློབ་འཛིན་འོག་མམ་ཚུ་ནང་ བཤད་ཡོད་དོ་བཟུམ་ རྣམས་དབྱེ་བརྒྱུད་ལུ་གོ་ནི་དང་། ཚིག་མཚན་ཟེར་མི་འདི་ སྐྱར་བསྟུ། རྒྱུ་སྟུད། ལྷག་བཅས། འབྱེད་སྟུད། དགའ་སྟུད། བེ་སྐྱ། དང་སྐྱ། དེ་སྐྱ། སྤྱི་སྐྱ། བདག་སྐྱ། དགག་སྐྱ་དང་བཅས་ གྲ་ ཡོད་པ་ ཡིན།

རྣམས་དབྱེ་དང་ ཚིག་མཚན་དེ་ཚུ་ཡང་ རྗེས་འཇུག་ལུ་སློབ་དགོ་པའི་སློབ་ གཞན་དབང་ཅན་དང་། རྗེས་འཇུག་ལུ་སློབ་མི་དགོ་ པའི་སློབ་ རང་དབང་ཅན་ཟེར་ ལག་གཉིས་ཡོད།

དང་པ་རྗེས་འཇུག་ལུ་སློབ་དགོ་པའི་སློབ་གཞན་དབང་ཅན། ཟེར་མི་དེ་ སྐྱར་བསྟུ། ལ་དོན། ཡི་གུ། རྒྱུ་སྟུད། ལྷག་བཅས། འབྱེད་སྟུད། ཚུ་ལུ་སྐབ་ཡིན། སློབ་དེ་ཚུ་ ལག་ལེན་འཐབ་ད་ རྗེས་འཇུག་དང་འབྲེལ་དགོ་ནི་དེ་གིས་ སློབ་ གཞན་དབང་ཅན་ཟེར་སྐབ་ཡིན།

གཉིས་པ་སློབ་རང་དབང་ཅན་ཟེར་མི་འདི་ བེ་སྐྱ། དང་སྐྱ། དེ་སྐྱ། སྤྱི་སྐྱ། བདག་སྐྱ། དགག་སྐྱ་དང་བཅས་ལུ་སྐབ་ཤི་ ཡིན། སློབ་དེ་ཚུ་ལག་ལེན་འཐབ་ད་ རྗེས་འཇུག་དང་འབྲེལ་མ་དགོ་ནི་དེ་གིས་ སློབ་གཞན་རང་དབང་ཅན་ཟེར་སྐབ་ཡིན།

སློབ་བཏང་ ལུ་ཆེ་བའི་དབང་གིས་ དབྱེ་བ་དེ་སླེ་ ཕྱེ་སློབ་ཡོད་རུང་ བླ་མ་གསལ་ལུ་དབྱེད་པ་ཅིན་ ད་རུང་ སློབ་གཞན་ དབང་ཅན་གྱི་ ལ་དོན་གྱི་སློབ་ རྣམས་གཉིས་དང་ འབྲུང་ལྷངས་ཀྱི་སློབ་ རྣམས་ལས་གཉིས་ཡང་ རྗེས་འཇུག་དང་འབྲེལ་མ་ དགོ་པ་ལས་ སློབ་རང་དབང་ཅན་གྱི་གངས་སུ་ཚུད་པ་ཡིན། དེ་ཚུ་ལུ་ སློབ་ཚུལ་ཚིག་མཚན་གྱི་འཇུག་པ་ཟེར་སྐབ་ཡིན། ད། རྣམས་དབྱེ་བརྒྱུད་ཀྱི་སློབ་ལས་ ཉེ་མ་ལྷོ་ཆར་ཡོད་པ་ལས་ ལུ་ལས་མར་ སློབ་ཚུལ་ཚིག་མཚན་གྱི་འཇུག་པའི་སློབ་ལས་ ལྷོ་བ་ཤི་ཡིན། དེ་ལས་ཡང་དང་པ། སྐྱར་བསྟུ་ཟེར་མི་འདི་ག་ཅི་བཟུམ་ཅིག་ལུ་སྐབ་ཤི་ཡིན་ན་དང་ འཇུག་ཚུལ་ཚུ་ག་དེ་ འབད་ཡིན་ན་ འདི་གི་སློབ་ལས་ལྷོ་བ་ཤི་ཡིན།

གོ་དོན།

སྐར་བསྐྱེད་ཟེར་མི་འདི་ རྫོང་ཚིག་གཅིག་གིས་ སྐབས་ཐོག་གི་ བརྗོད་དོན་ཚར་རེ་ མཚུགས་བསྐྱེད་པའི་ དོན་སྦྱོར་མི་གི་ཕྱད་ལུ་
 སྐབས་ཡིན། དཔེར་ན། ཡིན་ལོ། ལེགས་པས་གོ། ཡོད་དོ། ཐོབ་ལུག་གོ། རྒྱལ་ལོ། ལེགས་སོ། ཕྱག་འཚལ་ལོ། སྐབས་ཅིའོ།
 ཟེར་དོ་བཟུམ་དང་ ཕྱད་འཐོབ་ཐངས་ཀྱི་ཐད་ཁར་ འོག་ལུ་བཀོད་ཡོད་དོ་བཟུམ་ཡིན།
 འདི་ལུ་ཡང་ ང་བཅས་རའི་རྫོང་ཁ་འདི་གཞི་བརྟེན་ས་ ཚོས་སྐད་ཡིན་མ་ལས་ ཚོས་སྐད་ཀྱི་ ཕྱད་ འཚུགས་ཚུལ་དང་ རྫོང་
 ཁའི་ ཕྱད་ འཚུགས་ཚུལ་གཉིས་ཀྱི་ཁྱད་པར་ཕྱེ་སྟེ་སྐབས་ཅི་ཡིན།

ཚོས་སྐད་ཀྱི་སྐར་བསྐྱེད་ཕྱད།		རྫོང་ཁའི་སྐར་བསྐྱེད་ཕྱད།
རྫོང་ཁའི་སྐར་བསྐྱེད་ཕྱད།	ཕྱད།	གོ་དོན་ལོ་ལོ་སོ་སོ་རྒྱལ། རྫོང་ཁའི་སྐར་བསྐྱེད་ཕྱད་ ཡིན་ཏེ། ཅི་ཚིག་ཡི་དང་འདུག་ལུག་དང་། །པས་ མས་དོ་དེས་ལ་སོགས་པའི། རྫོང་སྐད་གོ་འཐོབ་ ན་མཐར་ལོ། །དེ་དོན་ལོ་སོ་སོ་མཐར་ལོ།མཐར་ མེད་རྫོང་སྐད་ལོ་ཉིད་སྐད། །ས་མཐར་སོ་དང་ལ་ མཐར་ལོ།
<p>དྲག་མཐར་ཉོ་དང་ མཐར་མེད་ལོ། གཞན་རྣམས་མིང་གི་ མཐར་དང་བསྐྱེད།</p>	<p>གོ་དོན་ལོ་ལོ་སོ་སོ། རོ་ལོ་སོ་ཉོ་སྐར་བསྐྱེད་ ཡིན།</p>	

དྲག་གསོ།

རྫོང་ཁའི་སྐར་བསྐྱེད་ཕྱད་ཚུལ་ས་ གོ་དོན་ལོ་སོ་སོ་ བཞི་ ཡོངས་ཀྱགས་འབད་ ལག་ལེན་འཐབ་ནི་ཡོད་རུང་ ཕྱད་ དོ་ དང་
 འོ་ གཉིས་ ཚིག་རེ་གཉིས་གཉིས་མ་གཏོགས་ རྒྱབ་ཆེན་འབད་ ལག་ལེན་འཐབ་ནི་མེད་པ་ཡིན་མ་ཤེས་དགོ་པའི་ཁར་
 ད་ལྟོ་གི་སྐབས་སུ་ དྲག་མཐར་ཉོ་ ཟེར་མི་འདི་ཡང་ རྫོང་ཚུ་གིས་ ཉ་གོ་བ་ལུ་ཁག་ཡོད་པ་ལས་ འདི་བཀོ་བཞག་སྟེ་
 གཞན་ཚུ་ལྟམ་གནང་ཟེར་ལུ་ཅི་ཡིན།

འབྱེད་སྐད་ཟེར་མི་འདི་ ཚོས་སྐད་ནང་འབད་བ་ཅིན་ འབྱེད་པ་ཟེར་ དབྱེ་གཞི་གཅིག་ལས་དབྱེ་བ་ལེ་ཤ་ཕྱེ་ནི་དང་།
 དབྱེ་བ་ལེ་ཤ་ཡོད་མི་ཚུ་ གཞི་གཅིག་ལུ་བསྐྱེད་མི་གི་ ཕྱད་ ཅིག་འབད་ནི་དེ་གིས་ འབྱེད་སྐད་ཟེར་སྐབས་ཡིན། འབྱེད་སྐད་ཀྱི་
 ཕྱད་ གམ་དམ་ནམ་འམ་བཞི་ཡིན། ཕྱད་ཚུ་གི་སྦྱོར་ཚུལ་ཡང་ རྫོང་ཁའི་སྐར་བསྐྱེད་ ད་ གི་མཐར་མར་ དམ། ན་ གི་མཐར་མར་
 བམ། རྫོང་ཁའི་སྐར་བསྐྱེད་ འ་ དང་ མཐར་མེད་ལུ་ གམ་ ཚུ་འཚུགས་ནི་ཡིན།

དཔེར་བརྗོད་ཀྱི་དབྱེ་བ་འདི་ ཚོས་སྐད་ཀྱི་སྐབས་ འབྱེད་པ་ལ་འཚུགས་པ་ སྐད་པ་ལ་འཚུགས་པ་ཟེར་ཡོད་རུང་ དེ་ཚུ་རྫོང་ཁའི་
 བར་ ཚོས་སྐད་ནང་ཡོད་དོ་བཟུམ་ འཚུགས་ནི་མེད། འབྱེད་སྐད་ཀྱི་ཕྱད་ཚུ་གིས་ རྫོང་ཁའི་བར་ དཔེར་ན།

- དཔེ་ཆ་ཤེས་གམ།
- རྫོང་ལུ་ཡོད་དམ།
- མི་ཡིན་ནམ།
- སེམས་དགའམ། ཟེར་ དྲི་བའི་དོན་ལུ་འཚུགས་ནི་དང་།
- ཤེས་གམ་མི་ཤེས་ཉ་མ་གོ།
- ཡིན་ནམ་མེན་ནམ་དོགས་པ་ཡོད། ཟེར་དོ་བཟུམ་ ཐེ་ཚོམ་ཀྱི་དོན་ལ་འཚུགས་པའི་དཔེར་བརྗོད་ཡིན།

ཚོས་སྐད་དང་རྗེས་ཁའི་འབྲེད་སྤྱད་ཀྱི་ཁྱད་པར།	
ཚོས་སྐད་ཀྱི་འབྲེད་སྤྱད།	རྗེས་ཁའི་འབྲེད་སྤྱད།
གམ་ངམ་དམ་ནམ་བམ་མམ་འམ། །རམ་ལམ་སམ་ཏམ་བཙུ་གཅིག་པོ། །སློབ་ཚུལ་སྤྱད་བསྐྱེད་སྐབས་དང་མཚུངས། །	འབྲེད་སྤྱད་གམ་དམ་ནམ་འམ་བཞི། །སློབ་ཚུལ་ད་དམ་ན་ནམ་དང་། །འ་དང་མཐའ་མེད་གཞན་ལ་གམ། །དྲི་དང་ཐེ་ཚོམ་དོན་ལ་འང་འཇུག།

ཁྱེད་ཀྱིས་འབད་བ་ཅིན་ འོག་ལུ་བཀོད་མི་ དཔེར་བཅོམ་ཚུ་ རྗེས་ཁའི་ནང་ལག་ལེན་འཐབ་སློལ་ཡོད་ག་? མེད་ག་? དབྱེ་བ་དབྱེད་དེ་ དོན་མཚམས་ཐུང་ཀྱ་བྲིས།

- དཔེ་ཆ་ཤེས་གམ།
- ཁྱོད་ལུ་ཡོད་དམ།
- མི་ཡིན་ནམ།
- སེམས་དག་འམ། ཟེར་ དྲི་བའི་དོན་ལུ་འཇུག་ནི་དང་།
- ཤེས་གམ་མི་ཤེས་ཏམ་གོ།
- ཡིན་ནམ་མེན་ནམ་དོགས་པ་ཡོད། ཟེར་དོ་བཟུམ་ ཐེ་ཚོམ་གྱི་དོན་ལ་འཇུག་པའི་དཔེར་བཅོམ་ཡིན།

ནི་སྐྱུ།

ནི་སྐྱུ་ ཟེར་བའི་སྐྱུ་འདི་གི་ འཇུག་ཐངས་བཤད་ནི་དེ་གིས་ ནི་སྐྱུ་ཟེར་སྐབ་ཡིན། དཔེར་བཅོམ་ནི།

ནི་ སྐྱེའི་དཔེར་བཅོམ་ལུ་དབྱེ་བ་ཅིན།

- འབྲུག་གི་རྒྱལ་ཁབ་ནི་ འཛམ་གླིང་རྒྱལ་ཁབ་ལས་སྤྱིད་ཤོས་ཅིག་ཡིན།
- ཆང་དང་སློལ་སྤྱོད་མི་འདི་ནི་ ག་བ་ལས་ཡང་སློལ་ཤོས་ཅིག་ཡིན།

ཟེར་དོ་བཟུམ་ གཞི་སྤྱིར་བཏང་ལས་ གཅིག་སོ་སོ་འབད་བཏོན་པའི་དོན་ལུ་འཇུག་པའི་ དགར་བ་སློན་པའི་དོན་ལུ་འཇུག་ནི་དང་།

- ཨོམ་ནི་རྒྱགས་ཚད་སྐྱུགས་ཡི།
- ར་པ་ཉིན་བཏབ་ཅི།
- བྱ་རམ་འདི་ནི་སྐྱུགས་ཡི།
- བསྐྱེད་པའི་བསྐྱེད་ཡི།

ཟེར་དོ་བཟུམ་ དེས་བཟུང་གི་དོན་ལུ་འཇུག་པའི་དཔེར་བཅོམ་དང་བཅས་ དབྱེ་བ་གཉིས་ཡོད་པ་ཡིན།

 **སློབ་ལུ་ ༡ པ།**

- ༡༽ ནི་སྐྱུ་ དགར་བ་དང་ དེས་བཟུང་གི་དོན་ལུ་འཇུག་པའི་ དཔེར་བཅོམ་ ༤ རེ་བྲིས།
- ༢༽ ནི་སྐྱུ་དང་ བྱ་ཚོགས་གི་ཚོགས་གོགས་ ནི་ གཉིས་ལུ་ཁྱད་པར་ག་ཅི་འདུག་གོ? དབྱེ་བ་བྲིས།

དང་སྐྱེ།

དང་ སྐྱེ་འདི་གིས་ དབྱེ་གཞི་ཅིག་གོང་ལུ་བཀོད་དེ་ དབྱེ་བ་རེ་རེ་བཞིན་དུ་ འོག་ལས་བཤད་པ་ད་ འབྱེད་པའི་དོན་ལུ་
འཇུག་པ་དང་། དབྱེ་བ་རེ་རེ་བཞིན་དུ་ གོང་ལུ་བཀོད་དེ་ དབྱེ་གཞི་ཅིག་འོག་ལུ་བཀོད་པ་ད་ སྐྱེད་པའི་དོན་ལུ་འཇུག་པ།
ཚོགས་སྤྱི་འབྲེལ་བ་ཙམ་སྦྱོར་པའི་ འབྲེལ་བའི་དོན་ལུ་འཇུག་པ་དང་བཅས་གསུམ་ཡོད།

དཔེར་ན། འབྲུག་གི་རྩ་བ་གསུམ་ཟེར་མི་འདི། མངའ་བདག་རྒྱལ་པོ་དང་། གཞུང་དང་། མི་སེར་གསུམ་ལུ་ལྷན་ཞུགས།
ཟེར་དོ་བཟུམ་ འབྱེད་པའི་དོན་སྦྱོར་པ་ལུ་འཇུག་པ།
གཉེན་གྲོགས་ལུ་དམ་ཚིག་བསྐྱེད་ནི་དང་། ཕམ་ལུ་ཞབས་ཉོག་ལུ་ཞུ་ནི་དང་། གོང་མ་ལུ་གུས་ཞབས་འབད་ནི་ཚུ་མི་ཡ་རབ་ཀྱི་བྱ་
སྦྱོར་ཞིན། ཟེར་དོ་བཟུམ་ སྐྱེད་པའི་དོན་ལུ་འཇུག་པ།
ཕམ་དང་སློབ་དཔོན། གཞུང་དང་མི་སེར། ཟེར་དོ་བཟུམ་ འབྲེལ་བའི་དོན་ལུ་འཇུག་པའི་དཔེར་བཅོམ་བཅས་ཡོད་པ་ཞིན།



སློབ་ལུ་ ༡ པ།

- ཚུད་ཀྱིས་ དང་སྐྱེ་ འབྱེད་པའི་དོན་ལུ་འཇུག་པའི་དཔེར་བཅོམ་ ༡ ཀྱབ།
- དང་སྐྱེ་ སྐྱེད་པའི་དོན་ལུ་འཇུག་པའི་དཔེར་བཅོམ་ ༡ ཀྱབ།
- དང་སྐྱེ་ འབྲེལ་བའི་དོན་ལུ་འཇུག་པའི་དཔེར་བཅོམ་ ༡ ཀྱབ།

དེ་དང་ལྗོངས།

ཚོས་སྐྱེད་ཀྱི་སྐབས་ སྤད་ དེ་ རྒྱུ་ལུ་གཅིག་གི་ འཇུག་ཐངས་ཚུ་སྦྱོར་དོ་ཡོད་པ་ལས་ དེ་སྐྱེ་ཟེར་སྐབས་ཞིན།
གོ་དོན། རྒྱུ་ལུ་འཇུག་ཚོས་སྐྱེད་དང་ཅོག་འབྲེལ་འབད་ སྤད་ དེ་ སྐྱེ་གིས་འཇུག་པ་མ་ཚད་ དེ་ དང་ཅོག་འབྲེལ་
འབད་ ཞེ་ གིས་ཡང་ འཇུག་ནི་ཡོད་པ་ལས་ དེ་ སྐྱེ་དང་ ཞེ་ སྐྱེ་ཟེར་སྐབས་ཞིན།

སློབ་ཐངས།

དེ་སྐྱེ་ དང་ ཞེ་སྐྱེ་ གིས་ འཇུག་ཚུལ་དཔེར་བཅོམ་ཡང་ དཔེར་ན། ཉེ་མའི་ལོ་ དེ་ བཤུ་ལུ་མའི་ལོ་ དེ་ བཤུ་
ཟེར་དོ་བཟུམ་ ལུ་སྦྱོར་པའི་ དོན་ལུ་འཇུག་ནི་དང་།
དེ་ སྐྱེ་འབད་དགོ། ཞེ་ སྐྱེ་མ་འབད། ཞེ་ སྐྱེ་འཇུག། དེ་ བཟུམ་ར་ཞིན། ཟེར་དོ་བཟུམ་ མཚུངས་དཔེ་གཞི་སྦྱོར་པའི་
སྐྱེ་ལུ་འཇུག་ནི་ཡོད།
ཅ་ལ་ དེ་ གི་གོང་། གནད་དོན་ དེ་ གི་ཐད་ཁར། ཞུམ་འཛོམས་ དེ་ གི་གོས་ཚོད། ཟེར་དོ་བཟུམ་ སྐྱེ་སྦྱོར་པའི་སྐྱེ་
འབད་འཇུག་ནི་དང་།
མོ་གིས་སྐབས་མི་ དེ་ བདེན་པས། ཀམ་གིས་བཤད་མི་ དེ་ ཞིན་པས། ཟེར་དོ་བཟུམ་ བདེན་པའི་དོན་སྦྱོར་པའི་སྐྱེ་
འབད་འཇུག་ནི།
ང་གིས་སྐབས་མི་ དེ་ འབད་ཡི་ག་? ཁོང་གིས་འབག་འོང་མི་ དེ་ གཞན་ལུ་མ་སྐྱབ། ཟེར་དོ་བཟུམ། གསང་བའི་དོན་

སློབ་པའི་སྐྱེ་འབད་འཇུག་ནི།

སྐྱ་མོ་ རྟེ་ ར་སྐད་ཉན་པས། རོ་ཁྱི་ རྟེ་ ར་ལེགས་པས། ཟེར་དོ་བཟུམ་ རེས་བཟུང་བཞན་པའི་སྐྱེ་དང་བཅས་ རུག་ རུ་འཇུག་ནི་ཡོད།



སློབ་ལཱ་ ༣ པ།

- ༡༽ རུས་སློབ་པའི་དཔེར་བཅོམ་ ༡ རུབ།
- ༢༽ བདེན་པའི་སློབ་པའི་དཔེར་བཅོམ་ ༡ རུབ།
- ༣༽ གསང་བའི་དོན་སློབ་པའི་ དཔེར་བཅོམ་ ༡ རུབ།

སྦྱོར་སྒྲིག་

སྦྱི་སྦྱེ་ཟེར་མི་འདི་གིས་ སྐབས་འཕྲོ་བ་དང་བསྐྱེད་ཏེ་ ག་ཅི་ལུ་ཡང་ གོ་བཏུབ་ལས་ སྦྱི་སྦྱེ་ཟེར་སྐབ་ཨིན། སྦྱི་སྦྱེའི་སྦྱད་ ག་ ག་ཅི་ ག་ཏེ་ ག་ལས་ བྱམ་ ག་དེ་སྦྱེ་ ག་དེ་མ་ཅིག་ ཟེར་མི་དང་བཅས་རུག་ཡོད།

དཔེར་བཅོམ་

- ག་དང་ག་ར་འབད་རུབ།
- ག་ཅི་དང་ག་ཅི་ར་ཨིན་རུབ།
- ག་ཏེ་ལས་ བཟུ་རུབ།
- ག་ལས་སྐྱོར་རུབ།
- བྱམ་ར་འབད་རུབ།
- ག་དེ་སྦྱེ་མཐོ་བསམ་བཏང་རུབ།
- ག་དེ་མ་ཅིག་ཡོད་རུབ། ཟེར་དོ་བཟུམ་ཨིན།



སློབ་ལཱ་ ༤ པ།

གོང་གི་དཔེར་བཅོམ་ཚུ་ལས་དཔྱེ་བཟུ་སྟེ་ རྩོད་ཀྱིས་ཡང་ འདི་བཟུམ་གྱི་དཔེར་བཅོམ་མ་འདམ་ རུག་བྱིས།

བདག་སྐྱེ་

བདག་སྐྱེ་ ཟེར་མི་འདི་ མིང་ཚིག་ག་ཅི་འབད་རུབ་ མིང་ཚིག་ཅིག་གི་ཤུལ་མ་ པ་སོ་མ་མོ་མི་ ཟེར་བའི་ཚིག་གོགས་ གསང་པ་སྐྱུར་མ་ད་ དེ་ལུ་དབང་བའི་བདག་སོ་དང་ དེ་དང་ལྷན་མི་ ཡང་ན་ དེ་འབད་མི་ གང་ཟག་ཅིག་ལུ་ གོ་ཚུགས་མི་ གི་སྐྱེ་ཅིག་ལུ་ བདག་སྐྱེ་ཟེར་སྐབ་ཨིན།

དཔེར་བཅོམ་

སོ་ནམ་པ། ཟེར་བའི་སྐབས་ སོ་ནམ་ ཟེར་བའི་ཚིག་འདི་ སོ་ནམ་གྱི་ལུ་ལུ་གོ་མ་ཨིན་རུབ་ འདི་ལུ་པ་སྐྱུར་མ་ ད་ སོ་ནམ་གྱི་ལུ་འབད་མི་ མི་འདི་ལུ་གོ་མ་ལས་ འདི་ལུ་བདག་སྐྱེ་ཟེར་སྐབ་ཨིན།

དཔེར་བརྗོད་གཞན་ཡང་། ཚེས་པ། ཚུམ་པ་པོ། འཛིན་བཟོ་པ། ཡིད་འོང་མ། ཀྱང་སྟོད་བཟའམོ། ཟེར་དོ་བཟུམ་ པ་པོ་མ་
མོ་ཚུ་ བདག་སྐྱ་གཙོ་བོ་དང་།

སྟོ་འབད་མི། བྱ་ལྟ་མི། དད་པ་ཅན། ཐགས་མཁན་མ། སྦྱིན་བདག། ཆང་ཟེ། སུང་ཟེ། ཟེར་དོ་བཟུམ་ མི་ ཅན་ ལྷན་
མཁན་ བདག་ ཟེ། ཚུ་བདག་སྐྱ་ཡན་ལག་ཡིན།

དགག་སྐྱ།

དགག་སྐྱ་ཟེར་མི་འདི་ སྐྱབ་ཚིག་བཀག་པའི་སྐྱ་ལུ་ དགག་སྐྱ་ཟེར་སྐྱབ་ཡིན། དགག་སྐྱའི་ཕྱད་ མ་ མི་ མེན་ མེད་
མིན་ ལྟ་ཡིན། དེ་གི་དཔེར་བརྗོད་ཀྱི་འཇུག་ཐངས་ཡང་། དཔེར་ན།

- མ་སྐྱབ།
- མི་འབད།
- ག་ཡང་མེན།
- ག་ཅི་ཡང་མེད།
- མིན་འདུག། ཟེར་དོ་བཟུམ་ མ་ དང་ མི་ གཉིས་པོ་ བྱ་ཚིག་དང་ བྱད་ཚིག་གི་གདོང་ཁར་འཇུག་པ་ཡིན།

དེ་འབདམ་ལས་ དགག་སྐྱ་ མི་ གི་ཤུལ་ལས་འཇུག་པའི་བྱ་ཚིག་ཚུ་ དུས་མ་འོངས་པ་འབྲི་དགོཔ་དང་། དགག་སྐྱ་ མ་གི་
ཤུལ་ལས་འཇུག་པའི་བྱ་ཚིག་ཚུ་ དུས་འདས་པ་འབད་འབྲི་དགོཔ་ཡིན།

ཡིན་ཏུང་ འཕྲལ་འཕྲལ་ དེ་སྐྱེ་མ་འབྲི་བར་བཞག་གནང་། ཟེར་དོ་བཟུམ་དང་། ཁོ་མ་གཏང་སྐྱ་ལེ། ཟེར་དོ་བཟུམ་ དགག་
སྐྱ་ སྐྱལ་ཚིག་འབད་འཇུག་པའི་སྐྱབས་ མ་གི་ཤུལ་ལས་འབད་ཏུང་ བྱ་ཚིག་མ་འོངས་པ་འབད་འབྲི་མ་ཡིན། དགག་སྐྱ་
མིན་ ཟེར་མི་འདི་ འདུག་དང་ལུག་ གཉིས་དང་གཅིག་ཁར་མ་གཏོགས་ གཞན་ཁར་སྐྱར་ཏེ་འབྲི་སྐོལ་མེད།



སྟོང་ལུ་ ༥ པ།

- ༡ ། དགག་སྐྱ་ཟེར་སྐྱབ་དགོཔའི་དོན་དག་ག་ཅི་ཡིན་ནེ་
- ༢ ། བདག་སྐྱ་དང་ མིང་མཐའ་ གཉིས་ཀྱི་བྱད་པར་ དཔེ་དང་སྐྱགས་ཏེ་བྲིས།
- ༣ ། དགག་སྐྱའི་ཕྱད་ མ་ མི་ མེད་ མིན་ མེན་ ཚུ་གི་དཔེར་བརྗོད་ ༣ རེ་བྲིས།



བརྗོད་བསྟུན།

- ཚིག་ཕྱད་ཟེར་མི་འདི་ ག་ཅི་ཡིན་ནེ་དང་ དེ་ལས་ སྐྱར་བསྐྱ། རྒྱན་སྐྱད། ལྷག་བཅས། འབྲེད་སྐྱད། དགར་སྐྱད།
འི་སྐྱ། དང་སྐྱ། དེ་སྐྱ། སྦྱི་སྐྱ། བདག་སྐྱ། དགག་སྐྱ་ཚུ་དང་། རྣམ་དབྱེ་དང་ ཚིག་ཕྱད་དེ་ཚུ་ཡང་ རྗེས་འཇུག་ལུ་
ལྷོས་དགོས་པའི་ཕྱད་དང་། རྗེས་འཇུག་ལ་ ལྷོས་མི་དགོས་པའི་ཕྱད་ ག་ཅི་རང་ཡིན་ནེ་ཚུ་ཤེས་ཚུགས།

- ཕྱད་འདི་ཚུ་ རྗེས་འཇུག་ལུ་ལྟོས་དགོས་པའི་ བྱུངས་ག་ཅི་ཡིན་ན་དང་ རྗེས་འཇུག་ལྟོས་མ་དགོ་པའི་ བྱུངས་ག་ཅི་ཡིན་ བ།
- སྤྱིར་བཏང་ རྩལ་ཆེ་བའི་དབང་གིས་ དབྱེ་བ་དེ་སྟེ་ ཕྱེ་སྟོལ་ཡོད་རུང་ རྣམ་གསལ་ལུ་དབྱད་པ་ཅིན་ ད་རུང་ ཕྱད་ གཞན་དབང་ཅན་གྱི་ ལ་དོན་གྱི་ཕྱད་ རྣམ་གཉིས་དང་ འབྱུང་བྱུངས་ཀྱི་ཕྱད་ རྣམ་ལས་གཉིས་ཡང་ རྗེས་འཇུག་ དང་འབྲེལ་མ་དགོ་པ་ལས་ ཕྱད་རང་དབང་ཅན་གྱི་གངས་སུ་ཚུད་དགོ་པའི་དགོས་པ་ཚུ་ཁ་གསལ་འབད་བཤད་དེ་ཡོད།



རང་ཉིད་སློབ་སྟོན་ དབྱེ་ཞིབ།

- ༡༽ གོང་ལུ་ ལྷག་མི་ཚོག་ཕྱད་ ༡༡ ཡོད་མི་ཚུ་ ག་ཅི་ར་ཡིན་ན་? རྩོད་གྱི་སེམས་ཁར་འདུག་ག་?
- ༢༽ སྤྱིར་བཏང་ཟེར་མི་འདི་ ག་ཅི་བཟུམ་ཅིག་ལུ་སྤྱོད་ཡིན་ན་? ལོག་སྟེ་དྲན་གསོ་འབད།
- ༣༽ ལྷག་བཅས་ཀྱི་ཕྱད་ ག་དེམ་ཅིག་ཡོད་ག་? འདི་ཚུ་ག་ཅི་ར་ཡིན་ན་? ཐོ་བཀོད་འབད་དེ་བཟུ།
- ༤༽ དང་སྐྱོ་གི་ནང་གསལས་ དབྱེ་བ་ག་ཅི་རང་འདུག་ག་?
- ༥༽ སྤྱི་སྐྱོ་ཟེར་སྤྱོད་དགོ་པའི་བྱུངས་ག་ཅི་ཡིན་ན་?
- ༦༽ དགག་སྐྱུ་ལུ་ ཕྱད་ ག་དེམ་ཅིག་འདུག་? འདི་ག་ཅི་དང་ ག་ཅི་རང་ཡིན་སྟོ་? དེ་དེ་བཞིན་ཐོ་བཀོད་འབད།

༡- ཡི་གུའི་སློབ་བཞུགས་སླུང་དང་སླུང་བཅས།

ལས་དོན།



- སླུང་བཅས་ཟེར་བའི་གོ་དོན་ཤེས་ཚུགས།
- སླུང་བཅས་ཀྱི་ཕྱད་ཚུ་ རོས་འཛིན་འབད་ཚུགས།
- ཕྱད་ཀྱི་འཇུག་པ་དང་འཇུག་ཏེ་ དཔེར་བཅོལ་བཞུགས།
- སླུང་སླུང་ཀྱི་ཕྱད་འཇུག་ཐངས་དང་ དབྱེ་བ་ཚུ་ཁ་གསལ་འབད་ཤེས་ཚུགས།

དོན་ལྡན།

སླུང་སླུང་ཟེར་མི་འདི་ ཚོགས་སྐྱེ་གཉིས་ཀྱི་དོན་ཚོགས་འབད་དང་ མ་འབད་པ། སླུང་པའི་དོན་དང་ བཟུང་པའི་དོན་ཚུ་ སློབ་མི་གི་ཕྱད་ཅིག་ལུ་ སླབ་ཨིན།

སླུང་སླུང་ཀྱི་ཕྱད་ ཡང་། རང་། རུང་། གསུམ་ཨིན། དེ་ལུ་ནང་གསེས་ཀྱི་དབྱེ་བ། མཐུན་པའི་སླུང་། མི་མཐུན་པའི་སླུང་། སླུང་པའི་དོན། བཟུང་པའི་དོན་ཟེར་བའི་ཡོད་པ་ཨིན།

༡༽ སླུང་སླུང་ཀྱི་གོ་དོན།

སླུང་སླུང་ཀྱིས་ཚོགས་སྐྱེ་གཉིས་ཀྱི་ དོན་མཐུན་པ་དང་ མི་མཐུན་པ་ གསལ་བྱེད་འབད་འཇུག་ནི་དེ་གིས་ སླུང་ཟེར་སླབ་ནི་ དང་། དོན་དངོས་སུ་མ་སླབ་ཚུང་ ཕྱད་དེ་གིས་བསྐྱེད་ཏེ་ བྱུགས་ཀྱི་གོ་ཚུགས་པ་ལས་ སླུང་པ་ཟེར་སླབ་ཨིན།

སླུང་སླུང་ཀྱི་ཕྱད་ ཡང་ རང་ རུང་ གསུམ་ རྗེས་འཇུག་གི་དབྱེ་བ་མེད་པར་འཇུག་ནི་འདི་གིས། དཔེར་ན།

ཨང་།	ཕྱད།	མཐུན་པའི་སླུང་ཀྱི་དཔེར་བཅོལ།
༡	ཡང་	དགའ་ ཡང་ དགའ།
༢	རང་	སློབ་ རང་ སློབ།
༣	རུང་	སློབ་ རུང་ སློབ།
ཨང་།	ཕྱད།	མི་མཐུན་པའི་སླུང་ཀྱི་དཔེར་བཅོལ།
༡	ཡང་	སླུང་ ཡང་ མ་སླུང།
༢	རང་	དགའ་འཇུག་ཡོད་ རང་ མེད།
༣	རུང་	སླུང་ རུང་ མི་ཉམ།
ཨང་།	ཕྱད།	སླུང་པའི་དོན་ལུ་འདཔེར་བཅོལ།
༡	ཡང་	སླུང་ ཡང་ རྩོམ་ལུགས།
༢	རང་	སློབ་དཔོན་གྱིས་ རང་ གསུངས་མས།
༣	རུང་	སློབ་གོ་གིས་ ཡང་ ཤེས་པས།

༡༽ ལྷག་བཅས།

ལྷག་བཅས་ཟེར་སླབ་མི་འདི་ ལྷག་བཅས་ཀྱི་ཕྱད་འདི་གིས་ ཚིག་གི་ལྷག་མ་གཞན་ ཡར་འདྲེན་ཚུགས་པའི་ལུས་པ་ ཡོད་པའི་ ཕྱད་ ཅིག་ལུ་སླབ་ཡིན། ལྷག་བཅས་ཀྱི་ཕྱད་ ལྷ་ ཉེ་ ཉེ་ གསུམ་རྗེས་འཇུག་དང་འབྲེལ་ཉེ་འཇུག་དགོས་ ལས་ ཕྱད་གཞན་དབང་ཅན་དང་། ལྷག་བཅས་ཀྱི་ཕྱད་ ལྷ་ འདི་རྗེས་འཇུག་དང་ འབྲེལ་མ་དགོས་པར་འཇུག་པ་ལས་ ཕྱད་རང་དབང་ཅན་ཟེར་སླབ་ཡིན།

ཨང་།	ཕྱད།	དཔེར་བརྗོད།
༡	ཉེ་	བསྐྱབས་ ཉེ་ བཞུགས།
༢	ལྷ་	ལྷ་བ་ ལྷ་ ཤེས།
༣	ཉེ་	འབད་ ཉེ་ བཟ།
༤	ལྷ་	མཚོ་བསམ་བཏང་ ལྷ་ འབད།

ད་རུང་ ལྷག་བཅས་ཀྱི་ཕྱད་དང་ཅོག་འབྲེལ་པའི་ གོ་དོན་སློབ་ཚུགས་པའི་ཚིག་གོ་གས་ ཞིན་མ་ལས། ཞིན་ན་ ཟེར་མི་ གཉིས་ཡང་ ལྷག་བཅས་ཀྱི་ ཕྱད་ གངས་སུ་འབད་ བཟུ་མི་ཡང་ཡོད། ཡིན་རུང་ ཚོས་སྐད་ཀྱི་སྐབས་ ཞིན་མ་ལས། ཞིན་ན་ ཟེར་མི་དང་ ཆ་འདྲ་བའི་ཚིག་ ཟེར་མི་འདི་ ལྷག་བཅས་ཀྱི་ཕྱད་ཀྱི་གངས་སུ་མེད་པ་ཡིན།

འདི་ལས་རྟ་བུར་ཉེ་ རྗོང་ཁའི་ནང་ཡང་ ལྷག་བཅས་ཀྱི་ཕྱད་དོ་མ་ ལྷ་ཉེ་དེ་སྤེ་ བཞི་རྒྱུང་མ་ཅིག་ཡིན་མ་འབད་སེམས་ ཁར་བཞག་དགོ།

ཚོས་སྐད་ཀྱི་ལྷག་བཅས་དང་ རྗོང་ཁའི་ལྷག་བཅས་ཀྱི་བར་ན་ རྒྱད་པར་འདི་ རྗོང་ཁའི་ནང་ ཕྱད་ ལྷ་ ཟེར་མི་འདི་ འབྲེལ་ཡོད་པ་མ་གཏོགས་ གཞན་ག་ར་ཅོག་ར་འབྲེལ། ལྷག་བཅས་ཀྱི་ཕྱད་འདི་ མང་ཤོས་ར་ བྱ་ཚིག་གི་ཤུལ་ལས་འཇུག་ གོ་ཡོད་པ་ཡིན། དེ་འབད་ལས་ ལྷག་བཅས་ཀྱི་ཉེ་མར་ འཇུག་པའི་བྱ་ཚིག་འདི་ བམ་ར་འབད་རུང་ ལུས་འདས་པའི་ ཡིག་སྐབ་ནང་འབད་འབྲི་དགོ།

ཨང་།	ཕྱད།	དཔེར་བརྗོད།
༡	ཉེ་	བསྐྱབས་ ཉེ་ བཞག།
༢	ལྷ་	བཏང་ ལྷ་ འབྲུ། ཟེར་དོ་བཟུམ་ཡིན།

འབྲེལ་སྤོང་།

ལྷག་བཅས་ཀྱི་ཕྱད་ ལྷ་ དང་མཚུངས་པ་གསལ་བྱེད་ཀྱི་སྐྱེ་ ལྷ་ ལྷག་བཅས་ཀྱི་ཕྱད་ ལྷ་ དང་འདྲི་ཚིག་གི་སྐྱེ་ ལྷ་ ཟེར་མི་ཚུ་ཡང་འཇུག་སྐོལ་ཡོད་པའི་ཁར་ ལྷག་བཅས་ཀྱི་ཕྱད་ ཉེ་ དང་ བམ་གངས་གཞན་འདྲེན་པའི་ ཉེ་ ལྷ་ དབྱེ་བ་བྱེས་ཉེ་ མ་འཛོལ་བར་འབྲི་ཤེས་དགོ།



སློབ་ལུ་ ༩ པ།

ལྷག་གི་དཔེ་བརྗོད་ཚུ་ལས་ དཔེ་བལྟ་སྟེ་ རྩོད་ར་གིས་ ལྷག་བཅས་ཀྱི་ཕྱད་ **སྟེ་ཉེ་དེ་** གསུམ་རྗེས་འཇུག་གི་འཇུག་པ་
དང་འཇུག་ཉེ་ དཔེ་བརྗོད་ ༥ རེ་རྒྱབ།



བརྟན་བརྩམས།

- རྒྱན་སྦྲུང་ཀྱི་ཕྱད་ཚུ་གིས་ ཚིག་སྲ་ཕྱི་གཉིས་མཐུན་པ་དང་ མ་མཐུན་པའི་རྒྱན་ལུ་འཇུག་པ་དང་ སྦྲུང་པ་དང་ བཞན་པའི་དོན་ཚུ་ལུ་ཡང་ འཇུག་པ་ཨིན།
- དེ་ལས་ ལྷག་བཅས་ཟེར་སྐབ་མི་འདི་ ལྷག་བཅས་ཀྱི་ཕྱད་འདི་གིས་ ཚིག་གི་ལྷག་མ་ཡར་འབྲེན་ཚུ་གས་པའི་ ལུས་པ་ཡོད་པའི་ཕྱད་ཅིག་ལུ་ སྐབ་ཨིན།



རང་ཉིད་སློབ་སྦྱང་ དབྱེ་ཞིབ།

- འོག་གི་རྗོད་ཚིག་ནང་ ཡིག་སྟེ་བ་དང་ཕྱད་ འཛོལ་ཉེ་ཡོད་མི་ཚུ་ ལེགས་བཅོས་འབད་དེ་བྲིས།
- ༡ ་ ས་ཁར་སྟོད་འདི་ ལུ་སིམ་སི་འབད་ དཔེ་ཆ་ལྟ་བུ་སྟོད།
 - ༢ ་ མི་དགོ་བའི་ལུ་ཚུ་འབད་ནི་ལས་འཛོམ་ཉེ་ བན་ཐོགས་པའི་ལུ་ལུ་ བཙོན་ལུགས་སྦྱང་སྟེ་སྟོད་དགོ།
 - ༣ ་ ཨ་ལུ་བཟུ་མ་ཤིས་པ་ཚུ་ཁྲིམས་སྤང་འགག་པ་གིས་གཟུང་ཉེ་ ཞིབ་དབྱུང་འབད་བཞིན་མ་ལས་ཉེས་ཁྲིམས་ཚུ་བཀའ་ལུ་ ལུགས།
 - ༤ ་ ཨའི་གིས་ ཉེ་མའི་བཞེས་སྟོ་ཚུ་སྟེ་འབད་ ར་བཅས་ཆ་ལུ་སྦྱག་ཉེ་སྟོད་ལུགས།

MATHEMATICS

1. TRIGONOMETRIC FUNCTION

Learning Objectives



- Apply addition and subtraction formula of trigonometric function in solving problems.
- Derive product formulae of trigonometric function.
- Convert sum and difference formulae into product and vice versa.
- Solve problems using double and triple angle formulae of the trigonometric function.

Introduction

As mentioned in earlier lessons, the concept of trigonometry has a wide application in lots of field like engineering, astronomy, navigation, electricity and many more. In this lesson, we are going to learn about the compound and multiple angle formulas of trigonometry ratio. The formula which contains more than one angle is known as compound angle formula.

Instruction: Study the notes given below to understand the concepts of addition and subtraction formulae.

1. Addition Formulae

- $\sin(A + B) = \sin A \cos B + \cos A \sin B$
- $\cos(A + B) = \cos A \cos B - \sin A \sin B$
- $\tan(A + B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$

Where A & B are two different angles.

Keynote: They are known as addition formulae because the two angles are connected with a plus sign.

In order to understand the application of the addition formula, let us look into an example given below:

Example: Compute $\sin 105^\circ$ from functions of 45° and 60° .

Solution: 105° is sum of 45° and 60°

Therefore, $\sin 105^\circ = \sin(45^\circ + 60^\circ)$

$$\sin(A + B) = \sin A \cos B + \cos A \sin B$$

$$\sin(45^\circ + 60^\circ) = \sin 45^\circ \cos 60^\circ + \cos 45^\circ \sin 60^\circ$$

We know that: $\sin 45^\circ = \cos 45^\circ = \frac{1}{\sqrt{2}}$, $\cos 60^\circ = \frac{1}{2}$, $\sin 60^\circ = \frac{\sqrt{3}}{2}$

Substituting in the above expansion;

$$\begin{aligned} \sin 105^\circ &= \frac{1}{\sqrt{2}} \times \frac{1}{2} + \frac{1}{\sqrt{2}} \times \frac{\sqrt{3}}{2} \\ &= \frac{1}{2\sqrt{2}} + \frac{\sqrt{3}}{2\sqrt{2}} = \frac{1+\sqrt{3}}{2\sqrt{2}} \end{aligned}$$



ACTIVITY 1

Instruction: Refer solved example above to compute the following questions using an addition formula.

Questions:

- i) $\cos 135^\circ$ from the functions of 45° and 90° .
- ii) $\tan 105^\circ$ from the functions of 45° and 60°

1. Subtraction Formulae

Replacing $B = -B$ in Addition Formula

$$a. \sin(A - B) = \sin A \cos B - \cos A \sin B$$

$$b. \cos(A - B) = \cos A \cos B + \sin A \sin B$$

$$c. \tan(A - B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}$$

Keynote: They are known as subtraction formulae because the two angles are connected with a minus sign.

Let us look into the example below to understand the application of the subtraction formula.

Example: Compute $\cos 15^\circ$ from functions of 45° and 60° .

Solution:

$$\cos 15^\circ = \cos(60^\circ - 45^\circ)$$

$$\text{using } \cos(A - B) = \cos A \cos B + \sin A \sin B$$

$$\cos(60^\circ - 45^\circ) = \cos 60^\circ \cos 45^\circ + \sin 60^\circ \sin 45^\circ$$

$$\begin{aligned} &= \frac{1}{2} \times \frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2} \times \frac{1}{\sqrt{2}} \\ &= \frac{1}{2\sqrt{2}} + \frac{\sqrt{3}}{2\sqrt{2}} \\ &= \frac{1 + \sqrt{3}}{2\sqrt{2}} \end{aligned}$$



ACTIVITY 2

Instruction: Refer the example above to compute the following questions using the subtraction formula.

Questions:

- i) $\sin 135^\circ$ from the functions of 180° and 45° .
- ii) $\tan 15^\circ$ from the functions of 45° and 30° .

2. Product Formulae

Product formulae are those formulas in which trigonometric functions are being multiplied.

i. Converting products into sum and differences

There are four formulae that convert products into sum and differences. Let us derive each formula.

Using the addition and subtraction formula of sine, we have;

$\sin(A + B) = \sin A \cos B + \cos A \sin B \dots\dots\dots(1)$
$\sin(A - B) = \sin A \cos B - \cos A \sin B \dots\dots\dots(2)$
<i>Adding (1) & (2)</i>
$\sin(A + B) = \sin A \cos B + \cos A \sin B \dots\dots\dots(1)$
$\sin(A - B) = \sin A \cos B - \cos A \sin B \dots\dots\dots(2)$
(+)
$\sin(A + B) + \sin(A - B) = 2 \sin A \cos B$

i. Therefore, $2 \sin A \cos B = \sin(A + B) + \sin(A - B)$

Similarly subtracting above two equations we obtained the second product formula as shown below:

$\sin(A + B) = \sin A \cos B + \cos A \sin B \dots\dots\dots(1)$
$\sin(A - B) = \sin A \cos B - \cos A \sin B \dots\dots\dots(2)$
(-) (-) (+)
$\sin(A + B) - \sin(A - B) = 2 \cos A \sin B$

ii. Therefore, $2 \cos A \sin B = \sin(A + B) - \sin(A - B)$.

By using addition and subtraction formula of cosine, we have;

$\cos(A + B) = \cos A \cos B - \sin A \sin B \dots\dots\dots(3)$
$\cos(A - B) = \cos A \cos B + \sin A \sin B \dots\dots\dots(4)$
<i>Adding (3) & (4)</i>
$\cos(A + B) = \cos A \cos B - \sin A \sin B$
$\cos(A - B) = \cos A \cos B + \sin A \sin B$
(+)
$\cos(A + B) + \cos(A - B) = 2 \cos A \cos B$

iii. Therefore, $2 \cos A \cos B = \cos(A + B) + \cos(A - B)$.

Similarly subtracting equation (3) & (4), we will get the 4th formula as shown below:

$\cos(A + B) = \cos A \cos B - \sin A \sin B$
$\cos(A - B) = \cos A \cos B + \sin A \sin B$
(-) (-) (-)
$\cos(A + B) - \cos(A - B) = -2 \sin A \sin B$
Multiplying by negative sign throughout, we have
$\cos(A - B) - \cos(A + B) = 2 \sin A \sin B$

iv. Therefore, $2 \sin A \sin B = \cos(A - B) - \cos(A + B)$

Keynotes: The four formulae hence obtained are:

- i. $2 \sin A \cos B = \sin(A + B) + \sin(A - B)$
- ii. $2 \cos A \sin B = \sin(A + B) - \sin(A - B)$
- iii. $2 \cos A \cos B = \cos(A + B) + \cos(A - B)$
- iv. $2 \sin A \sin B = \cos(A - B) - \cos(A + B)$

ii. Converting products into sum and differences

Replace $A + B = C$ & $A - B = D$ above obtained equations, we get

- i. $\sin C + \sin D = 2 \sin \frac{C+D}{2} \cos \frac{C-D}{2}$
- ii. $\sin C - \sin D = 2 \sin \frac{C-D}{2} \cos \frac{C+D}{2}$
- iii. $\cos C + \cos D = 2 \cos \frac{C+D}{2} \cos \frac{C-D}{2}$
- iv. $\cos C - \cos D = 2 \sin \frac{C+D}{2} \sin \frac{D-C}{2}$

To understand the application of these formulae, let us solve a few examples.

Example 1: Convert the product $75^\circ \cos 15^\circ$ into sum or difference:

Solution:

Using $2 \sin A \cos B = \sin(A + B) + \sin(A - B)$

$$\begin{aligned} 2 \sin 75^\circ \cos 15^\circ &= \sin(75^\circ + 15^\circ) + \sin(75^\circ - 15^\circ) \\ &= \sin 90^\circ + \sin 60^\circ \\ &= 1 + \frac{\sqrt{3}}{2} \\ &= \frac{2 + \sqrt{3}}{2} \end{aligned}$$

Example 2: Convert $\cos 79^\circ + \cos 11^\circ$ into product.

Solution:

$$\begin{aligned} \text{Using } \cos C + \cos D &= 2 \cos \frac{C+D}{2} \cos \frac{C-D}{2} \\ &= 2 \cos \frac{79^\circ + 11^\circ}{2} \cos \frac{79^\circ - 11^\circ}{2} \\ &= 2 \cos \frac{90^\circ}{2} \cos \frac{68^\circ}{2} \\ &= 2 \cos 45^\circ \cos 34^\circ \end{aligned}$$



ACTIVITY 3

Instruction: Study the above examples and convert the given equations of sum or difference into product and vice versa.

Given Equations:

- i. $2 \sin 48^\circ \cos 12^\circ$
- ii. $2 \sin 54^\circ \sin 66^\circ$
- iii. $\sin 12A + \sin 4A$
- iv. $\cos 80^\circ + \cos 10^\circ$

3. Double Angle Formulae

Double angle formulae are those trigonometric formulae which contain an angle in the form of two times the given angle. If A is a given angle then the double of A is $2A$, therefore double angle formula for given angle A contains angle as $2A$. Double angle formulae are derived from three addition formulae.

To derive double angle formulae, we have to substitute $B=A$ in the addition formula of $\sin(A+B)$, $\cos(A+B)$ & $\tan(A+B)$.

Let us first take $\sin(A+B)$

we know that,

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

substituting $B = A$

$$\sin(A+A) = \sin A \cos A + \cos A \sin A$$

$$\sin 2A = 2 \sin A \cos A$$

Hence the double angle formula obtained using $\sin(A+B)$ is

$$\boxed{\sin 2A = 2 \sin A \cos A}$$

Let us now use $\cos(A+B)$

$$\cos(A+A) = \cos A \cos A - \sin A \sin A$$

$$\cos 2A = \cos^2 A - \sin^2 A \dots \dots \dots (i)$$

substituting $\cos^2 A = 1 - \sin^2 A$ in equation(i), we get

$$\cos 2A = 1 - \sin^2 A - \sin^2 A$$

$$\cos 2A = 1 - 2\sin^2 A \dots \dots \dots (ii)$$

similarly, substituting $\sin^2 A = 1 - \cos^2 A$ in equation(i), we get

$$\cos 2A = \cos^2 A - (1 - \cos^2 A)$$

$$\cos 2A = \cos^2 A - 1 + \cos^2 A$$

$$\cos 2A = 2\cos^2 A - 1 \dots \dots \dots (iii)$$

Hence three forms of double angle formulae obtained using $\cos(A+B)$ are:

$$\boxed{\begin{array}{l} \text{i. } \cos 2A = \cos^2 A - \sin^2 A \\ \text{ii. } \cos 2A = 1 - 2\sin^2 A \\ \text{iii. } \cos 2A = 2\cos^2 A - 1 \end{array}}$$

Similarly, taking $\tan(A+B)$, we obtained the double angle formula for $\tan 2A$ as

$$\boxed{\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}}$$

Let us now look into some examples to solve a question using the double angle formula

Example 1: Simplify $2\sin 15^\circ \cos 15^\circ$ in lowest term

Solution:

Using $\sin 2A = 2 \sin A \cos A$ we get,

$$2\sin 15^\circ \cos 15^\circ = \sin 2(15^\circ) = \sin 30^\circ$$

Example 2: **Evaluate:** i. $1 - 2\sin^2 22.5^\circ$ & ii. $\frac{2\tan 22.5^\circ}{1-\tan^2 22.5^\circ}$

Solution: i

Using $\cos 2A = 1 - 2\sin^2 A$, we get

$$\begin{aligned} 1 - 2\sin^2 22.5^\circ &= \cos 2(22.5^\circ) \\ &= \cos 45^\circ \\ &= \frac{1}{\sqrt{2}} \end{aligned}$$

Solution ii. Using $\tan 2A = \frac{2\tan A}{1-\tan^2 A}$, we get

$$\begin{aligned} \frac{2\tan 22.5^\circ}{1-\tan^2 22.5^\circ} &= \tan 2(22.5^\circ) \\ &= \tan 45^\circ = 1 \end{aligned}$$



ACTIVITY 4

Solve the given equations using double angle formulae.

Given equations:

i. $2\sin 15^\circ \cos 15^\circ$

ii. $2\cos^2 157.5^\circ - 1$

iii. $\cos^2 \frac{\pi}{12} - \sin^2 \frac{\pi}{12}$

4. Triple Angle Formulae

Triple angle formulae are those trigonometric formulae which contains an angle in the form of $3A$, if A is a given angle. Triple angle formulae are also derived from addition formula by substituting $B=2A$.

Let us take $\sin (A+B)$

we know that,

$$\sin(A + B) = \sin A \cos B + \cos A \sin B$$

substituting $B = 2A$

$$\sin(A + 2A) = \sin A \cos 2A + \cos A \sin 2A$$

substituting $\cos 2A = 1 - 2\sin^2 A$ & $\sin 2A = 2\sin A \cos A$

$$\sin 3A = \sin A(1 - 2\sin^2 A) + \cos A 2\sin A \cos A$$

$$= \sin A - 2\sin^3 A + 2\sin A \cos^2 A$$

substituting $\cos^2 A = 1 - \sin^2 A$

$$= \sin A - 2\sin^3 A + 2\sin A(1 - \sin^2 A)$$

$$= \sin A - 2\sin^3 A + 2\sin A - 2\sin^3 A$$

$$\boxed{\sin 3A = 3\sin A - 4\sin^3 A}$$

Keynote: When you derive the triple angle formula for $\sin 3A$, all the function should be in the form of sine and for $\cos 3A$, all the function should be in cosine.



ACTIVITY 5

1. Derive the triple angle formula of $\cos 3A$ using the relations given above.



Summary

Addition formulae are:

- $\sin (A + B) = \sin A \cos B + \cos A \sin B$
- $\cos (A + B) = \cos A \cos B - \sin A \sin B$
- $\tan (A + B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$

Subtraction formulae are:

- $\sin (A - B) = \sin A \cos B - \cos A \sin B$
- $\cos (A - B) = \cos A \cos B + \sin A \sin B$
- $\tan (A - B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}$

Converting products into sum and differences formulae are:

- $2 \sin A \cos B = \sin(A + B) + \sin(A - B)$
- $2 \cos A \sin B = \sin(A + B) - \sin(A - B)$
- $2 \cos A \cos B = \cos(A + B) + \cos(A - B)$
- $2 \sin A \sin B = \cos(A - B) - \cos(A + B)$

Converting products into sum and differences formulae are:

- $\sin C + \sin D = 2 \sin \frac{C+D}{2} \cos \frac{C-D}{2}$
- $\sin C - \sin D = 2 \sin \frac{C-D}{2} \cos \frac{C+D}{2}$
- $\cos C + \cos D = 2 \cos \frac{C+D}{2} \cos \frac{C-D}{2}$
- $\cos C - \cos D = 2 \sin \frac{C+D}{2} \sin \frac{D-C}{2}$

Double angle formulae are:

- $\sin 2A = 2 \sin A \cos A$
- $\cos 2A = \cos^2 A - \sin^2 A$
- $\cos 2A = 1 - 2 \sin^2 A$
- $\cos 2A = 2 \cos^2 A - 1$
- $\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$

Triple angle formulae are:

- $\sin 3A = 3 \sin A - 4 \sin^3 A$
- $\cos 3A = 4 \cos^3 A - 3 \cos A$

**Self-check for Learning**

Answer the following questions and solve it in your notebook.

1. Using the addition and subtraction formulae of a trigonometric function, prove that

$$i. \cos\left(\frac{\pi}{3} + x\right) = \frac{\cos x - \sqrt{3} \sin x}{2}$$

$$ii. \sin(A - 45^\circ) = \frac{1}{\sqrt{2}}(\sin A - \cos A)$$

2. Convert $\cos 12A + \cos 8A$ into product.

2. TRIGONOMETRIC EQUATIONS

Learning Objectives



- Define trigonometric equation.
- Differentiate between particular solution and general solution.
- Calculating general and particular solution of trigonometric equation.
- Applying general solution in calculating particular solution of the trigonometric equation.

Introduction

Trigonometric equations are those equations that involve trigonometric functions of unknown angles.

Examples: $\sin x = 0$, $\cos^2 x - \sin^2 x = \frac{1}{4}$, $\sin\left(\theta + \frac{\pi}{4}\right) = \frac{1}{2}$

Trigonometric equations are applied in finding distance, height, and patterns in nature, calculating inclination, and measuring areas. Trigonometric equations are used in many fields like engineering, physics, archaeology, navigation, oceanography, marine biology, video games, and music. This lesson will mainly focus on finding the solution of trigonometric equations of sines and cosines.



ACTIVITY 1

Instruction: Read the information given below to understand the method to find the solutions of sine and cosine functions.

A solution of the trigonometric equation is a value of an unknown angle that satisfies the equation. The trigonometric equation will have an unlimited number of solutions. The solution lying between 0° to 360° is called a **principal solution**. Since the trigonometric functions are periodic (a function that repeats its values in regular intervals or periods), a solution generated by means of periodicity is known as a **general solution**. To find the solution of the trigonometric equation, we will always find the **general solution** unless stated in the question. The principal solution can be obtained from a general solution.

A general solution of equations of sines and cosines functions

i. $\sin \theta = 0$

since $\sin 0 = \sin \pi = \sin(-\pi) = \sin 2\pi = \sin(-2\pi) = \dots = 0$

The equation $\sin \theta = 0$ is satisfied by the following values of θ .

$\theta = 0, \pm\pi, \pm2\pi, \pm3\pi, \pm4\pi, \dots$

In short, the above solution can be written as $\theta = n\pi$, where n is an integer.

Therefore, the **General solution** of the equation $\sin \theta = 0$ is $\theta = n\pi, n \in I$

ii. $\cos \theta = 0$

The equation $\cos \theta = 0$ is satisfied by the following values of θ .

$$\theta = \pm \frac{\pi}{2}, \pm \frac{3\pi}{2}, \pm \frac{5\pi}{2}, \pm \frac{7\pi}{2}, \dots$$

Because $\cos \theta = \cos \frac{\pi}{2} = \cos \left(-\frac{\pi}{2}\right) = \cos \frac{3\pi}{2} = \cos \left(-\frac{3\pi}{2}\right) = \cos \frac{5\pi}{2} = \cos \left(-\frac{5\pi}{2}\right) = \dots = 0$

In short, the above solution can be written as $\theta = (2n+1)\frac{\pi}{2}$, where n is an integer.

Therefore, the **general solution** of the equation $\cos \theta = 0$ is $\theta = (2n+1)\frac{\pi}{2}, n \in I$

iii. Similarly, the general solution of $\sin \theta = \sin \alpha$ is $\theta = n\pi + (-1)^n \alpha$, where $n \in I$ and $\cos \theta = \cos \alpha$ is $\theta = 2n\pi \pm \alpha, n \in I$

Key Notes;

- A general solution of the equation $\sin \theta = 0$ is $\theta = n\pi, n \in I$
- A general solution of the equation $\cos \theta = 0$ is $\theta = (2n+1)\frac{\pi}{2}, n \in I$
- General solutions of $\sin \theta = \sin \alpha$ is $\theta = n\pi + (-1)^n \alpha$, where $n \in I$ and general solution $\cos \theta = \cos \alpha$ is $\theta = 2n\pi \pm \alpha, n \in I$



ACTIVITY 2

Instruction: Refer the solved examples below and solve the questions that follow in your notebook.

Examples:

i) Find the general values of θ if $2\sin \theta - 1 = 0$

Solution:

$$2\sin \theta - 1 = 0,$$

$$2\sin \theta = 1$$

$$\sin \theta = \frac{1}{2}$$

$$\therefore \theta = \sin^{-1} \left(\frac{1}{2} \right)$$

$$\theta = 30^\circ = \frac{\pi}{6}$$

$$i.e \sin \theta = \frac{1}{2} = \sin \frac{\pi}{6}$$

Hence general solution is $\theta = n\pi + (-1)^n \frac{\pi}{6}, n \in I$

ii) Find the general values of θ if $\sqrt{3}\sec\theta = -2$

Solution:

$$\sqrt{3}\sec\theta = -2$$

$$\sec\theta = -\frac{2}{\sqrt{3}}$$

$$\cos\theta = -\frac{\sqrt{3}}{2}$$

$$\theta = \cos^{-1}\left(-\frac{\sqrt{3}}{2}\right)$$

$$\theta = \frac{5\pi}{6}$$

$$\text{Hence, } \theta = 2n\pi \pm \frac{5\pi}{6}$$

iii) Solve $2\sin\theta\cos\theta = \cos\theta$ ($0^\circ < \theta < 360^\circ$)

Solution:

This question is for finding a particular solution since the interval is given between 0° and 360° .

$2\sin\theta\cos\theta = \cos\theta$ $2\sin\theta\cos\theta - \cos\theta = 0$ $\cos\theta(2\sin\theta - 1) = 0$ $\therefore \cos\theta = 0 \quad \text{or} \quad (2\sin\theta - 1) = 0$	
$\theta = \cos^{-1}0 = \frac{\pi}{2}$ $\therefore \cos\theta = 0 = \cos\frac{\pi}{2}$ <p>Hence, general solution is $\theta = (2n+1)\frac{\pi}{2}$</p>	$(2\sin\theta - 1) = 0$ $2\sin\theta = 1$ $\sin\theta = \frac{1}{2}$ $\theta = \sin^{-1}\frac{1}{2} = \frac{\pi}{6}$ <p>Hence, general solution is $\theta = n\pi + (-1)^n \frac{\pi}{6}$</p>

Keynote: To find angles between 0° and 360° , we have to substitute n as 1 only because 360° is just one rotation.

substituting $n = 1$ in $\theta = (2n+1)\frac{\pi}{2}$ $\theta = (2 \times 1 + 1)\frac{\pi}{2}$ $\theta = \frac{3\pi}{2}$	substituting $n = 1$ in $\theta = (2n+1)\frac{\pi}{2}$ $\theta = (2 \times 1 + 1)\frac{\pi}{2}$ $\theta = \frac{3\pi}{2}$ substituting $n = 1$ in $\theta = n\pi - (-1)^n \frac{\pi}{6}$ $\theta = 1 \times \pi + (-1)^1 \frac{\pi}{6}$ $= \pi - \frac{\pi}{6}$ $= \frac{5\pi}{6}$
--	--

Therefore Values of θ is $\frac{\pi}{6}, \frac{\pi}{2}, \frac{5\pi}{6}$ and $\frac{3\pi}{2}$

The questions for practice

- Find the general values of θ if
 - $\sqrt{2} \cos \theta - 1 = 0$
 - $\sin \theta = -\frac{\sqrt{3}}{2}$
- Find the values of θ between 0° and 360° satisfying the following equations
 - $2 \sin^2 \theta = \sin \theta$
 - $2 \sin \theta - 1 = 0$



Summary

- A solution of the trigonometric equation should satisfy the given equation.
- A trigonometric equation will have a general solution and a particular solution.
- A trigonometric equation will have many solutions since it is periodic in nature.
- The solutions which lie between 0° to 360° is called a principal solution.



Self-check for Learning

Answer the following questions and crosscheck your answer with the solution given at the end of this booklet.

- What is the meaning of a solution of the trigonometric equation?
- Differentiate between general and particular solutions.
- How a particular solution is calculated using a general solution?
- Write a particular solution for $\sin \theta = 1$?

3. INVERSE TRIGONOMETRIC FUNCTIONS

Learning Objectives



- Apply addition and subtraction of trigonometric function in solving problems.
- Derive product formulae of trigonometric function.
- Convert sum and difference formulae into product and vice versa.
- Solve problems using double and triple angle formulae of the trigonometric function.

Introduction

Inverse trigonometric functions arise when we want to calculate angles from side measurements in triangles.

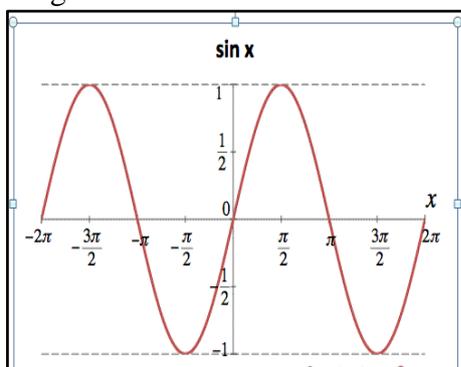


ACTIVITY 1

Interpret the meaning of inverse trigonometric functions

- If $\sin \theta = x$, then $\theta = \sin^{-1} x$
- Thus we see that $t\text{-ratio}^{-1}$ is a symbol that denotes an angle and called as:
Inverse trigonometric function or 'arc t-function'
- $t\text{-ratio}^{-1}$ stands for \sin^{-1} , \cos^{-1} , \tan^{-1} , and so on or '**arc sin x**', '**arc cosx**' and so on.
- **Remember $t\text{-ratio}^{-1} \neq (t\text{-ratio})^{-1}$**
Example; $\sin^{-1} x \neq (\sin x)^{-1}$ why? $(\sin x)^{-1}$ represents $\frac{1}{\sin x} = \operatorname{cosec} x$
- The six basic trigonometric functions are not one-to-one (their values repeat periodically (Look at sin graph given below).
- However, we can restrict their domains to intervals on which they are one-to-one.

Let us see the sine graph. This graph is a periodic function. The values are keep on repeating at regular intervals



Graph of trigonometric functions are all periodic functions. None of them pass the horizontal test and are not one-one function.

Horizontal line test will pass only if we impose **restriction on the domain** of the function.

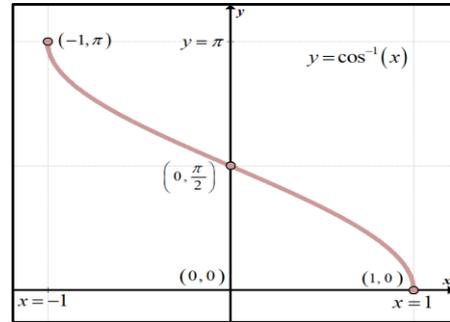
Taking an example of sine function graph and restricting its domain to

$$\left[-\frac{\pi}{2}, \frac{\pi}{2} \right],$$

it becomes one-one function since it passes horizontal line test.

If we graph the cos inverse function, it will look like the adjacent graph

$$y = \cos^{-1} x$$



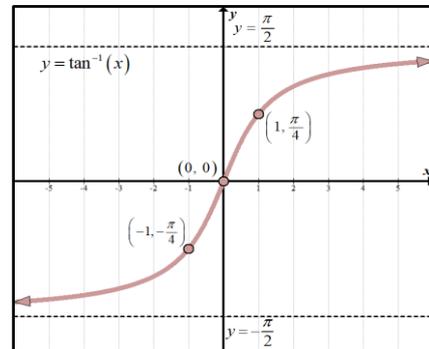
Horizontal line test will pass only if we impose restriction on the domain of the cosine function to

$$[0, \pi]$$

$$y = \tan^{-1} x$$

Horizontal line test will pass only if we impose restriction on the domain of the tan function to

$$\left[-\frac{\pi}{2}, \frac{\pi}{2} \right]$$



Principle Value

The numerically **smallest value of the angle** of an inverse trigonometric function. The **domain** of a **function** $f(x)$ is the set of all values for which the function is defined, and the **range** of the function is the set of all values that function takes.

Functions	Domain	Range
$y = \sin^{-1}x$	$[-1, 1]$	$\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$
$y = \cos^{-1}x$	$[-1, 1]$	$[0, \pi]$
$y = \tan^{-1}x$	$(-\infty, \infty)$	$\left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$
$y = \operatorname{cosec}^{-1}x$	$(-\infty, \infty) - (0)$	$\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$
$y = \sec^{-1}x$	$(-\infty, \infty) - (0)$	$[0, \pi]$
$y = \cot^{-1}x$	$(-\infty, \infty)$	$(0, \pi)$



ACTIVITY 2

Instruction: Observing the solved examples carefully, solve the questions that follow by using the principal values of inverse trigonometric functions.

Example: Find the prime values of the following:

i) $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$	ii) $\cot^{-1}\left(\frac{1}{\sqrt{3}}\right)$	iii) $\cos^{-1} 0$
<i>solution :</i>		
i) Let $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right) = \theta$, $\sin \theta = \frac{\sqrt{3}}{2} = \sin 60^\circ$; $\therefore \theta = 60^\circ = \frac{\pi}{3}$		
ii) Let $\cot^{-1}\left(\frac{1}{\sqrt{3}}\right) = \theta$, $\cot \theta = \frac{1}{\sqrt{3}} = \cot 60^\circ$ $\therefore \theta = 60^\circ = \frac{\pi}{3}$		
iii) $\cos^{-1} 0 = \theta$, $\cos \theta = 0 = \cos 90^\circ$; $\therefore \theta = 90^\circ = \frac{\pi}{2}$		

Question 1

Find the values of:

i) $\sin^{-1} 0$ ii) $\cos^{-1}\left(\frac{1}{2}\right)$ iii) $\tan^{-1}(-1)$



ACTIVITY 3

- Self-adjusting property

i) $\sin^{-1}(\sin \theta) = \theta$, for all $\theta \in \left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$	$\sin(\sin^{-1} x) = x$, for all $x \in [-1, 1]$
ii) $\cos^{-1}(\cos \theta) = \theta$, for all $\theta \in [0, \pi]$	$\cos(\cos^{-1} x) = x$, for all $x \in [-1, 1]$
iii) $\tan^{-1}(\tan \theta) = \theta$, for all $\theta \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$	$\tan(\tan^{-1} x) = x$, for all $x \in (-\infty, \infty)$
iv) $\operatorname{cosec}^{-1}(\operatorname{cosec} \theta) = \theta$, for all $\theta \in \left[-\frac{\pi}{2}, \frac{\pi}{2}\right], \theta \neq 0$	$\operatorname{cosec}(\operatorname{cosec}^{-1} x) = x$, for all $x \in \mathbb{R} - (-1, 1)$
v) $\sec^{-1}(\sec \theta) = \theta$, for all $\theta \in [0, \pi], \theta \neq \frac{\pi}{2}$	$\sec(\sec^{-1} x) = x$, for all $x \in \mathbb{R} - (-1, 1)$
vi) $\cot^{-1}(\cot \theta) = \theta$, for all $\theta \in (0, \pi)$	$\cot(\cot^{-1} x) = x$, for all $x \in \mathbb{R}$

Instruction: Observing the solved examples carefully, solve the following questions by using the self-adjusting property.

Example: Evaluate; a. $\sin^{-1}(\sin \frac{\pi}{3})$ b. $\sin^{-1}(\sin \frac{5\pi}{6})$

a. $\sin^{-1}(\sin(\frac{\pi}{3}))$

$$\sin^{-1}(\sin(\frac{\pi}{3})) = \frac{\pi}{3} \left(\text{Since, } \sin^{-1}(\sin \theta) = \theta, \text{ for all } \theta \in \left[-\frac{\pi}{2}, \frac{\pi}{2}\right] \right)$$

b. $\sin^{-1}\left(\sin \frac{5\pi}{6}\right)$

Solution: $\sin^{-1}\left(\sin \frac{5\pi}{6}\right) = \frac{5\pi}{6}$,

Which doesn't lie between $-\frac{\pi}{2}$ and $\frac{\pi}{2}$

So, we write $\sin \frac{5\pi}{6} = \sin\left(\pi - \frac{\pi}{6}\right) = \sin \frac{\pi}{6}$

Substitute $\sin \frac{5\pi}{6} = \sin \frac{\pi}{6}$

Therefore, $\sin\left(\frac{5\pi}{6}\right) = \frac{\pi}{6}$.

Question 2

Find the values of:

i) $\cos^{-1}(\sin 220)$ ii) $\tan^{-1}\left(\tan \frac{\pi}{10}\right)$ iii) $\cot\left(\tan^{-1} \frac{4}{5}\right)$



Summary

- $t\text{-ratio}^{-1}$ is a symbol that denotes an angle and called as **inverse trigonometric function** or 'arc t-function'.
- Remember **$t\text{-ratio}^{-1} \neq (t\text{-ratio})^{-1}$** .
- The **domain** of a **function** $f(x)$ is the set of all values for which the function is defined.
- The **range** of the function is the set of all values that function takes.



Self-check for Learning

Using the property, solve the following questions.

Find the values of:

1) $\tan^{-1}(1) + \cos^{-1}\left(-\frac{1}{2}\right) + \sin^{-1}\left(-\frac{1}{2}\right)$

2) $\sec^{-1}\left(\sec \frac{7\pi}{6}\right)$

3) Cosec A, if $\sin^{-1} \frac{1}{3} = A$

4. ALGEBRA: APPLICATION OF DETERMINANTS

Learning Objectives



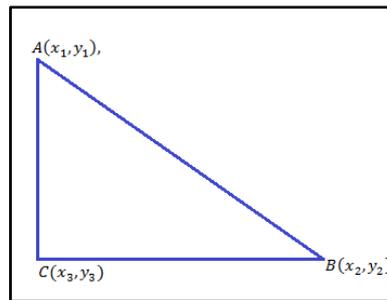
- Calculate the area of a triangle using determinant.
- Use determinant to prove that the given three points are collinear.
- Calculate area of a quadrilateral.
- Solve linear system of equations using Cramer's rule.

Introduction

In this lesson, we will focus on the applications of determinants in mathematics. There are many applications of determinant in mathematics like calculating the areas of two-dimensional geometric shapes but it is widely used in solving linear systems of equations.

Area of Triangle

Let us consider the triangle whose vertices are $A(x_1, y_1)$, $B(x_2, y_2)$ and $C(x_3, y_3)$ as shown below.



Then the area of the triangle with given vertices $A(x_1, y_1)$, $B(x_2, y_2)$ and $C(x_3, y_3)$ using determinant is calculated as:

$$\Delta = \frac{1}{2} \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}, \text{ Expanding along } c_1 \quad \Delta = \left| \frac{1}{2} [x_1(y_2 - y_3) - x_2(y_1 - y_3) + x_3(y_1 - y_2)] \right|$$

where Δ denotes area of triangle and modulus sign indicates that area is always positive.

Let us solve an example to get the clear concept of calculating the area of the triangle using determinants.

Example: Find the area of a triangle whose vertices are $(-2, -3)$, $(3, 2)$, $(-1, -8)$

Solution: The area of the triangle with given vertices are

$$\Delta = \left| \frac{1}{2} \begin{vmatrix} -2 & -3 & 1 \\ 3 & 2 & 1 \\ -1 & -8 & 1 \end{vmatrix} \right|$$

Expanding along c_3

$$\begin{aligned} \Delta &= \left| \frac{1}{2} [1(-24+2) - 1(16-3) + 1(-4+9)] \right| \\ &= \left| \frac{1}{2} [-22 - 13 + 5] \right| = 15 \text{ sq.units} \end{aligned}$$



ACTIVITY 1

Instruction: Find the area of triangle whose vertices are

- i. $(3, 8)$, $(-4, 2)$ and $(5, -1)$
- ii. $(-3, 5)$, $(3, -6)$ and $(7, 2)$

Collinear

Collinear is a condition in which three points lie on a straight line. Three points are said to be collinear, if the area of the triangle is Zero. (i.e, three points A, B and C lie on a same straight line when the area of triangle ABC is equal to zero.)

Example 1: Using the determinant prove that the point $(11, 7)$, $(5, 5)$ and $(-1, 3)$ are collinear.

Solution:

$$\Delta = \left| \frac{1}{2} \begin{vmatrix} 11 & 7 & 1 \\ 5 & 5 & 1 \\ -1 & 3 & 1 \end{vmatrix} \right|$$

Expanding along c_3

$$\begin{aligned} \Delta &= \left| \frac{1}{2} [1(15+5) - 1(33+7) + 1(55-35)] \right| \\ &= \left| \frac{1}{2} [20 - 40 + 20] \right| = \frac{1}{2} \times 0 = 0 \end{aligned}$$

Since the area of the triangle is zero, the given points are collinear.

Example 2: Find the value of 'k' so that the points (3, -2), (k, 2) and (8, 8) are collinear.

Solution:

$$\Delta = \begin{vmatrix} 3 & -2 & 1 \\ k & 2 & 1 \\ 8 & 8 & 1 \end{vmatrix}$$

Expanding along c_3

$$\Delta = \left| \frac{1}{2} [1(8k-16) - 1(24+16) + 1(6+2k)] \right|$$

Since the points are collinear, $\Delta = 0$

$$0 = \left| \frac{1}{2} [8k - 16 - 40 + 6 + 2k] \right|$$

$$0 = \left| \frac{1}{2} [10k - 50] \right|$$

$$0 = 10k - 50$$

$$k = \frac{50}{10} = 5$$

$$\therefore k = 5$$



ACTIVITY 2

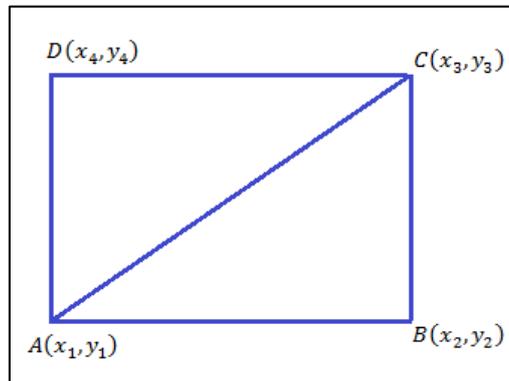
- Prove that the given points (0, 3), (4, 6) and (-8, -3) are collinear.
- For what value of k the points (5, 5), (k, 1) and (11, 7) are collinear.

Area of Quadrilateral

Quadrilateral is any two-dimensional shape with four vertices or sides. Square, rectangle and parallelogram are some examples of the quadrilateral.

Let us consider a quadrilateral whose vertices are

$A(x_1, y_1)$, $B(x_2, y_2)$, $C(x_3, y_3)$ and $D(x_4, y_4)$, then the area of quadrilateral ABCD is the sum of area of triangle ABC and ACD as shown in the diagram below.



Area of quadrilateral ABCD = Area of ΔABC + Area of ΔACD

$$= \frac{1}{2} \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} + \frac{1}{2} \begin{vmatrix} x_1 & y_1 & 1 \\ x_3 & y_3 & 1 \\ x_4 & y_4 & 1 \end{vmatrix}$$

Example: Find the area of quadrilateral whose vertices are A (1, -1), B (3, 1), C (-2, 3) and D (-1, -2).

Solution:

Area of quadrilateral ABCD = Area of ΔABC + Area of ΔACD

$$\begin{aligned} &= \frac{1}{2} \begin{vmatrix} 1 & -1 & 1 \\ 3 & 1 & 1 \\ -2 & 3 & 1 \end{vmatrix} + \frac{1}{2} \begin{vmatrix} 1 & -1 & 1 \\ -2 & 3 & 1 \\ -1 & -2 & 1 \end{vmatrix} \\ &= \frac{1}{2} [11 - 1 + 4] + \frac{1}{2} [7 + 3 + 1] \\ &= \frac{1}{2} \times 14 + \frac{1}{2} \times 11 \\ &= 7 + \frac{11}{2} = \frac{25}{2} \text{ sq. units} \end{aligned}$$



ACTIVITY 3

Find the area of the quadrilateral whose vertices are A (0, 0), B (1, 2), C (5, -1) and D (1, 3).

Solving System of Linear Equations by Determinant or Cramer's Rule

Linear system of equations is a collection of one or more linear equations with the same set of variables. For example, $2x + 3y = 1$ & $3x - y = 2$ is a linear system of equations with two variables. There can be a linear system of equations with three variables with three equations. The solution of the linear system of equations is the value of variables that satisfies all the equations. You have already studied a few strategies like elimination, substitution and comparison to find the solution of the linear system of equation with two variables in 10th standard. Let us study about using determinant in solving the linear system of equations. The method of using determinant to solve the linear system of equation is also known as Cramer's rule

Consider the linear system of equations $ax + by = c$ & $dx + ey = f$, where x and y are the variables and other letters as constant.

We need to follow the following steps:

Step 1: Evaluate D, D is a determinant formed by the coefficients of the variables.

For the above equations,

$$D = \begin{vmatrix} a & b \\ d & e \end{vmatrix}$$

coefficient of x

coefficient of y

Keynote: Arrange the coefficient of the first variable in the first column and coefficient of the second variable in the second column. If there is the third variable, then the coefficient of the third variable should be placed in the third column.

Step 2: If $D=0$, then the determinant method is not applicable. However, if $D \neq 0$, then the given system of equations has a unique solution. To get the unique solution find D_x , D_y and D_z .

For the above equations the determinant D_x and D_y is shown below:

$$D_x = \begin{vmatrix} c & b \\ f & e \end{vmatrix} \quad D_y = \begin{vmatrix} a & c \\ d & f \end{vmatrix}$$

replace coefficient of x with constant
replace coefficient y with constant

For the given equation the constants are c & f .

Step 3: Evaluate the value of x and y as $x = \frac{D_x}{D}$ & $y = \frac{D_y}{D}$

Example 1: Linear system of equation with two variables

Use Cramer's rule to solve $7x + 2y - 25 = 0$ and $2x - y - 4 = 0$

Solution:

$$7x + 2y = 25$$

$$2x - y = 4$$

$$\text{Step 1: } D = \begin{vmatrix} 7 & 2 \\ 2 & -1 \end{vmatrix} = -7 - 4 = -11$$

Since $D \neq 0$, the given system of equation has solution

Step 2:

$$D_x = \begin{vmatrix} 25 & 2 \\ 4 & -1 \end{vmatrix} = -25 - 8 = -33$$

$$D_y = \begin{vmatrix} 7 & 25 \\ 2 & 4 \end{vmatrix} = 28 - 50 = -22$$

$$\text{Step 3: } x = \frac{D_x}{D} = \frac{-33}{-11} = 3 \text{ \& } y = \frac{D_y}{D} = \frac{-22}{-11} = 2$$

Hence $x = 3$ & $y = 2$

Example 2: Linear system of equation with three variables

Using determinant, solve the linear system of equation

$$-4x + 2y - 9z = 2, 3x + 4y + z = 5, x - 3y + 2z = 8$$

$$-4x + 2y - 9z = 2$$

$$3x + 4y + z = 5$$

$$x - 3y + 2z = 8$$

$$D = \begin{vmatrix} -4 & 2 & -9 \\ 3 & 4 & 1 \\ 1 & -3 & 2 \end{vmatrix} \Rightarrow D = -4(8+3) - 2(6-1) - 9(-9-4) \Rightarrow D = -44 - 10 + 117 = 63$$

$$D_x = \begin{vmatrix} 2 & 2 & -9 \\ 5 & 4 & 1 \\ 8 & -3 & 2 \end{vmatrix} \Rightarrow D_x = 2(8+3) - 2(10-8) - 9(-15-32) = 22 - 4 + 423 = 441$$

$$D_y = \begin{vmatrix} -4 & 2 & -9 \\ 3 & 5 & 1 \\ 1 & 8 & 2 \end{vmatrix} \Rightarrow D_y = -4(10-8) - 2(6-1) - 9(24-5) = -8 - 10 - 171 = -189$$

$$D_z = \begin{vmatrix} -4 & 2 & 2 \\ 3 & 4 & 5 \\ 1 & -3 & 8 \end{vmatrix} \Rightarrow D_z = -4(35+15) - 2(24-5) + 2(-9-4) = 188 - 38 - 26 = -252$$

$$\therefore x = \frac{D_x}{D} = \frac{441}{63} = 7, y = \frac{D_y}{D} = \frac{-189}{63} = -3, z = \frac{D_z}{D} = \frac{-252}{63} = -4$$

Hence the solution is $x = 7$, $y = -3$ and $Z = -4$

Solve the following system of equation using determinant.

i. $7x - 2y = -7$ & $2x - y = 1$

ii. $5x - 7y + z = 11$, $6x - 8y - z = 15$ & $3x + 2y - 6z = 7$



Summary

- Area of 2d shapes with given vertices can be calculated using determinant.
- When the area of a triangle is zero, we say that the given three points are collinear.
- Determinants are also used in solving a linear system of equation. This method of using determinant in finding a solution of a linear system of equation is known as Cramer's rule.

**Self-check for Learning**

Instruction: Answer the following questions.

- i. Find the value of x , if the area of a triangle with vertices $(x,4)$, $(2, -6)$ and $(5, 4)$ be 35 sq. units
- ii. If (x, y) , $(a, 0)$ and $(0, b)$ are collinear, then using determinant, prove that
$$\frac{x}{a} + \frac{y}{b} = 1$$
- iii. Use Cramer's rule to solve the linear system of equation.
 $x - y = 1$, $x + z = -6$ & $x + y - 2z = 3$

5. ALGEBRA: PROPERTIES OF DETERMINANTS

Learning Objectives



- Understand the properties of determinants with examples.
- Apply them in finding factors.
- Prove the given statement by applying the properties.

Introduction

Determinants have some properties that are useful as they permit us to give the same result with different and simple arrangements.

**ACTIVITY 1****Properties of Determinants**

For any square matrix A , $|A|$ satisfies the following properties:

- i. *If all the elements of a row (or column) are zeros, the value of the determinant is zero.*

$$\text{Let } A = \begin{vmatrix} 1 & 5 & 3 \\ 0 & 0 & 0 \\ -4 & 6 & -9 \end{vmatrix}$$

$$\text{Now, by expanding row wise } A = 1 \begin{vmatrix} 0 & 0 \\ 6 & -9 \end{vmatrix} - 5 \begin{vmatrix} 0 & 0 \\ -4 & -9 \end{vmatrix} + 3 \begin{vmatrix} 0 & 0 \\ -4 & 6 \end{vmatrix} = 0$$

- ii. *If the rows and columns of a determinant are interchanged (transposed), the value of the determinants remains the same. $|A^T| = |A|$.*

$$\begin{vmatrix} 1 & 2 & 3 \\ -5 & 0 & 4 \\ 6 & -2 & 1 \end{vmatrix} = \begin{vmatrix} 1 & -5 & 6 \\ 2 & 0 & -2 \\ 3 & 4 & 1 \end{vmatrix}$$

- iii. *If any two rows or columns are interchanged, the value of the determinant remains the same but takes the opposite sign.*

$|A_1| = -|A_2|$, where A_2 is the determinant formed by interchanging any two rows or columns of A_1 .

Try the following task.

$$\text{If } A_1 = \begin{vmatrix} 2 & 1 & 4 \\ -3 & 0 & 2 \\ 4 & 1 & -2 \end{vmatrix} \text{ and } A_2 = \begin{vmatrix} 2 & 4 & 1 \\ -3 & 2 & 0 \\ 4 & -2 & 1 \end{vmatrix} \text{ (interchanging 2nd and third columns)}$$

verify that $A_1 = -A_2$ by expansion

- iv. *If two rows or columns of a determinant are identical (or proportional), the value of the determinant is zero.*

Note: *Identical* means the corresponding elements are the same. *Proportional* means the corresponding elements are multiplied by the same constant number.

What will be the value of $\begin{vmatrix} 1 & 2 & 5 \\ -5 & 0 & 3 \\ -10 & 0 & 6 \end{vmatrix}$? Can you justify your answer?

- v. *If all the elements in one row (or column) be multiplied by the same constant number k , then the determinant itself is multiplied by that constant number k .*

Corollary: *Multiplying a determinant by a constant number k means multiplying the elements of one row or column by k .*

$$k \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = \begin{vmatrix} ka_1 & b_1 & c_1 \\ ka_2 & b_2 & c_2 \\ ka_3 & b_3 & c_3 \end{vmatrix} = k \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & kb_2 & kc_2 \\ a_3 & b_3 & c_3 \end{vmatrix}$$

- vi. *If elements of a row or a column in a determinant are expressed as the sum or difference of two or more elements, then the given determinant can be expressed as the sum or difference of two or more determinants.*

$$\begin{vmatrix} a_1 \pm d_1 & b_1 & c_1 \\ a_2 \pm d_2 & b_2 & c_2 \\ a_3 \pm d_3 & b_3 & c_3 \end{vmatrix} = \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} \pm \begin{vmatrix} d_1 & b_1 & c_1 \\ d_2 & b_2 & c_2 \\ d_3 & b_3 & c_3 \end{vmatrix}$$

- vii. *To each element of a row or a column, the equimultiples of corresponding elements of other rows or columns are added or subtracted, the value of the determinant remains the same.*

$$\begin{vmatrix} 2 & 1 & 4 \\ -3 & 0 & 2 \\ 4 & 1 & -2 \end{vmatrix} = -14$$

$$\begin{vmatrix} 2 & 5 & 4 \\ -3 & 2 & 2 \\ 4 & -1 & -2 \end{vmatrix}$$

This determinant is formed by changing the elements of C_2 by adding C_3 elements to C_2 . But the value remains the same when we expand. Check your answer.



ACTIVITY 2

Let us try to solve or find the value of determinants given below by using the properties.

- i) Show that by applying the properties and not by expansion.

$$\begin{vmatrix} 1 & 2 & -3 \\ -3 & 2 & 2 \\ -3 & -6 & 9 \end{vmatrix} = 0$$

Solution:

$$\begin{vmatrix} 1 & 2 & -3 \\ -3 & 2 & 2 \\ -3 & -6 & 9 \end{vmatrix} = -3 \begin{vmatrix} 1 & 2 & -3 \\ -3 & 2 & 2 \\ 1 & 2 & -3 \end{vmatrix} \quad (\because -3 \text{ is a common factor in } R_3)$$

$$-3 \times 0 = 0 \quad (\because R_1 \text{ and } R_3 \text{ are identical})$$

ii) Prove that:

$$\begin{vmatrix} 1 & 1 & 1 \\ x & y & z \\ x^2 & y^2 & z^2 \end{vmatrix} = (x-y)(y-z)(z-x)$$

$$\begin{vmatrix} 1 & 1 & 1 \\ x & y & z \\ x^2 & y^2 & z^2 \end{vmatrix}$$

$C_2 \rightarrow C_2 - C_1$ and $C_3 \rightarrow C_3 - C_2$ (using property number vii)

$$\Rightarrow \begin{vmatrix} 1 & 0 & 0 \\ x & -(x-y) & -(y-z) \\ x^2 & -(x^2-y^2) & -(y^2-z^2) \end{vmatrix}$$

as (-) is a common factor in C_2 and C_3 ,

$$\begin{vmatrix} 1 & 0 & 0 \\ x & x-y & y-z \\ x^2 & (x-y)(x+y) & (y-z)(y+z) \end{vmatrix} \quad [\text{since } (x^2 - y^2) = (x-y)(x+y)]$$

$$\Rightarrow (x-y)(y-z) \begin{vmatrix} 1 & 0 & 0 \\ x & 1 & 1 \\ x^2 & x+y & y+z \end{vmatrix} \quad [(x-y) \text{ is a common factor in } C_2 \text{ and } (y-z) \text{ is in } C_3]$$

By expansion

$$(x-y)(y-z) \cdot 1 \begin{vmatrix} 1 & 1 \\ x+y & y+z \end{vmatrix} = (x-y)(y-z)[(y+z)-(x+y)] = (x-y)(y-z)(z-x)$$

Hence proved.



Summary

- If all the elements of a row (or column) are zeros, the value of the determinant is zero.
- If the rows and columns of a determinant are interchanged (transposed), the value of the determinants remains the same. $|A^T| = |A|$.
- If any two rows or columns are interchanged, the value of the determinant remains the same but takes the opposite sign.
- $|A_1| = -|A_2|$, where A_2 is the determinant formed by interchanging any two rows or columns of A_1 .
- If two rows or columns of a determinant are identical (or proportional), the value of the determinant is zero.

- If all the elements in one row (or column) be multiplied by the same constant number k , then the determinant itself is multiplied by that constant number k .
- If elements of a row or a column in a determinant are expressed as the sum or difference of two or more elements, then the given determinant can be expressed as the sum or difference of two or more determinants.
- To each element of a row or column, the equimultiples of corresponding elements of other rows or columns are added or subtracted, the value of the determinant remains the same.



Self-check for Learning

Instruction: Using the properties, prove that:

$$i) \begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ b+c & c+a & a+b \end{vmatrix} = 0$$

$$ii) \begin{vmatrix} x & y & z \\ x^2 & y^2 & z^2 \\ x^3 & y^3 & z^3 \end{vmatrix} = xyz(x-y)(y-z)(z-x)$$

$$iii) \begin{vmatrix} x+k & x & x \\ x & x+k & x \\ x & x & x+k \end{vmatrix} = k^2(3x+k)$$

SCIENCE STREAM

1. BIOLOGY

1.1. PHOTOSYNTHESIS

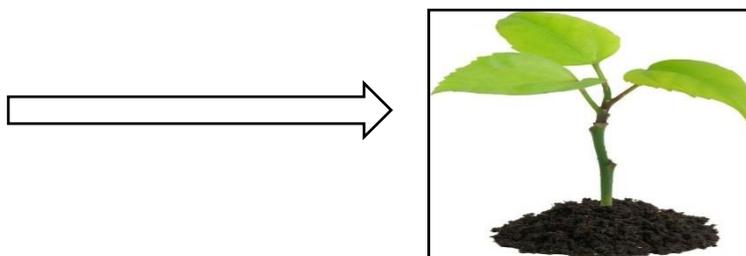
Learning Objectives



- Explain photosynthesis as energy transfer process.
- Describe the structure of chloroplast.
- Relate two phases of photosynthesis.
- Explain the rate of photosynthesis in relation to law of limiting factor.

Introduction

Can we synthesise the food that we eat? NO! Right! Then which organism can synthesise their food?



Plants!

There are some photosynthetic microorganisms as well which can prepare their food. In this lesson, you will learn about the synthesis of food by plants through a process known as PHOTOSYNTHESIS.

What is photosynthesis?

It is a process of synthesis of carbohydrates (glucose) from CO_2 and H_2O by the green plants using sunlight absorbed by chlorophyll.

Where does photosynthesis occur?

Chloroplasts are the site for photosynthesis. They are present in green parts of the plants like leaves, stem, sepal, etc. Let us now look into the structure of chloroplast (As you read through each point refer to the diagram).

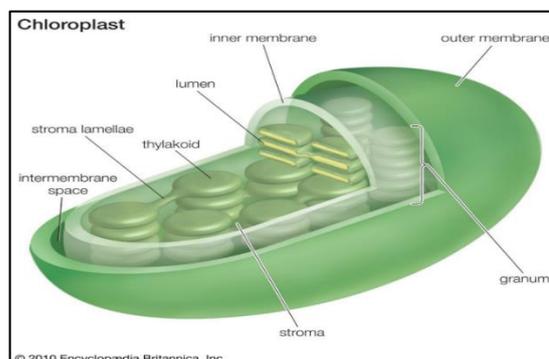
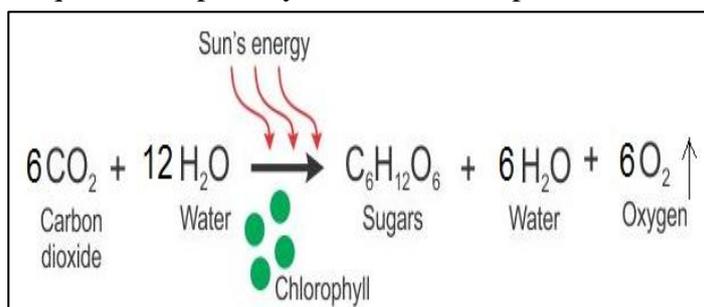


Figure: Ultra Structure of Chloroplast

- Each chloroplast is bounded by a double membrane envelope.
- The double membrane encloses inside a proteinaceous matrix called the **stroma**.
- Embedded in the stroma is an elaborated system of membranous lamellae. Lamellae are stacked one over another which is known as Grana. These Grana are interconnected by stroma lamellae. Each granum is composed of a disc-like structure called thylakoids.

Mechanism of Photosynthesis

An overall chemical equation for photosynthesis can be represented as follow:



The overall process of photosynthesis is not as simple as it appears from the above equation. Photosynthesis involves two distinct phases:

1. Light-dependent reaction (Hill reaction or photophosphorylation)
2. Light-independent reaction (dark reaction or biosynthetic phase)

Light-dependent Reaction (Hill reaction or photophosphorylation)

- This phase occurs in the thylakoid membrane of the chloroplast.
- Light is necessary for this reaction to occur.
- It consists of four stages (Light absorption, water splitting, the release of oxygen and formation of ATP and NADPH).
- This phase is associated with the absorption of light rays by the pigments of two photosystems, i.e., Photosystem I (P₇₀₀) and Photosystem II (P₆₈₀).

***Note:** Photosystem are light harvesting complex made up of chlorophyll molecules and are located in thylakoid membrane. They are named as P₇₀₀ and P₆₈₀ respectively depending upon the wavelength of light they absorb. Photosystem I (P₇₀₀) absorbs light of wavelength 700nm and Photosystem II absorbs light of shorter wavelength i.e., 680nm.*

Non-Cyclic Photophosphorylation

Refer to the diagram below every time you read a point. Every point is marked in the diagram for your understanding.

- i. Photosystem II (P₆₈₀) absorbs light at 680 nm and lower wave-length and becomes activated.
- ii. Its electrons become energised and a pair of electrons move out of reaction centre to higher energy level, making PS II positively charged.
- iii. The electrons lost from PS II is replaced by Photolysis of water and PS II comes to a normal state. During photolysis of water, oxygen is released as by product.

- iv. The electrons lost from the PS II are accepted by Primary electron Acceptor.
- v. The electrons are then transferred through Electron Transport Chain (are series of electron carrier compound in thylakoid membrane) to PS I (P₇₀₀).
- vi. When electrons travel down the Electron Transport Chain (ETC), the electrons lose energy which is used in the synthesis of ATP from ADP.
- vii. PS I on receiving lights of longer wavelength raise its electron to higher energy level.
- viii. The energised electron is received by Ferredoxin.
- ix. From Ferredoxin the electrons go down to NADP, which also receives 2H⁺ ions produced from photolysis of water and is reduced to NADPH.
- x. The net product from the light reaction is **ATP, NADPH** and **oxygen**.
- xi. In this phase there is a synthesis of energy (ATP) in the chloroplast in presences of light, hence it is also called as **photophosphorylation**.
- xii. In this phase, electrons lost from PS II is used by PS I and is not returned to them, hence it is also known as **non-cyclic photophosphorylation**.
- xiii. In **non-cyclic photophosphorylation**, it involves both PS I and PS II. Whereas cyclic photophosphorylation involves only PS I. The electron released from it returns after passing through a series of electron transport chain.

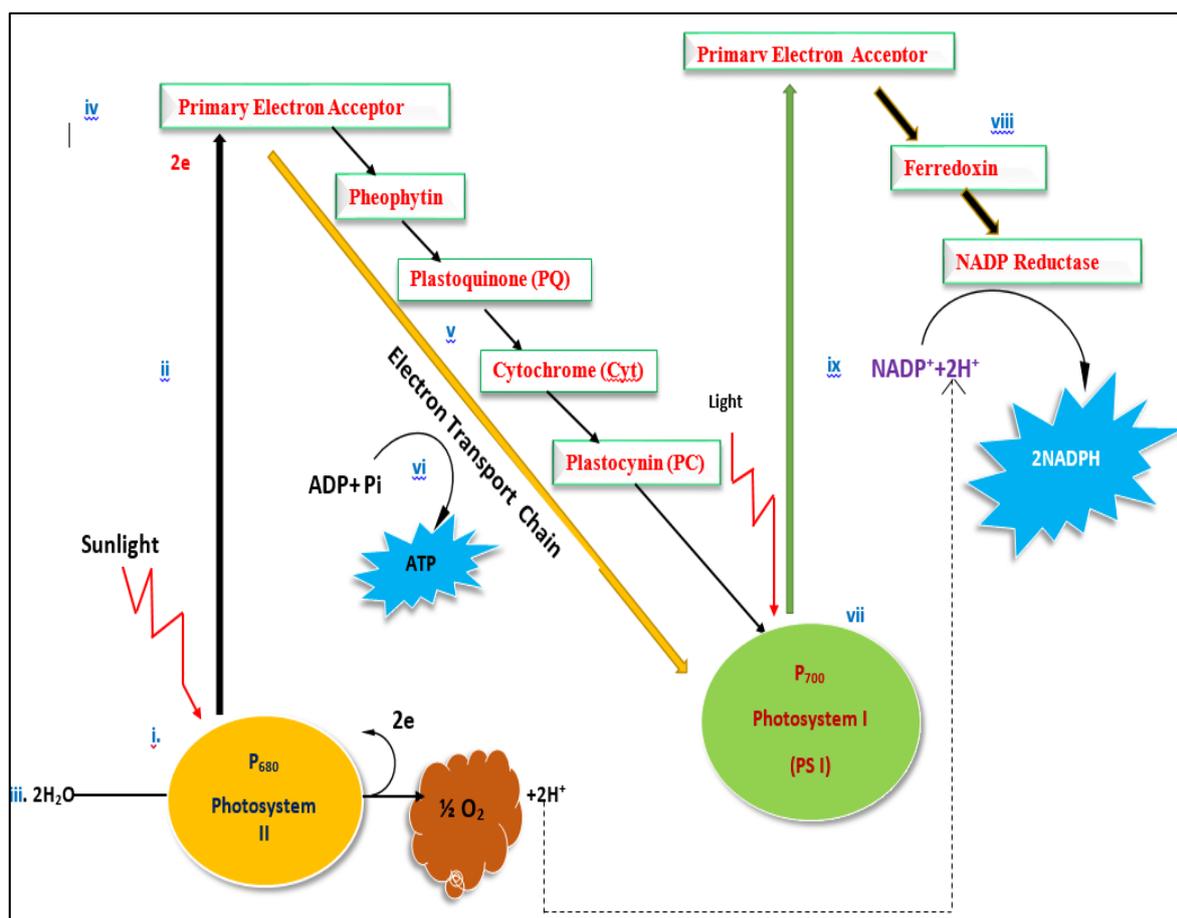


Figure: Non-cyclic Photophosphorylation



ACTIVITY 1

1. Where does light reaction occur in chloroplast?
2. What are the products of light reaction?
3. How is light reaction connected to dark reaction?

Cyclic Photophosphorylation

In this only Photosystem I functions, and Photosystem II becomes inactive.

- When lights of only longer wavelengths are available, only PS I gets activated.
- The activated PS I, releases a pair of electrons from the reaction centre, creating an electron-hole in the reaction centre P₇₀₀.
- The released pair of electron is accepted by primary electron carrier, which then passes through a chain of electron carrier, ferredoxin(fd), plastoquinone (PQ), Cytochrome complex, Plastocyanin (PC) and finally back to chlorophyll P₇₀₀ of PSI, thus filling the electron holes.
- At each step of electron transfer, the electrons lose potential energy which is used in the synthesis of ATP.
- In this, the electrons lost from the reaction centre return back to the reaction centre, it is termed as **cyclic photophosphorylation**.
- In cyclic photophosphorylation, only ATP is formed.

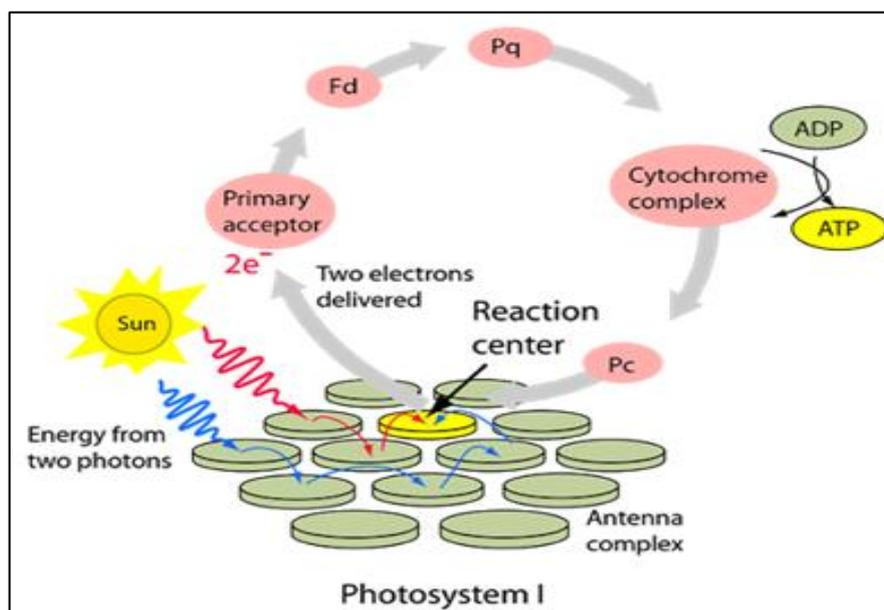


Figure: Cyclic Photophosphorylation

Light-independent Reaction (Dark reaction or biosynthetic phase)

- This phase is independent of light, i.e., without using light energy and may occur in light or dark at night.
- It occurs in the stroma of a chloroplast.

- This phase utilises ATP and NADPH for fixing and reducing carbon dioxide to form carbohydrate (glucose).
- In different plants, the process of dark reaction or CO₂ fixation occurs differently. However, most of the plants fix CO₂ through the Calvin cycle or Calvin- Benson Cycle or C₃ cycle.

Calvin Cycle or Calvin- Benson Cycle or C₃ Cycle

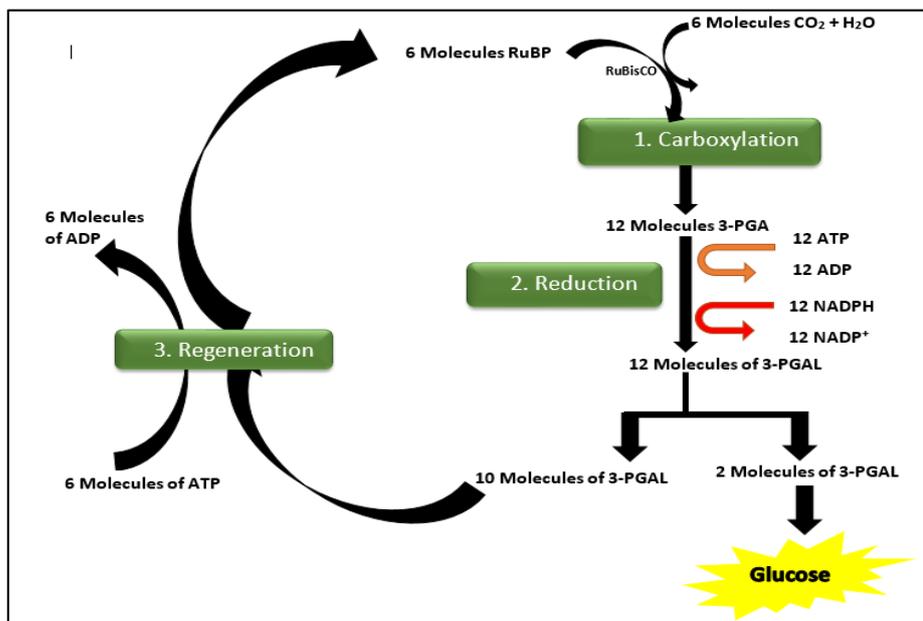


Figure: Calvin Cycle

In the Calvin cycle, the first stable product of CO₂ fixation is a 3 carbon compound, phosphoglyceric acid or 3-phosphoglycerate. Therefore, this cycle of carbon fixation is known as or C₃ cycle and plants performing such cycle as C₃ plants.

Each Calvin cycle is completed in three phases:

i. Carboxylation Phase

Addition of CO₂ to a compound is known as carboxylation. In this phase, 6 molecules of 5-carbon compound, Ribulose 1, 5-biphosphate (RUBP) undergoes carboxylation by 6 molecules of carbon dioxide to form 12 molecules of 3-phosphoglycerate (3-PGA). This reaction is catalysed by Ribulose 1,5-biphosphate carboxylase oxygenase or RuBisCO enzyme.

ii. Reduction Phase

12 molecules of 3-PGA are further phosphorylated by 12 molecules of ATP and then reduced by 12 molecules of NADPH to 12 molecules of 3-phosphoglyceraldehyde (3PGAL). Out of 12 molecules of 3-PGAL 2 molecules of 3PGAL is reduced to glucose.

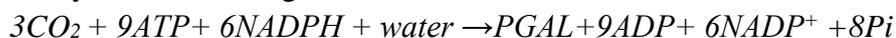
iii. Regeneration Phase

Remaining 10 molecules of 3-PGAL utilises 6 more molecules of ATP to regenerate Ribulose 1, 5-biphosphate (RUBP) for continuity of the cycle.



ACTIVITY 2

1. Analyse the reaction given below.

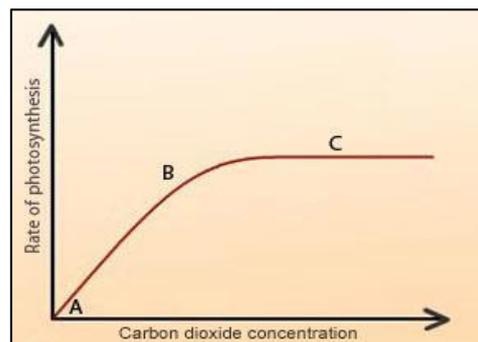


2. What is the role of 3-PGAL in the Calvin cycle?

Factors Affecting the Rate of Photosynthesis

1. Carbon Dioxide Concentration

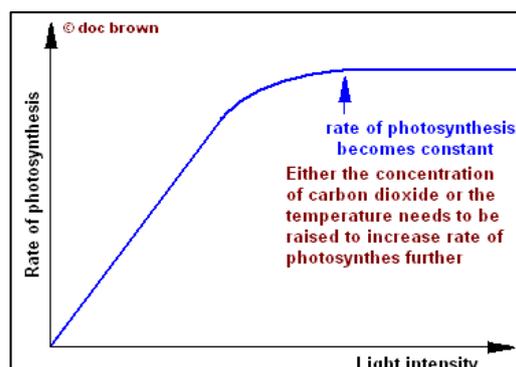
Increase in carbon dioxide concentration increases CO_2 fixation hence increases the rate of photosynthesis to the optimum level. The higher concentration of CO_2 beyond the optimum level could be damaging to the plants.



2. Light Intensity

The light between wavelength of 400nm and 700nm is the most effective for photosynthesis and these lights are called **photosynthetically active radiations**.

Under low light intensity rate of photosynthesis is low. As the intensity of light increases, the rate of photosynthesis increases. But at a high light intensity, the rate of photosynthesis decreases because other factors become limiting or chlorophyll molecules get destroyed at high light intensity called **Photo-oxidation**.



3. Temperature

In the presence of plenty of light and carbon dioxide, photosynthesis increases with the rise in temperature until it becomes maximum. Thereafter, there is a fall in the rate of photosynthesis because other factors become limiting.

Law of Limiting Factor

It states that when a process is controlled by several factors, the rate of the process is controlled by the rate of limiting factor.

For example, let us take photosynthesis as a process. Rate of Photosynthesis is controlled by several factors, like carbon dioxide concentration, light intensity and temperature.

The rate of photosynthesis will be maximum if all the factors are present in optimum concentration. If one of the factors is less in amount then that factor will lower the rate of photosynthesis.



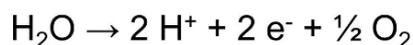
Summary

- Photosynthesis is the route by which virtually all energy enters the ecosystem.
- A chloroplast is the site of photosynthesis.
- Photosynthesis involves two distinct phases; light-dependent and light-independent reaction.
- The light-dependent occurs in the thylakoid membrane of chloroplast and light-independent occurs in the stroma of a chloroplast.
- The end products of the light reaction are ATP, NADPH and oxygen.
- In different plants, the process of dark reaction or CO₂ fixation occurs differently. However, most of the plants fix CO₂ through the Calvin cycle.
- Law of limiting factor states that when a process is controlled by several factors, the rate of the process is controlled by the rate of limiting factor.

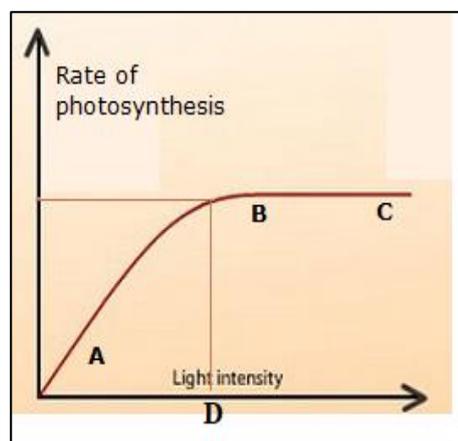


Self-check for Learning

- i. Based on the equation given below, answer the following questions:



- (a) Where does this reaction take place in plants?
 (b) What is the significance of this reaction?
- ii. What is the role of 3-PGAL in the Calvin cycle?
- iii. The figure given below shows the effect of light on the rate of photosynthesis. Study the graph and answer the following questions
- (a) At which point (A, B or C) in the graph is the light a limiting factor?
 (b) What could be the limiting factor at point C?
 (c) What does D represent on the curve?
- iv. What would be your life on the earth without chlorophyll? Explain.
- v. How are plants responsible for reducing global warming? Explain from the point of photosynthesis.



1.2. DNA FINGER PRINTING

Learning Objectives



- Explain the principle behind DNA fingerprinting.
- Describe the procedure involved in DNA fingerprinting.
- State practical applications of DNA fingerprinting.

Introduction

IMAGINE!

You are a special crime investigator and you are assigned a *Burglary Case*. At the crime scene, you found a bloodstain and no other evidence. You are assigned to find out the culprit amongst the three suspects:



Suspect 1



Suspect 2



Suspect 3

Figure: Suspects of the Crime

Who could be the culprit?

How will you find out the culprit?

Every organism is unique. Like a fingerprint, each person has a unique DNA fingerprint. This may help you to solve the murder case.

What is DNA fingerprinting or DNA profiling?

It is the method of identifying DNAs of a different person by locating the differences in the arrangement of nucleotides in the specific regions of the DNA sequence which are repeated several times (i.e., repetitive DNA).

The technique of DNA Fingerprinting was devised by Alec Jeffrey.

Principle of DNA Fingerprinting

Every cell in our body contains DNA. About 99.9% of DNA between two individual is the same. Remaining 0.1% shows differences in the arrangement of nucleotides. This makes every human genetically unique.

This 0.1% of DNA base pair sequence keeps repeating many times within a genome (the haploid set of chromosomes in each cell of a multicellular organism), and we call it as a repetitive DNA. Repetitive DNA is normally found in Satellite DNA.

For example, look into the DNA of two individuals given in Figure below, in both the individuals the repeating sequence of base pair is AGTCGGTAAG, but its number of repetition in both the individual is different. It is repeated 6 times in individual 1 and 8 times in Individual 2.

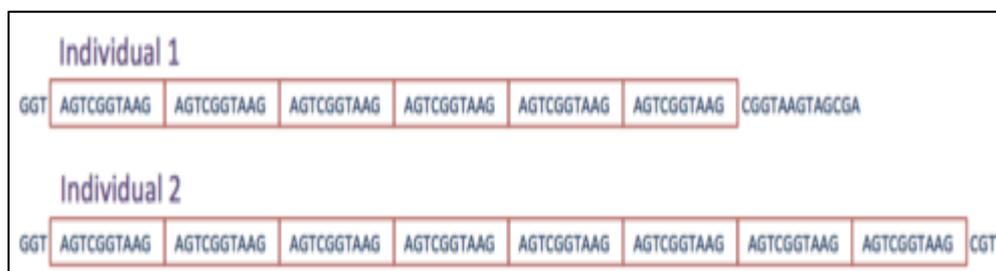


Figure: Repeating Sequence of Base Pair in Two Individuals

Similarly, this kind of repetition of base pair in DNA is different in all the individuals. This makes us genetically different from each other.

Depending on the size of the repeats, the repeated regions are classified into two categories namely Short Tandem Repeat and Variable Number of Tandem Repeat. **Short Tandem Repeat (STR)** consists of 2- 6 base pair sequence which is repeated several number of times. The **Variable Number of Tandem Repeat (VNTR)** consists of base-pair sequence more than STR and repeats a variable number of times (more repeats than STR). The variation in the sequence of base-pair and number of repeats make every individual unique.

DNA fingerprinting involves in identifying differences in the repetitive DNA sequence. As a result, every individual has a distinct composition of VNTRs, and this is the main principle of DNA fingerprinting

Procedure of DNA Fingerprinting

- In DNA fingerprinting, Single-stranded radio labelled VNTRs are used as probes.
- A probe is a small piece of radioactive DNA. It determines which DNA fragment can be seen at the end of the experiment.
- The DNA to be profiled is separated and then hybridized with the probe to identify similarities and differences. DNA for profiling is isolated from WBCs of blood, semen, vaginal swabs, skin cells and cells from root hairs, etc.
- DNA profiling involves the following steps:
 - i. Isolation of DNA by high-speed ultracentrifugation.

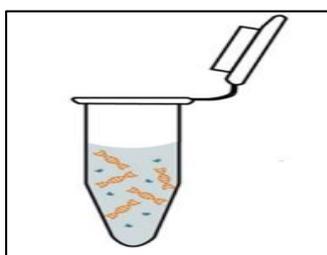


Figure: Centrifuge for the Separation of DNA

- ii. DNA amplification by polymerase chain reaction (PCR) in case the sample of extracted DNA is small.
- iii. Fragmentation of amplified DNA into segments of variable length by digesting with restriction endonuclease enzymes.

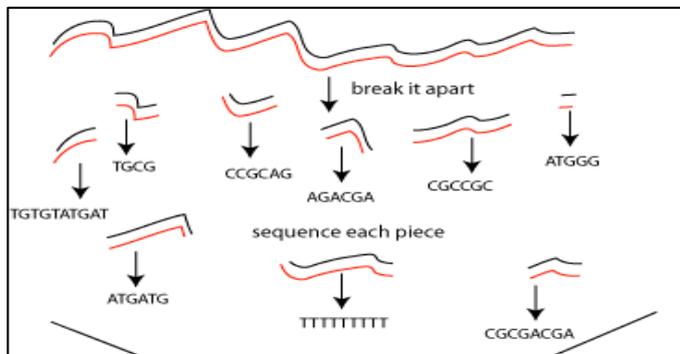


Figure: Fragmentation of DNA

- iv. Separation of DNA fragments by electrophoresis over agarose gel.

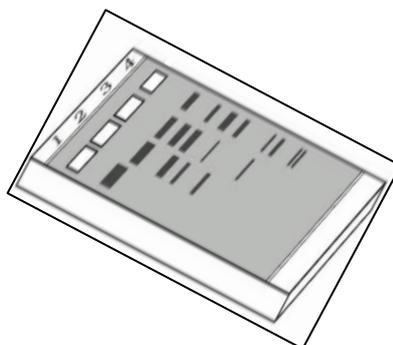


Figure: Electrophoresis

- v. Denaturation of DNA fragments by alkali treatment. Alkali is added into the gel electrophoresis to separate the double-stranded DNA fragments into single strands.
- vi. Transfer of single-stranded DNA fragments from the gel onto a synthetic membrane, such as nitrocellulose or nylon.

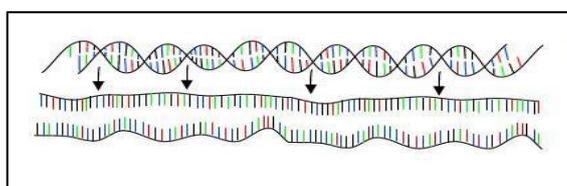
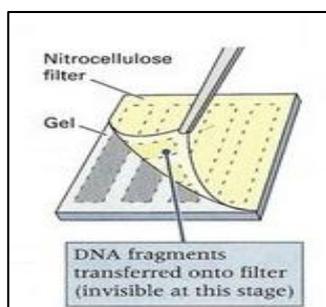


Figure: Transfer of Single-Stranded DNA Fragments onto a Membrane

- vii. Fixation of separated DNA fragments to the membrane by exposing to UV light.
- viii. Hybridization of a single-stranded DNA with radiolabeled VNTR probes.

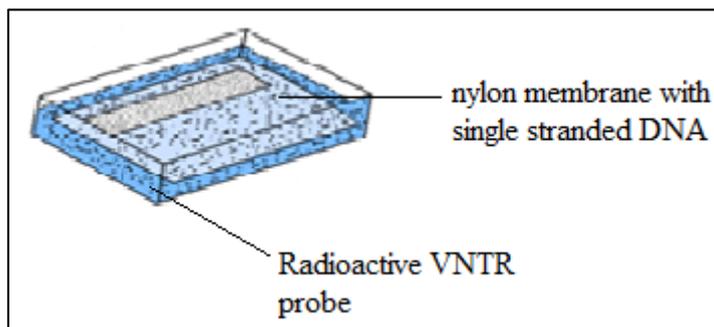


Figure: Hybridization of Single-Stranded DNA

- ix. Exposure of membrane containing hybrids of radioactive DNA probes and VNTR to X-rays so that the hybridized radioactive VNTRs appear as dark bands.

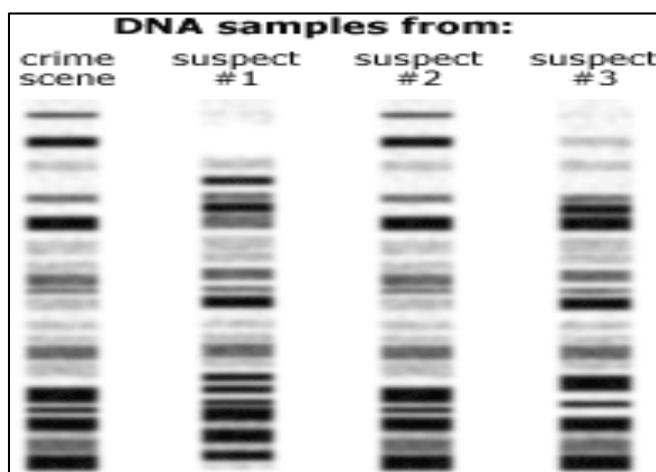


Figure: Autoradiogram

- x. This film provides a DNA profile and is called autoradiogram. Now these bands when **compared with the other known samples**, will give the final result of the DNA fingerprinting.



ACTIVITY 1

1. Now that you have learnt about DNA fingerprinting, compare the DNA fingerprints (autoradiogram) of the blood sample obtained from the crime scene with that of the suspects given in Figure on Autoradiogram and identify the main criminal.

Application of DNA Fingerprinting

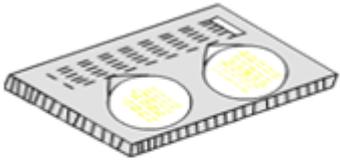
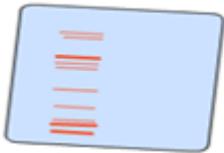
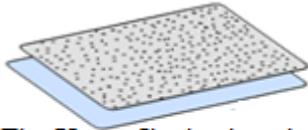
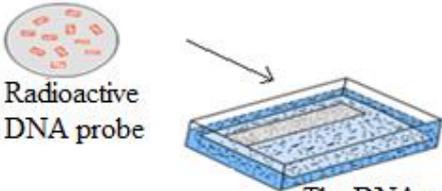
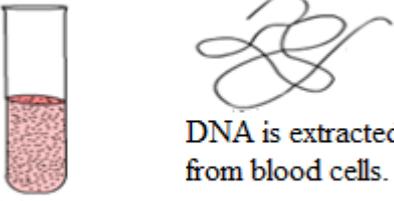
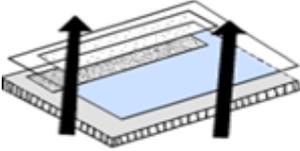
1. It enables identification of criminals or potential suspects whose DNA may match evidence left at the crime scene.
2. It helps in exonerating persons wrongly accused of crimes.
3. It is used to infer the blood relationship in the members of the same family (kinship analysis).

4. It is used in determining whether a particular male is the father of a given child or not (Paternity dispute).
5. It is used in parentage determination.
6. Studying genetic ancestry of the human population.
7. Identify the gender and identity of a deceased person.
8. Studying endangered species in conservation biology.



ACTIVITY 2

Instruction: Arrange the diagram below in sequence to complete the DNA fingerprinting process.

 <p>The DNA fragments are separated by electrophoresis over agarose gel.</p> <p style="text-align: center;">1</p>	 <p>DNAs are cut into fragments using restriction enzyme.</p> <p style="text-align: center;">2</p>
 <p>The X-ray film is developed to make visible the pattern of bands which is known as a DNA fingerprint.</p> <p style="text-align: center;">3</p>	 <p>The X-ray film is placed next to membrane to detect radioactive pattern.</p> <p style="text-align: center;">4</p>
 <p>Radioactive DNA probe</p> <p>The DNA probe binds to a specific DNA sequences on the membrane.</p> <p style="text-align: center;">5</p>	 <p>Blood sample</p> <p>DNA is extracted from blood cells.</p> <p style="text-align: center;">6</p>
<p style="text-align: left;">7</p>  <p>The DNA band pattern in the gel is transferred on a nylon membrane by southern blotting technique.</p>	



Summary

- DNA fingerprinting is the method of identifying DNAs of a different person by locating the differences in the arrangement of nucleotide in the specific regions of DNA sequence.
- 0.1% of DNA sequence keeps repeating many times within a genome and we call it as a repetitive DNA.
- DNA fingerprinting involves identifying differences in the repetitive DNA sequence.
- DNA profiling is used in identifying the criminal, infer the blood relationship in the members of the family and even determining the father of a given child.



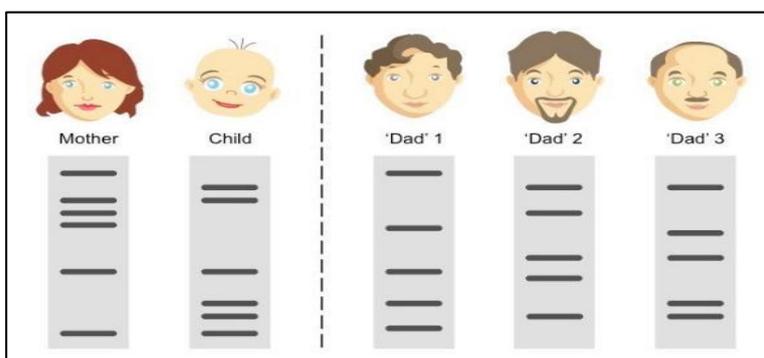
Self-check for Learning

Answer the following questions in your notebook.

1. Choose the most appropriate answer.
 - i. In DNA profiling, polymerase chain reaction;
 - A. cuts STRs with restriction endonuclease enzyme,
 - B. amplifies DNA,
 - C. draws DNA fragments to positive poles, or
 - D. denatures DNA fragments.

- ii. Which man is the actual father of the child? (Source:

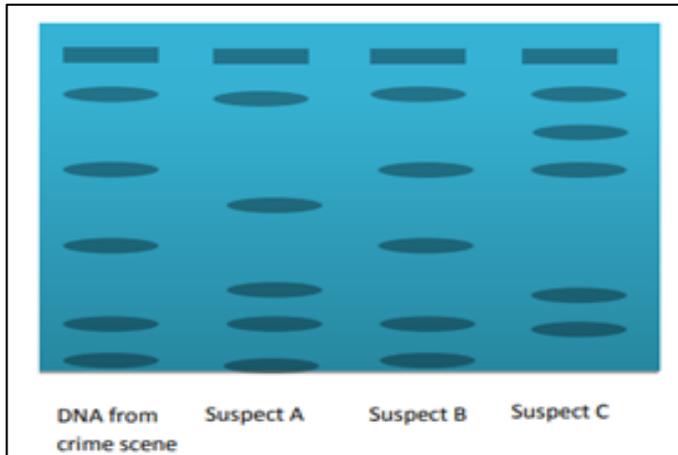
<https://quizizz.com/admin/quiz/5bd30a2d7b2852001bb87178/dna-fingerprinting>)



- A. Dad 1
 - B. Dad 2
 - C. Dad 3
 - D. None
- iii. Bloodstains are found at the site of a murder. If the DNA Profiling technique is to be used for identifying the criminal, which of the following is ideal for use?
 - A. Serum
 - B. Erythrocytes
 - C. Leucocytes
 - D. Platelets.

2. Answer the following questions.

- a. What is the significance of VNTR probes in DNA fingerprinting?
- b. The result of DNA fingerprint carried out on a DNA sample found at a burglary is shown below. Explain which suspect is most likely to have committed the crime.



(Source: <https://mathsmadeeasy.co.uk/wp-content/uploads/2017/10/DNA-Fingerprinting-Questions-AQA-OCR.pdf>)

- c. DNA is obtained from a small sample of blood from an individual. What must happen to this sample before electrophoresis can be carried out?
- d. Can identical twins have the same DNA fingerprints? Justify.

1.3. DNA REPLICATION

Learning Objectives



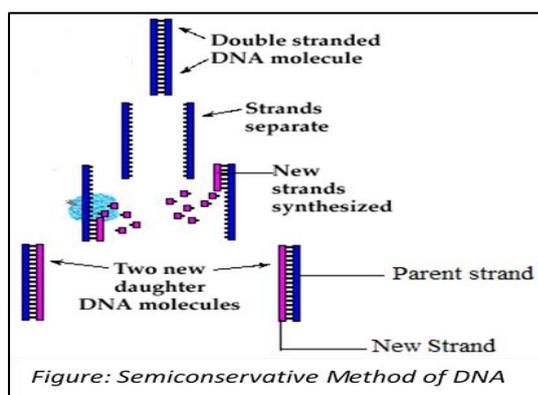
- Explain the semiconservative replication of DNA.
- Describe the process of DNA replication.
- Differentiate between leading and lagging strand of DNA.

Introduction

DNA forms the molecular basis of heredity and is responsible for storing and transferring information about hereditary characters.

Every time a cell divides, it needs to carry out DNA replication prior to cell division. DNA replication takes place during S-phase of the cell cycle.

Semiconservative Method of Replication



During DNA replication, the two strands of DNA separate and each strand serves as a template on which a new complementary strand is synthesised.

In the diagram on the left, each daughter DNA molecule formed is a hybrid, conserving one parental strand and synthesising the other one. This method of DNA replication is described as a **semiconservative method**.

Enzyme Required in DNA Replication

About 20 or more different proteins are required during DNA replication. These enzymes are collectively called **DNA replicase system or replisomes**.

These enzymes are:

- DNA polymerase I*: For proofreading. It identifies and replaces wrong base pairs with correct nitrogenous base pairs.
- DNA polymerase III*: facilitate the polymerisation of a new DNA chain.
- Helicase*: Unwinds the two strands of DNA.
- Single strand binding proteins (SSB)*: stabilise the single-stranded DNA.
- Topoisomerase*: release tension developed on DNA strand due to unwinding.
- DNA Ligase*: Joins the fragments of DNA.
- Exonuclease*: removes RNA primer and replace with DNA nucleotides.

You will understand the functions of each enzyme as you read through the process of DNA replication.

Process of Replication of DNA

DNA replication involves a number of steps. Each step is governed by a specific enzyme.

- i. The deoxyribonucleotide monophosphate (dAMP, dGMP, dCMP, dTMP) which occur in nucleoplasm (cytoplasm of nucleus), are activated into triphosphates (dATP, dGTP, dCTP, dTTP) by uniting with ATP. This process is called **phosphorylation**.
- ii. DNA replication is initiated at a definite sequence of nucleotides, called initiation point or origin of replication (Ori C).
- iii. Specific **initiator protein DnaA** recognises the initiation point and binds to it.
- iv. **Initiator protein DnaA** denatures the two DNA strands.

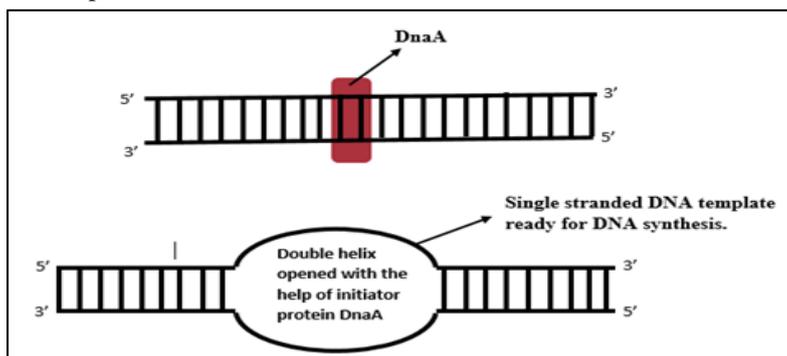


Figure: Denaturing of DNA by DnaA Protein.

- v. Two **helicase** enzymes bind to each strand of *denatured* DNA and unwind the DNA creating two potential replication forks. Single-stranded binding proteins (SSB proteins) binds to the Single-stranded DNA to stabilize them.

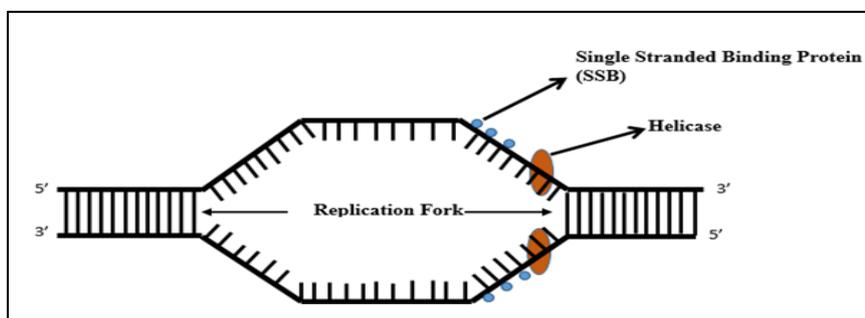


Figure: Showing Binding of Helicase Enzyme to Unwind DNA and Formation of Replication Fork.

- vi. As DNA strands unwind it creates tension on the two ends of strands. This tension is released by the **topoisomerase** enzyme. In bacteria, **topoisomerase** is called **DNA gyrase**.

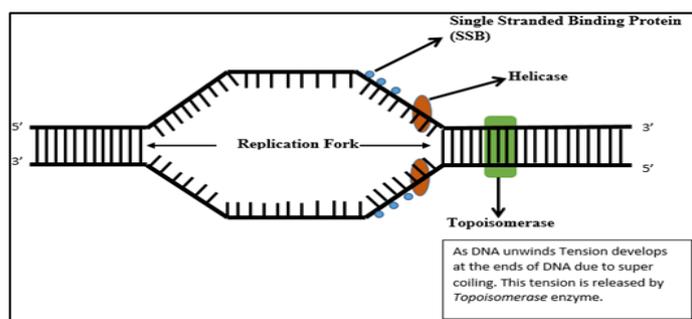


Figure: Showing the Function of Topoisomerase Enzyme

- vii. Before the synthesis of new complementary strands, a short sequence of RNA called **RNA primer** is synthesised on the DNA template using RNA polymerase (primase) enzyme. RNA primer is synthesised on the DNA template because the enzyme **DNA polymerase** cannot initiate synthesis of new DNA strand but it can only polymerase growth of DNA chain on RNA primer.

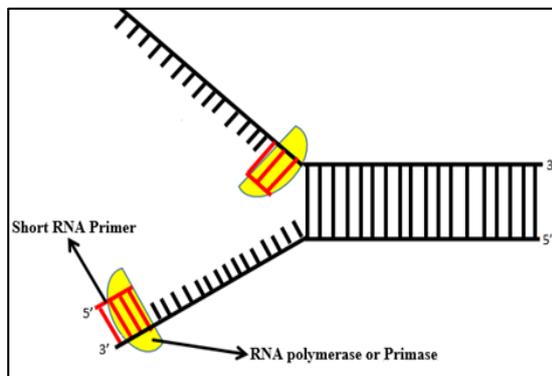


Figure: Synthesis of RNA Primer

- viii. Deoxyribonucleotide triphosphate (dATP, dGTP, dCTP, dTTP) pairs with appropriate nitrogenous bases on DNA template strand according to base pair rule, i.e., A=T and G=C.
- ix. The new strands of DNA are formed in 5' → 3' direction on 3' → 5' template.

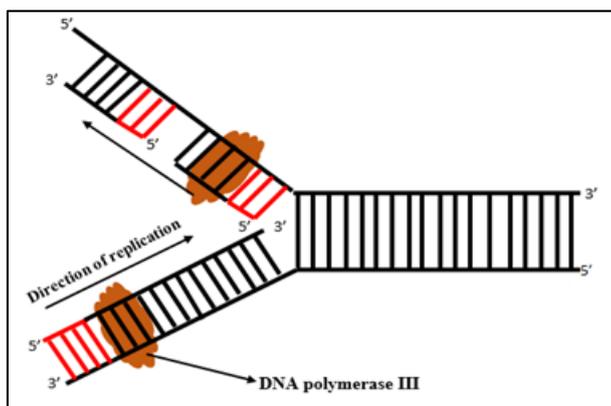


Figure: Action of DNA Polymerase III

- x. The new DNA strand synthesised using 3' → 5' template strand (parent strand) is synthesised continuously in 5' → 3' direction as one piece and is known as a leading strand.

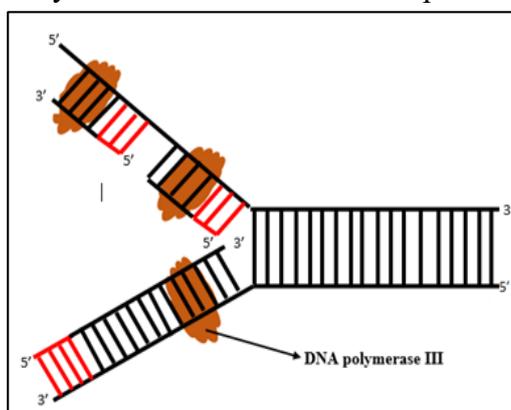


Figure: Leading Strand of DNA

- xi. Whereas the new DNA strand synthesised using 5' → 3' template strand is also synthesised in 5' → 3' direction, but it occurs differently. The new DNA strand on 5' → 3' parent strand is synthesised in short segments known as **Okazaki fragments** (discovered by Reiji Okazaki). Since the replication occurs discontinuously on 5' → 3' template strand hence it's known as lagging strand.
- xii. Synthesis of each Okazaki fragment begins with RNA primer and the polymerisation of the DNA strand is carried out by *DNA polymerase III* enzyme.

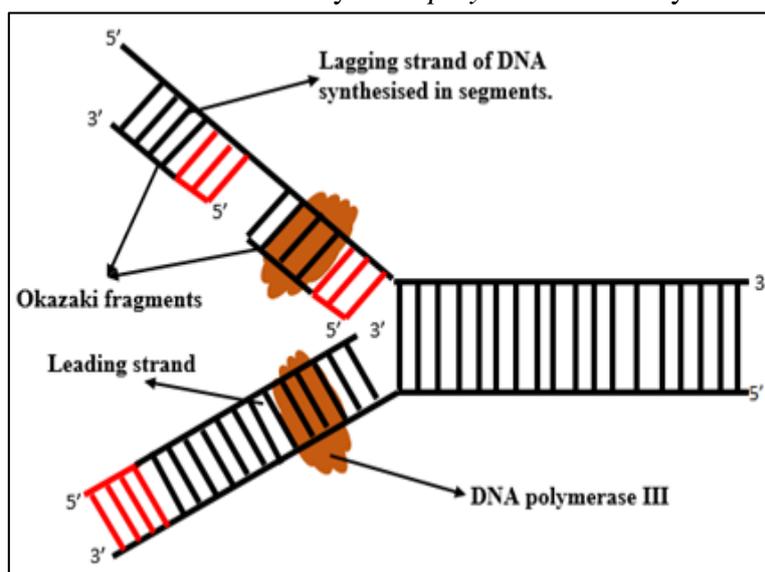


Figure: Showing Okazaki Fragments and Lagging Strand of DNA

- xiii. Once the DNA replication is completed, the RNA primers are removed by the action of *exonuclease* enzyme and replaced with DNA nucleotides.

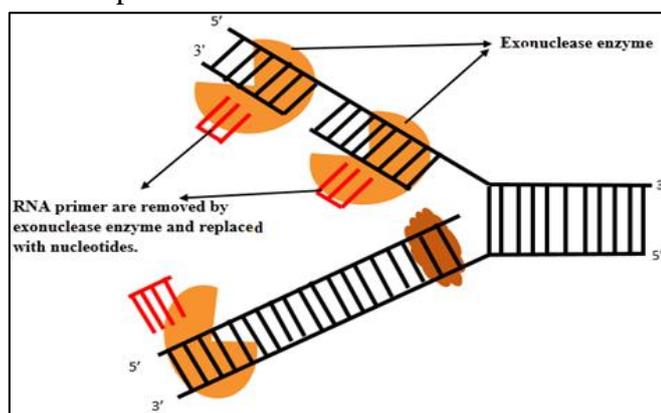


Figure: Showing the Activity of Exonuclease Enzyme

- xiv. The gaps between the Okazaki fragments are filled with complementary bases by *DNA polymerase I*. Finally the Okazaki fragments are joined by *DNA ligase*.

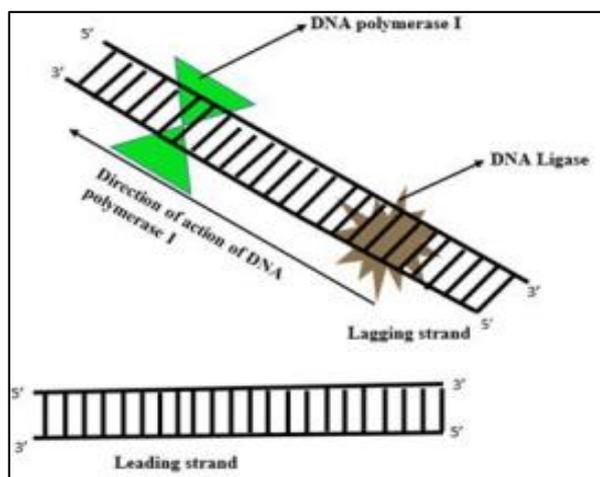


Figure: Showing the Activity of DNA Polymerase I and DNA Gyrase

- xv. The specificity of base pairing ensures accurate replication. But, sometimes, wrong bases do enter the new chain during synthesis. *DNA polymerase I* enzymes identifies and replaces these forbidden base pairs with correct nitrogenous base pairs. This is called proofreading.



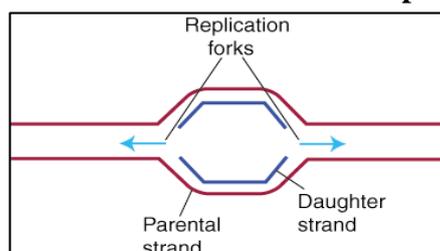
ACTIVITY 1

1. Where and how are Okazaki fragments formed?
2. How are errors that occur during DNA replication repaired?
3. Why is DNA replication in $3' \rightarrow 5'$ template discontinuous?
4. What is the significance of *helicase*, *topoisomerase* and single-stranded-DNA-binding proteins during DNA replication?
5. How is the torque (tension) generated by the unwinding of DNA strands relieved?

Unidirectional and Bidirectional DNA Replication

DNA replication in DNA starts at one point and proceeds in one direction. This is called **unidirectional DNA replication**.

However, in eukaryotes and many prokaryotes, DNA replication occurs in both directions from the origin of replication. Therefore, in the two replication forks are formed at each origin of replication. This is called **bidirectional replication**.



Why is DNA synthesized only in $5' \rightarrow 3'$ direction?



Summary

- DNA replication is a semiconservative method.
- DNA replication requires around 20 different enzymes which are collectively called **DNA replicase system or replisome**.
- DNA replication begins at the initiation point recognised by DnaA protein.
- DNA is synthesised in $5' \rightarrow 3'$ direction.
- DNA synthesised in $5' \rightarrow 3'$ direction using $3' \rightarrow 5'$ template strand is synthesised continuously and is called the leading strand.
- New DNA strand synthesised using $5' \rightarrow 3'$ template strand is synthesised in segments called Okazaki fragments, and is called lagging strand.
- In eukaryotes, two replications are formed at each origin of replication and replication occurs in both directions. This is called bidirectional replication.



Self-check for Learning

Instruction: Review the lesson to check your understanding of the topic by answering the following questions.

2. Explain the semiconservative method of DNA replication.
3. Where and how are Okazaki fragments formed?
4. How are errors that occur during DNA replication repaired?
5. Why is DNA replication in $3' \rightarrow 5'$ template discontinuous?
6. What is the significance of helicase, topoisomerase and single-stranded-DNA-binding proteins during DNA replication?
7. How is the torque (tension) generated by the unwinding of DNA strands relieved?

1.4. EVOLUTION

Learning Objectives



- Describe different theories of evolution.
- Relate the theories to the evolution of different species.

Look at the picture given below. What do you see?

Introduction

Some billions of years ago we were some ape-like creature. Can you believe that we have evolved from an-ape like ancestor? How do you think we evolve from an-ape like ancestor? We have evolved through a gradual process of change over a long period of time.

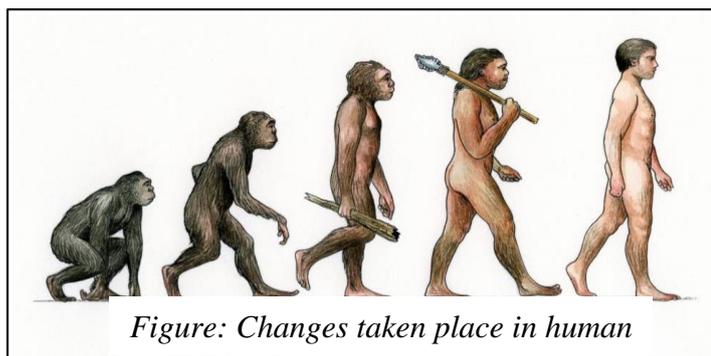


Figure: Changes taken place in human

This process of gradual changes in an organism to form more and more complex, organised and efficient forms over a long period of time is called **Organic evolution** or **Biological evolution**.

Various theories regarding the Mechanism of evolution have been postulated by different evolutionists.

1. Lamarck's Theory of Inheritance of Acquired Characters (Lamarckism)

- This theory was put forward by a French biologist Jean Baptiste de Lamarck.
- This theory states that the changes in the structure or function of any organ, acquired by an individual during its lifetime in response to change in the environment, are inherited by offspring and keep on adding over a period of time. This changes led to the origin of new species.

Example: Evolution of Long-neck in Giraffe.

- According to Lamarck, Giraffes have evolved from some deer-like ancestor who had short neck and forelimbs and grazed on grass.
- As the climate changed, the area became dry, grassland became desert and vegetation was replaced with few high trees. The leaves of these high trees were the only food available to the ancestors of Giraffe.
- For obtaining food from tall trees, they had to continuously stretch their neck and forelegs.
- The continuous stretching of neck to reach the tree leaves resulted in gradual elongation of the neck and forelimbs.

- e. The change in the neck was then transmitted to the member of the next generation, in which further elongation occurred due to similar effort. This in due course of time resulted in the present day long neck Giraffe.

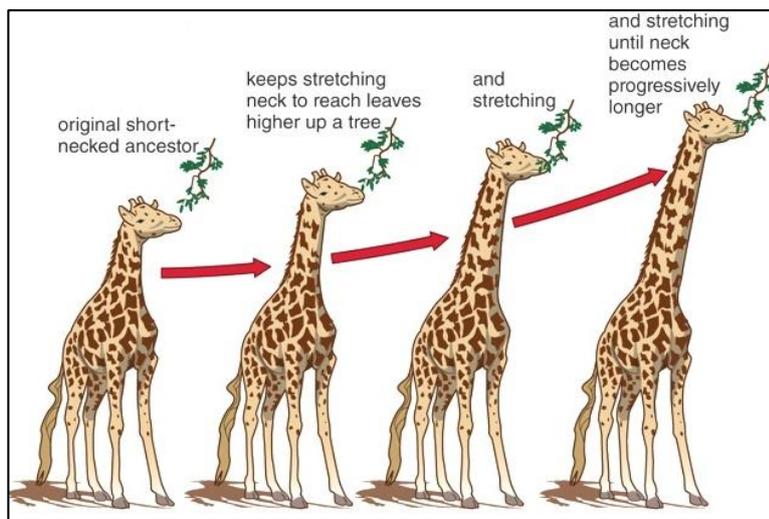


Figure: Evolution of Longneck in Giraffe According to Lamarck

(Source: <https://connect.collins.co.uk>)



ACTIVITY 1

If Lamarck Theory of evolution were to be true, then how would you explain the evolution of modern day snake presuming that the ancestor of snakes to be some short-limbed lizard like organism? Contradict Lamarck Theory of evolution of snake with that of Darwinism.

2. Darwin's Theory of Natural Selection (Darwinism)

This theory was put forward by Charles Darwin, and is based on seven postulates:

- i. *Over Production:* All living organism has the tendency to produce offspring in large number for continuity of their race.
- ii. *Limited Space and Time:* Space in the universe remains constant. The ultimate source of food for plants and animals also remains constant.
- iii. *Struggle for Existence:* Due to limited resources like food, air and water, and increase in a number of organisms due to overproduction. There is intense competition for existence among the organism for obtaining the limited resource. The struggle could be
 - a. *Intraspecific:* Competition among the member of same species for survival.
 - b. *Interspecific:* Competition between the members of different species.
 - c. *Struggle with Environment:* Struggle of living beings with the change of environments such as heat, cold, drought, flood and storm.
- iv. *Variations:* The offspring are similar to their parents and also exhibit resemblance to each other. But they are not identical. They differ to some extent in shape, size, colour and behaviour. This means that variation is the law of nature. No two individual are the same. Variations are non-directional which means, they may be beneficial,

harmful or even neutral. The useful variation has an advantage over harmful variation as it helps the organism to survive.

- v. *Natural Selection and Survival of the Fittest:* Just like man selects animals and plants with the desired character, Darwin believed that Nature also selects those individuals with a useful variation. The variation that can better adapt to the changing environment. This sorting out of individuals with useful variation was called **natural selection** by Darwin and **survival of the fittest** by Wallace.
- vi. *Inheritance of Useful Variation:* The individual that has survived from the struggle for existence transmit their useful variation to the offspring. Thus, offspring of the selected individual is born to fit the environment.
- vii. *Formation of New Species:* New variation appears in every generation and supplements the useful variation inherited from parents. Thus, variation keeps on accumulating and after several generations, offspring become markedly different forming new species.

Example: Evolution of long neck in Giraffe by Darwin

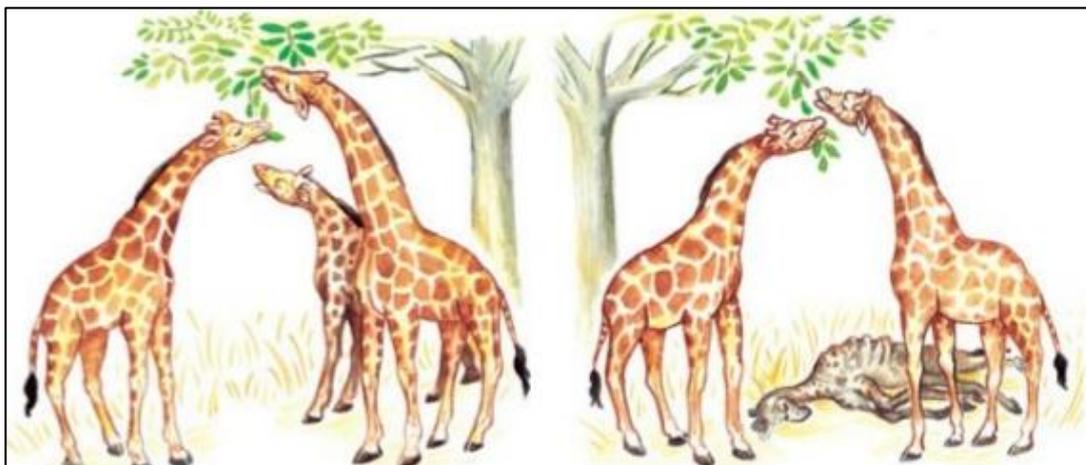


Figure: Evolution of Long Neck in Giraffe according to Darwin

(Source: <https://app.emaze.com/@ALCLFIZW#9>)

Darwin explained the evolution of long neck in giraffe by presuming that both the long and short neck giraffe existed in the ancestral population of giraffe. The longer neck giraffe was more successful in reaching the soft leaves of the trees for feeding. Therefore, nature selected long neck giraffe progeny generation after generation. Selection of longer neck giraffe for several generations resulted in a present day long neck giraffe.



ACTIVITY 2

1. Contradict Darwin's Theory of Natural selection with that of Lamarck theory of Acquired character.
2. What kind of competition is shown in the figure below?

3. Mutation Theory of Evolution

The theory was proposed by Hugo DeVries. According to this theory, new species arises from the pre-existing ones in a single generation by the sudden appearance of distinct heritable changes. DeVries called such sudden distinct heritable changes as **mutations**.

The main postulates of mutation theory are:

- i. All organism has tendency to change or mutate.
- ii. Mutations always appear fill-fledged. There is no incipient stage in the development of character or organ.
- iii. A mutation may appear in different members of the same population or same species giving rise to several related species.
- iv. Mutations are in determinant, i.e., they appear in all direction and may be harmful or useful.
- v. Mutations are subjected to natural selection. Beneficial mutations are favoured by nature and harmful are eliminated by the death of an organism.
- vi. Mutations may appear again and again from generation after generation.

4. Modern Synthetic Theory of Evolution.

According to the modern synthetic theory of evolution, the units of evolution are populations of species. It means that it's the gene pool of a population that changes, evolves and diversifies. Natural selection does not operate only on the genome of a single individual but on the gene pool of a population.

Modern synthetic theory of evolution is a reconciliation of Darwinism and Mutation theory. According to this concept, genetic variation in the gene pool of population and natural selection are two main elemental forces of evolution.

i. Genetic variations are introduced by:

- a. Mutation: Is a sudden change in the genetic material.
- b. Recombination: New combination of genes due to crossing over and exchange of segment between non-sister chromatids during meiosis and random fusion of male and female gametes.
- c. Hybridization: Combination of the genes from different varieties or species resulting in the production of new species.
- d. Gene flow: The intermingling of genes of two populations of species by hybridisation or migration.

ii. Natural Selection

Nature selects those organisms which can best adapt to their environment and reproduce at a higher rate producing more offspring, thus contributing more genes to the gene pool of a population. The less adaptive individuals produce less number of offspring and contribute less gene to the gene pool. This is known as **differential reproduction**.

If differential reproduction continues for several generations, genes of those individuals which produce more offspring will increase in number in the gene pool of a population.

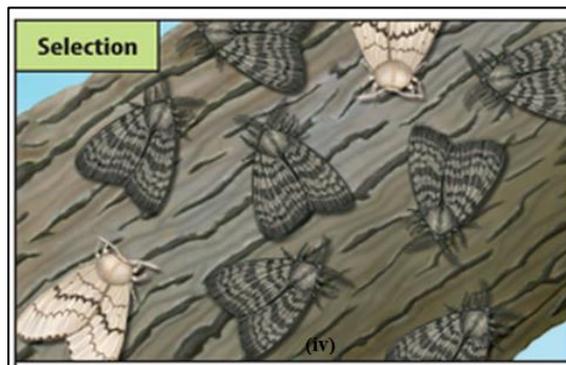
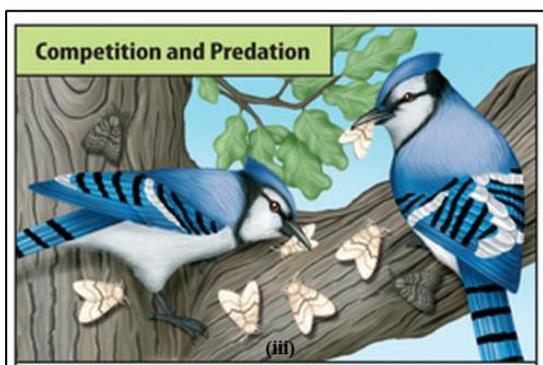
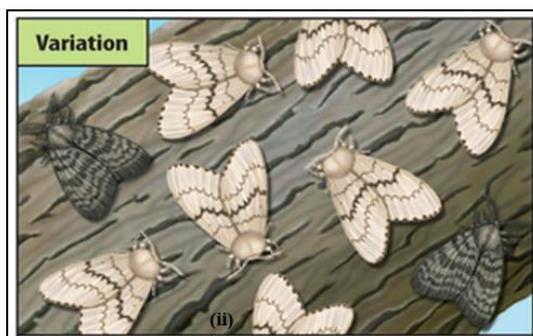
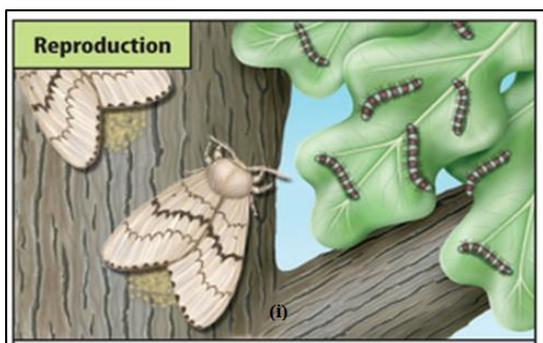
Natural selection conserves and multiplies those genes that have the highest level of adaptive efficiency to the population in its existing environment.

Note: Gene pool is the total number of genes of every individual in a population.



ACTIVITY 3

Instruction: Based on the pictorial story given below, explain how natural selection favoured the selection of Black peppered moth over the light coloured moth.



Summary

- Evolution is a continuous, gradual and orderly change happening in an organism.
- Lamarck's Theory of inheritance of Acquired Characters (Lamarckism) is based on transmission of acquired character to the offspring which keeps on adding and after several generation offspring becomes different from its ancestor and results in the formation of new species.
- Darwin's theory of natural selection (Darwinism) is based on an organism with useful variation survives the struggle for existence and those survived to transmit their variation to the next generation. Accumulation of variation over several generations results in new specie.
- The modern concept of evolution (Synthetic theory) is based on genetic variation and natural selection as the two main elemental force of evolution.



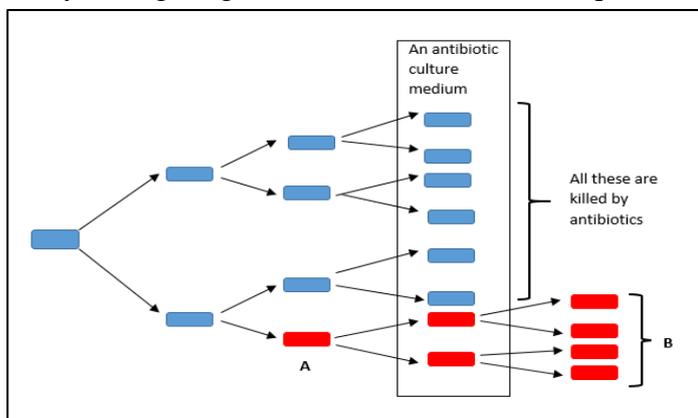
Self-check for Learning

Answer the following questions in your notebook.

1. Why is genetic variability essential for the survival of the species?
2. What kind of competition is shown in the figure below? Which kind of competition is more severe and why?



3. Which kind of competition can lead to cannibalism among organism?
4. How does natural selection differ from an artificial selection in terms of organic evolution?
5. Why do you think most mosquitoes are DDT (insecticides) resistant?
6. Study the figure given below and answer the questions that follow:



- a. Which phenomenon is taking place in the above diagram?
- b. What are A and B?
- c. Why have certain bacteria survived in an antibiotic medium?
- d. Enumerate the steps involved during the development of antibiotic resistance in bacteria, according to Darwin's theory of natural selection.

1.5. SPECIES AND SPECIATION

Learning Objectives



- Explain species.
- Describe the factors that contribute to speciation.
- State the difference between allopatric and sympatric speciation.

Introduction

Did you know that there was no life on the earth some 3.5 billion years ago?

But today there are huge varieties of plants and animals inhabiting the earth. For instance, Bhutan, which represents a small geographical area of the world hosts;

- over 5600 vascular plants species,
- around 200 species of mammals,
- around 743 species of birds, and
- Bhutan stands as biodiversity hotspots.

What are species? Do you think plants are species?



Figure: *Plants*



Figure: *Equus Quagga (Zebra)*

Do the above two organisms belong to the same species?



Figure: *Equus Caballus (Horse)*



Figure: *Equus Asinus (Donkey)*

What about these two organisms? Do they belong to the same species?

Species: Species are a group of organism that closely resembles each other, freely interbreed among themselves and produce fertile offspring.

Speciation: Speciation is the origin and evolution of new species from previously existing species.

Factors Favouring Speciation

1. Reduction of Gene Flow

Gene flow is a transfer of genes from one gene pool to another gene pool. If there is a movement of an individual from one population to another, this shows that there is a free flow of genes, which results in the exchange of genes. Gene flow happens through migration and hybridisation. When there is a formation of a certain barrier, like river, mountain or due to reproductive isolation within or between the populations then, the free gene flow is restricted. As a result, a member of a population becomes different from the existing population which ultimately results in the formation of new species.

2. Reproductive Isolation

Prevents different species from mating. Such kind of isolation hinders fertilization. Reproductive isolation helps to promote genetic variability. If there is no reproductive isolation, then the mutant form will freely interbreed normal forms which will either lead to mixing of genotype or loss of mutant form. Thus, no new species will be formed. There are different types of reproductive isolation.

a) Habitat Isolation

Organism living in the same region but occupy different habitats, so the potential mates do not meet. Example: The two cricket species below prefer to live in a different environment- sandy soil in disturbed area vs. loamy natural soil at the edge of the forest, which contributes to their reproductive isolation.

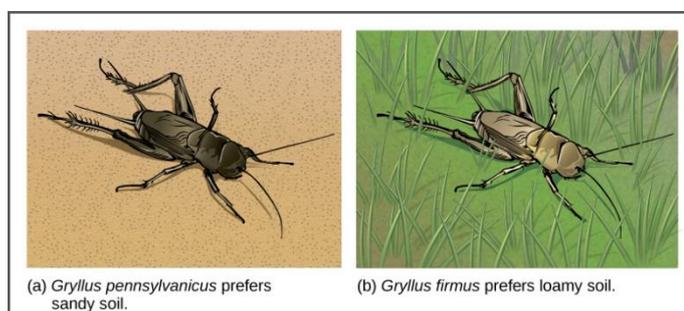


Figure: Crickets

b) Temporal Isolation

Organisms occupy the same region but become sexually mature at different time. Example: The two frog species below are reproductively isolated because the frog on left reproduce earlier in the year than the frog on the right.



Figure: *Rana aurora*

Figure: *Rana boylii*.

c) Mechanical Isolation

Fertilization is prevented by differences in structure of reproductive organ. Differences in the structure of reproductive organ prevents mating.

Example: Polar bear and koala bear have different reproductive structure.



Figure: Polar bear



Figure: Koala Bear

d) Behavioural Isolation

Organism is isolated due to different and incompatible sexual behaviour before mating.

Example: Similar bird will not interbreed because of different mating song.



Figure: Western Meadowlark



Figure: Eastern Meadowlark

3. Genetic drift

The random changes in the allele frequency occurring in a small population by chance alone is called genetic drift.

According to this concept, mutation arising in small population may be either fixed or lost by chance irrespective of being beneficial or harmful. Which means that sometimes in a small population unfavourable characters may be fixed or beneficial character may be lost.

Bottleneck effect and founder effect are responsible for genetic drift.

a) Bottleneck Effect

- Population crash leads to elimination of majority of individuals leaving few surviving individuals.
- These surviving individuals becomes the progenitors (forefather) which will undergo lot of changes in the characters of the population as compared to the characters in the previous population.
- Such phenomenon causing reduction in allele frequencies and loss of some alleles from the gene pool in a random fashion by chance is called **bottleneck effect**.

To understand this better let us take an example of the population of rabbit given in the figure.

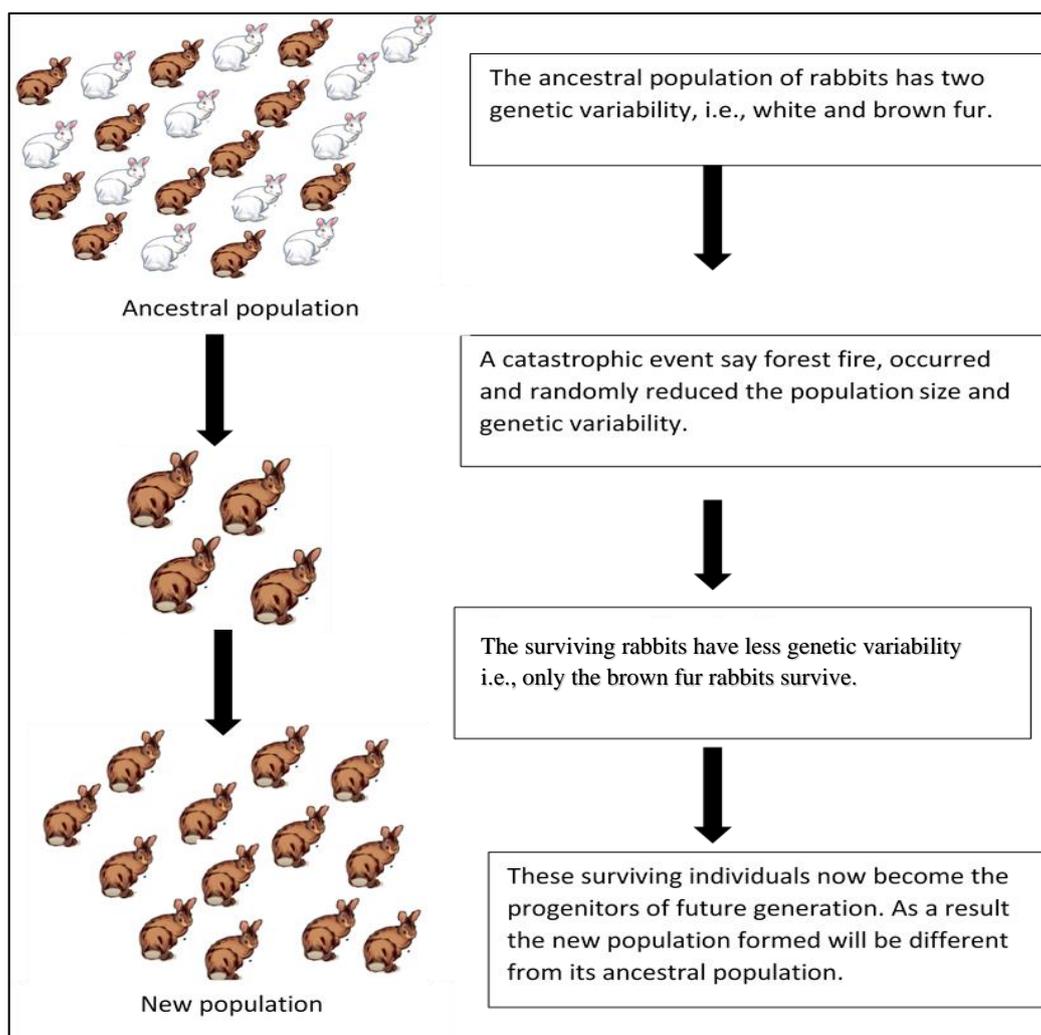


Figure: The Bottleneck Effect

b) Founder effect

- Few founder individuals from a parental population move to a new geographical area.
- Founders carry only a limited portion of parental gene pool.
- The gene pool of founders may be homozygous for certain characters, and lack the allele for other character.
- It means that different founder colonies will possess different gene pools and will soon become different from each other and from parent population. Such an effect is known as **founder effect**.

Let take the examples of white and brown fur rabbits.

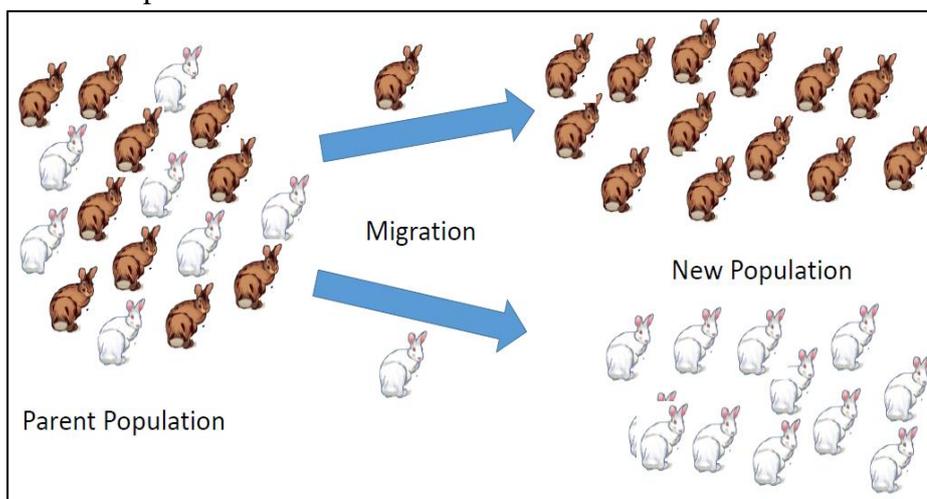


Figure: Founder Effect

The parent population has equal number of white and brown rabbits. Now, say may be due to intense intraspecific competition, few of the individual leaves the parent population and inhabit new geographical area, let's say few brown rabbits moved out of the parent population and established themselves in new area. Similarly few white individuals from the parent population also moves out and establish new population in another new geographical area. This lead to the formation of two different populations of rabbit. After several generation the two population become entirely different from each other, leading to speciation.



ACTIVITY 1

1. Why is gene flow important in agriculture ecosystem?
2. Reproductive isolation is essential for speciation. Why?

Types of Speciation

1. Allopatric Speciation

Sometimes a large population formerly enjoying continuous distribution gets separated into two or more subpopulation due to some geographical barrier like mountain, river and desert. The gene pool of these geographically isolated population accumulate independent genetic variation and natural selection operates separately on each gene pool. In due course of time, these gene pools become more and more diverse and reproductive isolation is established. This splitting of species into two or more geographically isolated species is called **Allopatric Speciation** or **Parapatric Speciation**.

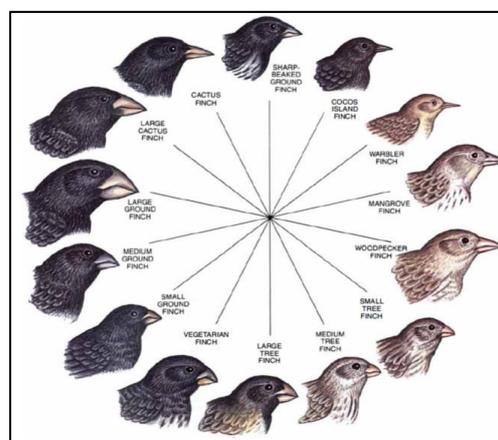


Figure: Darwin's Finches

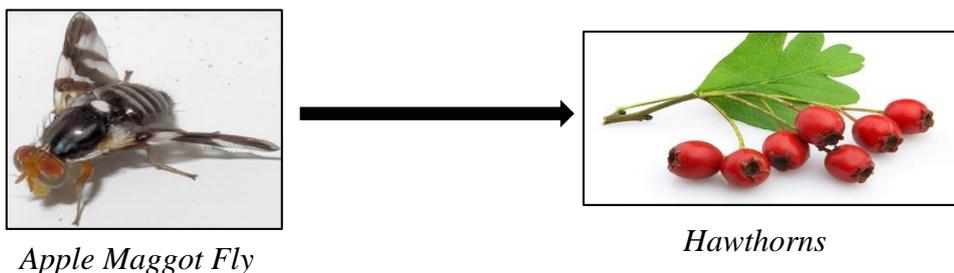
Example: Darwin's Finches

A few seed eating finches, probably migrated from the mainland of Equador (South America) and their progeny spread out on 40 islands, each with different geographical features and different ecological niche. The population of finches on different islands became geographically and finally reproductively isolated evolving into different species of Finches. These species differ from one another in shape and size of their beak and the type of food they ate.

2. Sympatric Speciation

When few individuals of a species within a same geographical area suddenly become reproductively isolated from the main population, they form new species. This is called sympatric speciation and the species as sympatric species. Polyploidy and hybridisation are two main method of introducing sudden reproductive isolation.

*Example: An extremely recent example of sympatric speciation may be occurring in the apple maggot fly, *Rhagoletis Pomonella*. Apple maggot flies used to lay their eggs only on the fruit of hawthorn trees.*



But less than 200 years ago, some apple maggot flies began to lay their eggs on apples instead. Now there are two groups of apple maggot flies: one that lays eggs on hawthorns and one that lays eggs on apples.



Males look for mates on the same type of fruit that they grew on, and females lay their eggs on the same type of fruit that they grew up on. Therefore, flies that grew up on hawthorns will raise offspring on hawthorns, and flies that grew up on apples will raise offspring on apples. There are already genetic differences between the two groups, and over a long period of time, they could become separate species. This shows how speciation can occur even when different subgroups of the same species have the same geographic range.

Note: Usually an organism is represented by diploid set of chromosomes ($2n$). In polyploidy organism have chromosomes more than diploid set. For example triploid- $3n$, tetraploid- $4n$, pentaploids- $5n$ and hexaploid- $6n$.



Summary

- Species are group of organism that closely resembles each other, freely interbreed among themselves and produce fertile offspring.
- Speciation is the origin and evolution of new species from previously existing species.
- Gene flow, reproductive isolation and genetic drift favours speciation.
- Reproductive isolation prevents mating of different species.
- The random changes in the allele frequency occurring in a small population by chance is called genetic drift.
- Allopatric species arises due to geographical isolation and sympatric speciation arises due to reproductive isolation.



Self-check for Learning

Answer the following questions in your notebook.

1. A population of lizards is split by an earthquake which leaves half of the population on an island and the other half on the mainland. These lizards can't swim. What type of speciation is likely to occur?
2. An ecologist observes a population of snakes on an island for one month every year. After the eleventh month, he sees that the snake population has been declined, and decides to wait for the snakes to repopulate before coming back for further observation. When he returns after five years, he finds a very homogenous looking population of snakes. What is the name of the effect he observed?
3. Why is gene flow important in agriculture ecosystem?
4. Reproductive isolation is essential for speciation? Why?

1.6. MUSCLES

Learning Objectives



- Explain the importance of muscles.
- Discuss the mechanism of muscle contraction.

Introduction

You use muscles every day to do activities. Right now you are using muscles to breathe, circulate blood, and move your hand to read through SIM.

Muscles are specialised tissue formed of specialised elongated cells called **muscle fibres or myofilaments**. Muscles have special properties of **electric excitability, extensibility or contractility**. Excitability is due to unequal distribution of charges across plasma membrane of muscle cells and contractility is due to the presences of **myofibril** formed of highly contractile protein (**Actin and Myosin**).

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Types of Muscles

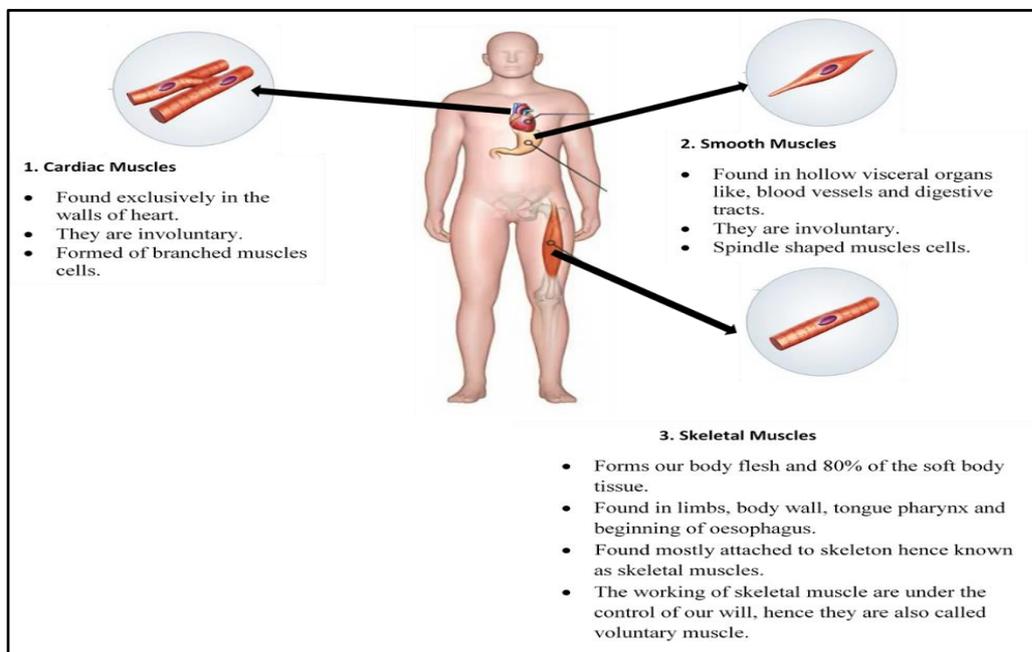


Figure: Human Body Showing location of Different Types of Muscles

Structure of Skeletal muscle fibres.

- Each muscle fibre is long, unbranched and cylindrical cell.
- It is covered with thin elastic membrane called sarcolemma.
- Sarcolemma encloses inside multinucleated cytoplasm or sarcoplasm.
- The nuclei lies toward periphery.
- Embedded in the sarcoplasm is numerous Myofibrils, which are tightly packed in parallel bundle separated by thin sheet of cytoplasm.
- Myofibril forms the contractile apparatus of muscle fibres.
- Each myofibril have transverse striation in the form of alternating dark and light band. Because of this striation, these muscles are called striated or stripped muscles.

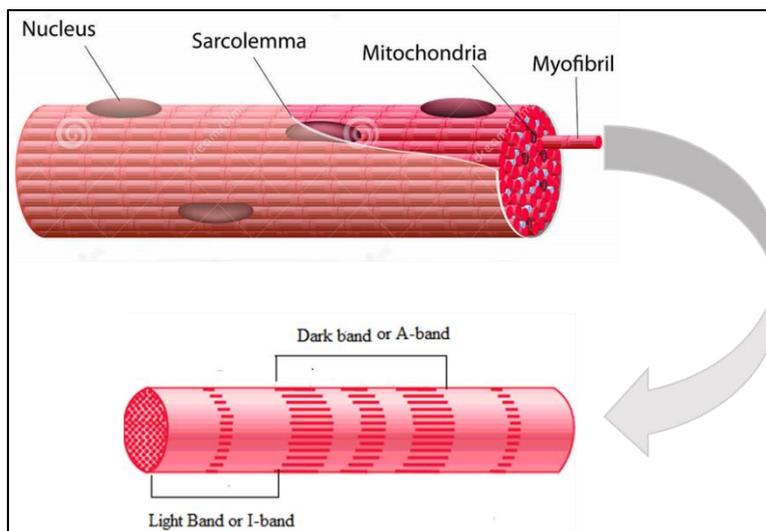


Figure: Muscle fibres (above) and myofibril
(Source: <https://medical-dictionary.thefreedictionary.com>)



ACTIVITY 1

- Why skeletal muscles are also known as striated muscles?
- What if all the skeletal muscles in our body are involuntary muscles?

Ultrastructure of Myofibril

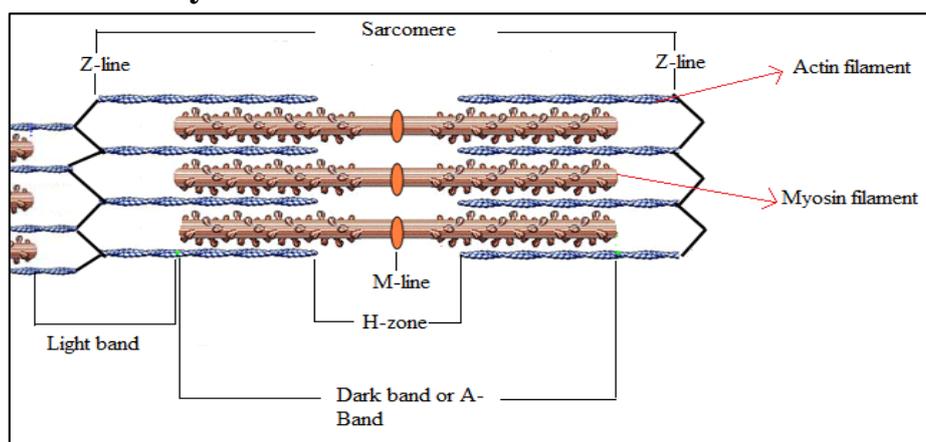


Figure: Ultrastructure of Myofibril showing Sarcomere (Source: <https://socratic.org>)

i. Light Bands or Isotropic bands (I-bands)

- Light bands are formed of actin filaments or secondary myofilaments (Actin filaments are formed of actin protein)
- Each I-band is bisected at midpoint by a thin dark membrane, the **Z-line** or **Z-disc** or Krause's membrane.
- Actin filaments are firmly attached to Z-disc.
- The part of myofibril between two adjacent Z-disc is known as **sarcomere**.
- Sarcomere is the unit of contraction. Myofibril is composed of serially repeated sarcomeres.

ii. Dark band or Anisotropic band or A-band

- Dark bands are formed of thick myosin filament or primary filament (Myosin filament are formed of myosin protein)
- The myosin filaments are free at both the ends and the ends are partially overlapped by actin filaments.
- Portion of A- band which is not over lapped by actin filaments is called **H-zone** or **Hensen's line**.
- A narrow dark line passes through H-band, called the M-line or M-band or M-membrane.

Structure of Contractile Protein**Actin Filament**

- Each actin filament is formed of two strands of F-actin spirally coiled around each other. Each F-actin is formed of many globular protein, G-actin joined together. Actin filament has sites for binding of myosin head. Two regulatory protein *Troponin* and *tropomyosin* is associated with actin. These regulatory protein covers the active binding site of action, when muscle is at rest.

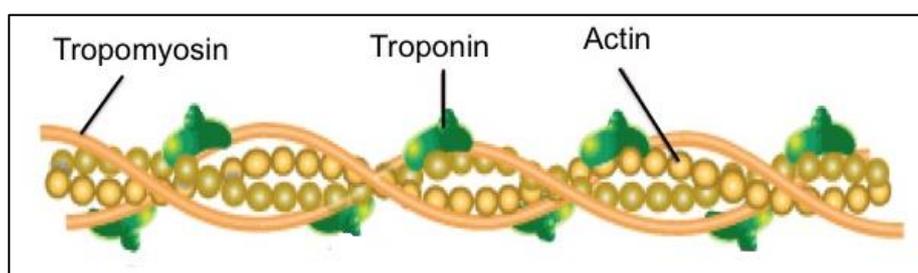


Figure: Actin Filament (Source: <https://experiment.com>)

Myosin Filament

- Myosin filament is formed of myosin protein. Myosin protein is formed of monomeric and meromyosin.
- Each meromyosin has two heads, which projects out from the myosin filament. It has the actin binding site, site for binding ATP and Ca^{2+} and ATPase enzyme.

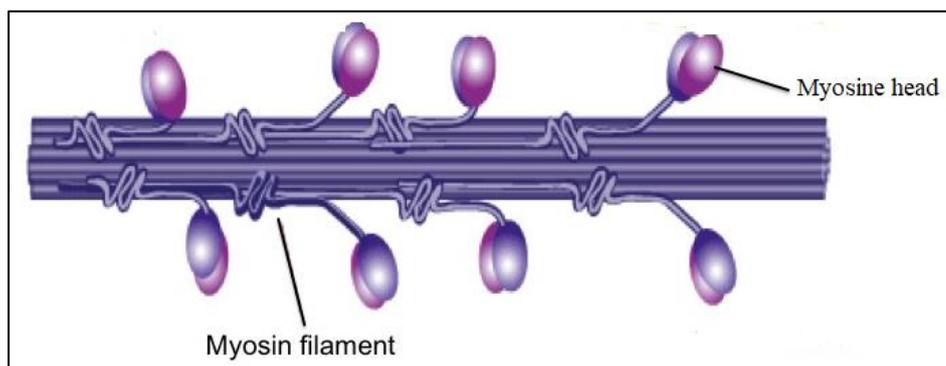


Figure: Myosin Filament (Source: <https://experiment.com>)

What would happen if all the skeletal muscles in our body are involuntary?

Sliding Filament Theory of Muscle Contraction

When muscles is at rest, the actin and myosin filaments lie parallel to each other.

Actin filaments partially overlap the two ends of myosin filaments.

The H-zone and I-band of sarcomere is wide.

During muscles contraction, the thin actin filament from both the ends of sarcomere slides towards H-zone between thick myosin filaments till H-zone disappears completely and width of I-band is reduced.

The sarcomere shortens in size and also the whole muscle filament.

This mechanism of muscle contraction is known as **sliding filament theory**.

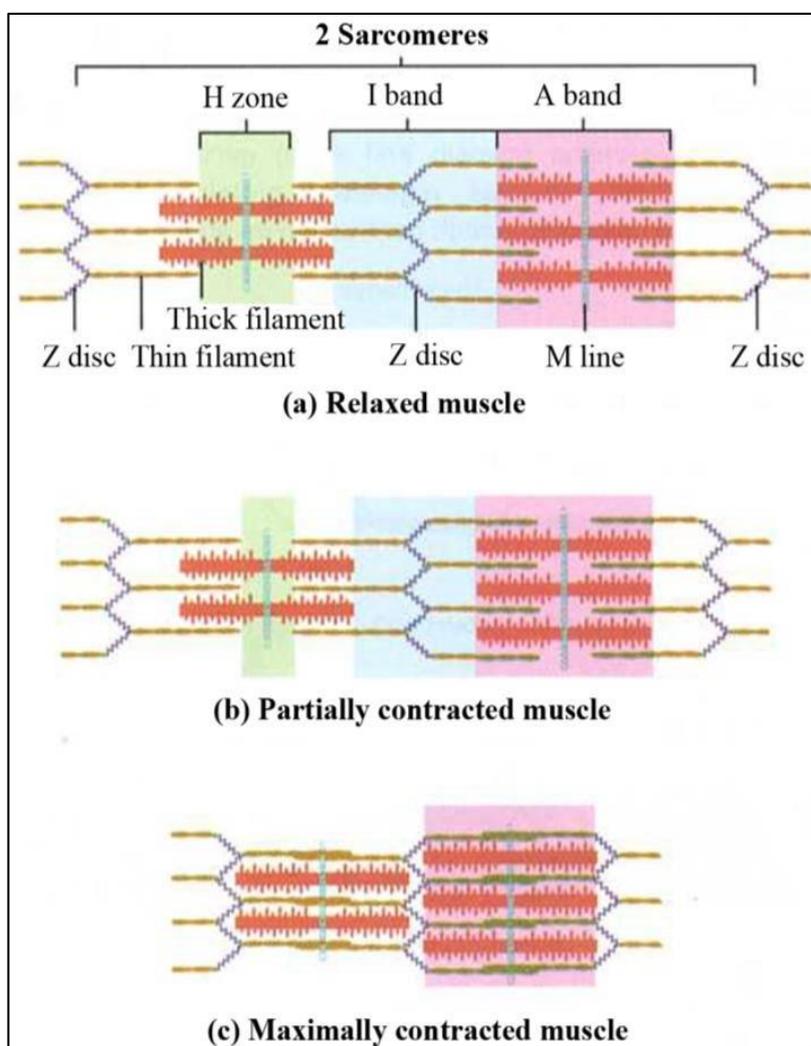
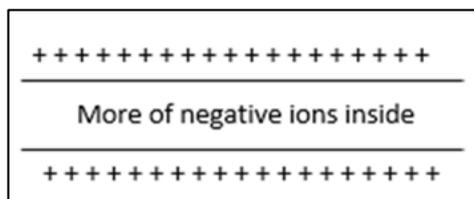


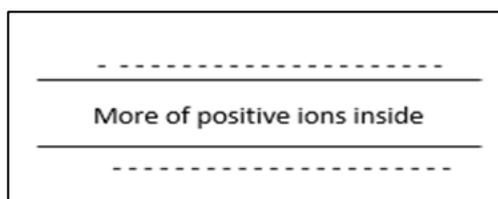
Figure: Sliding of Actin Filament over Myosin during Muscle Contraction.

(Source: <https://www.researchgate.net>)

Note: When muscle is at rest, the sarcolemma of every muscle fibre is **polarised**, which means outer side of sarcolemma has more positive ions than inner surface. The potential differences across the membrane of resting muscle fibre is called **resting potential**. The figure given below shows a resting membrane potential or polarised membrane.



When muscle fibres are stimulated, the permeability of sarcolemma to Na^+ ions increases. As a result, Na^+ enters inside and the inner surface now becomes more positive compared to outer surface. The muscle fibre is now said to be **depolarised**. This sets up **action potential**. The figure given below show depolarised membrane



Biochemical Events during Muscle Contraction.

1. An impulse from neuron reaches neuromuscular junction (Junction where end of neuron meets the muscle), and causes the release of neurotransmitter into synaptic cleft. This depolarises the sarcolemma and sets up action potential.

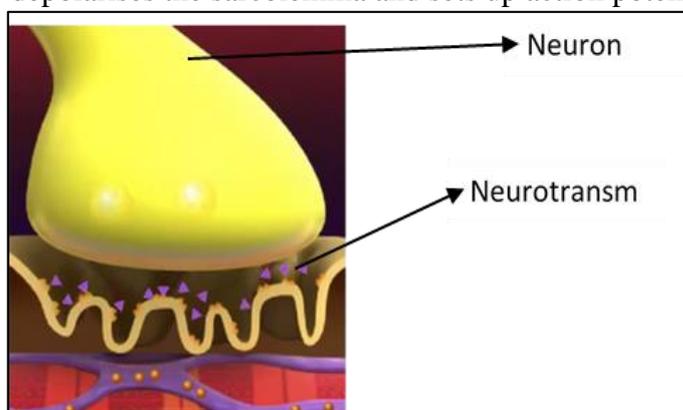
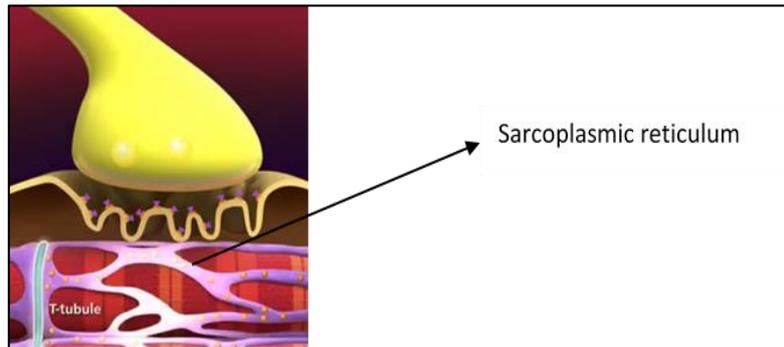
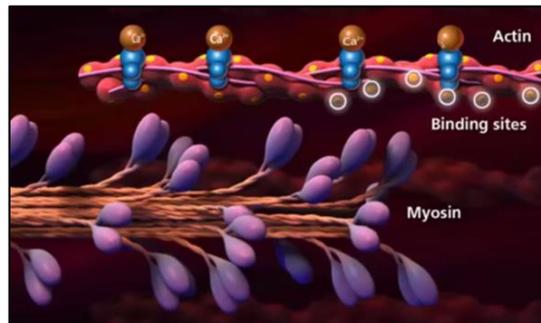


Figure: Sliding of Actin Filament over Myosin during Muscle Contraction

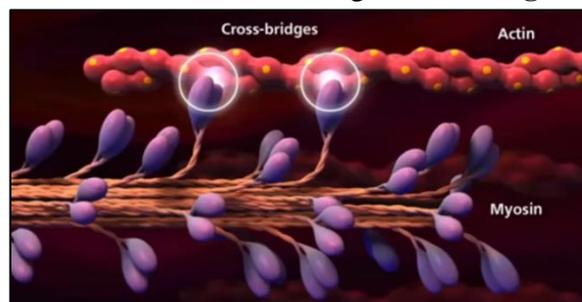
- Action potential is transmitted to T-tubules of sarcoplasmic reticulum. It causes the release of Ca^{2+} ions from it.



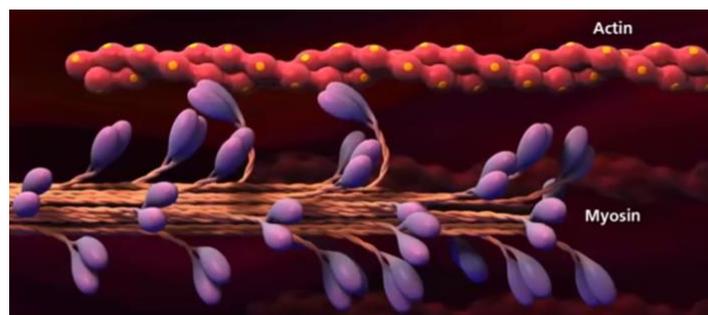
- Ca^{2+} ions bind to troponin and tropomyosin protein associated with actin filament. Ca^{2+} ions displace the troponin and tropomyosin and expose the active binding site on actin filament.



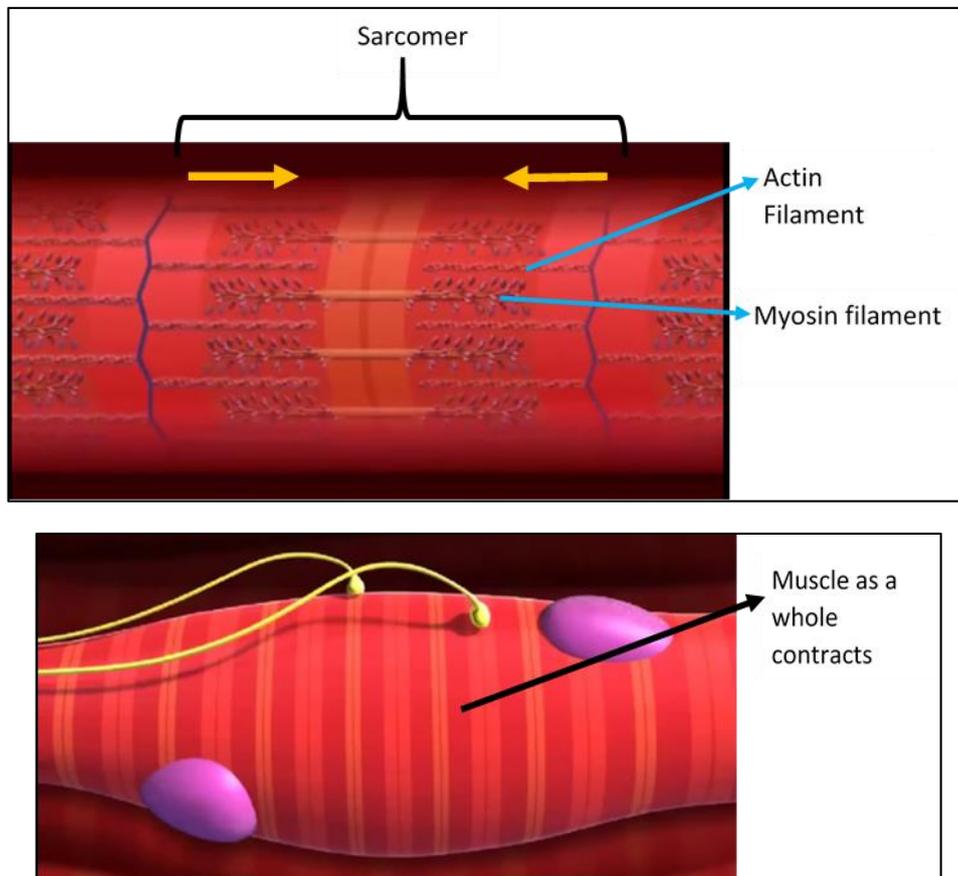
- Ca^{2+} ions also act on myosin head activating them to release energy from ATP. Energy is used to move head of myosin head toward active site on actin filament. Myosin head binds to the active site on actin filament forming **Cross-bridges**.



- Now the head of the myosin filaments moves pulling the actin filament towards H-zone.



6. As the actin filaments from opposite ends of sarcomere move towards each other, H-zone disappears, I-band shortens and sarcomere contracts causing contraction of entire muscles.



(Source for picture: snap shot from <https://www.youtube.com>)

7. When stimulation stops, the positive ions stops entering inside, the resting potential is resumed.
8. As a result, the Ca^{2+} ions are pumped into sarcoplasmic reticulum, level of Ca^{2+} ions falls and troponin and tropomyosin move back to their original position, blocking the active sites on actin filament.
9. Finally, actin filament return to their original position and sarcomeres return to their normal length and muscle relax.

Summary

- Muscles are made of muscle fibres.
- Electric excitability, contractility and elasticity are the properties of muscle.
- The sarcomere functions as contractile unit.
- Nerve impulse triggers the muscle movement.



Self-check for Learning

Answer the following questions in your notebook.

1. What prevents the formation of cross-bridges between the actin and myosin filaments in a resting muscle?
2. What causes the muscle fibre to lengthen when it relaxes?
3. Parathyroid hormone in our body is responsible for controlling calcium level in our blood. If the hormone is inadequately produced in our body, how would it affect the muscle contraction?
4. How would physical exercise help in maintaining health of a muscle?

1.7. TRANSMISSION OF NERVE IMPULSES

Learning Objectives



- Explain the organisation of human nervous system.
- Describe the structure of neuron.
- Explain the mechanism of transmission of impulse through the neurons.

Introduction

In all complex animals including man, coordination between stimulus and response, and integration between various organ and organ systems is achieved through two system:

Nervous system and **endocrine system**.

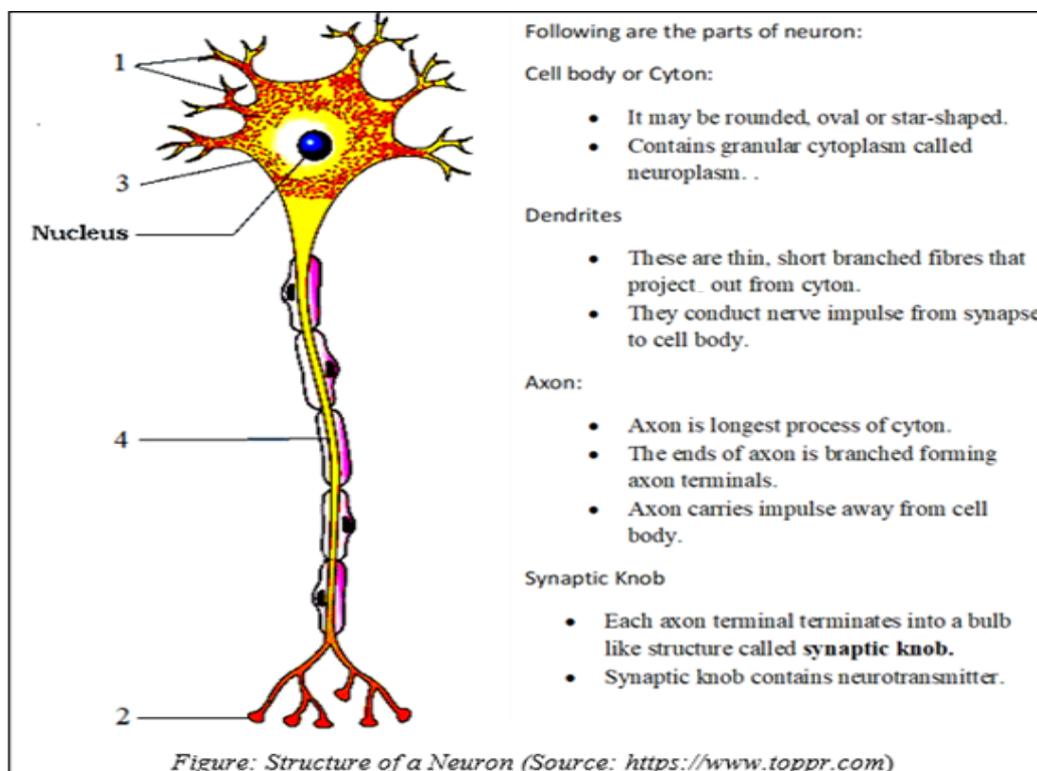
In this lesson we will be focusing on the **Nervous System**.

Human nervous system consists of network of highly specialised cells called **Neurons**. Neuron is the structural and functional unit of nervous system.



ACTIVITY 1

Instruction: Study the figure given below and label the parts of neuron numbered 1, 2, 3 and 4. Make use of the the clues given on the right side of the figure.



Human Nervous System

The basic plan of Human Nervous System is as follows:

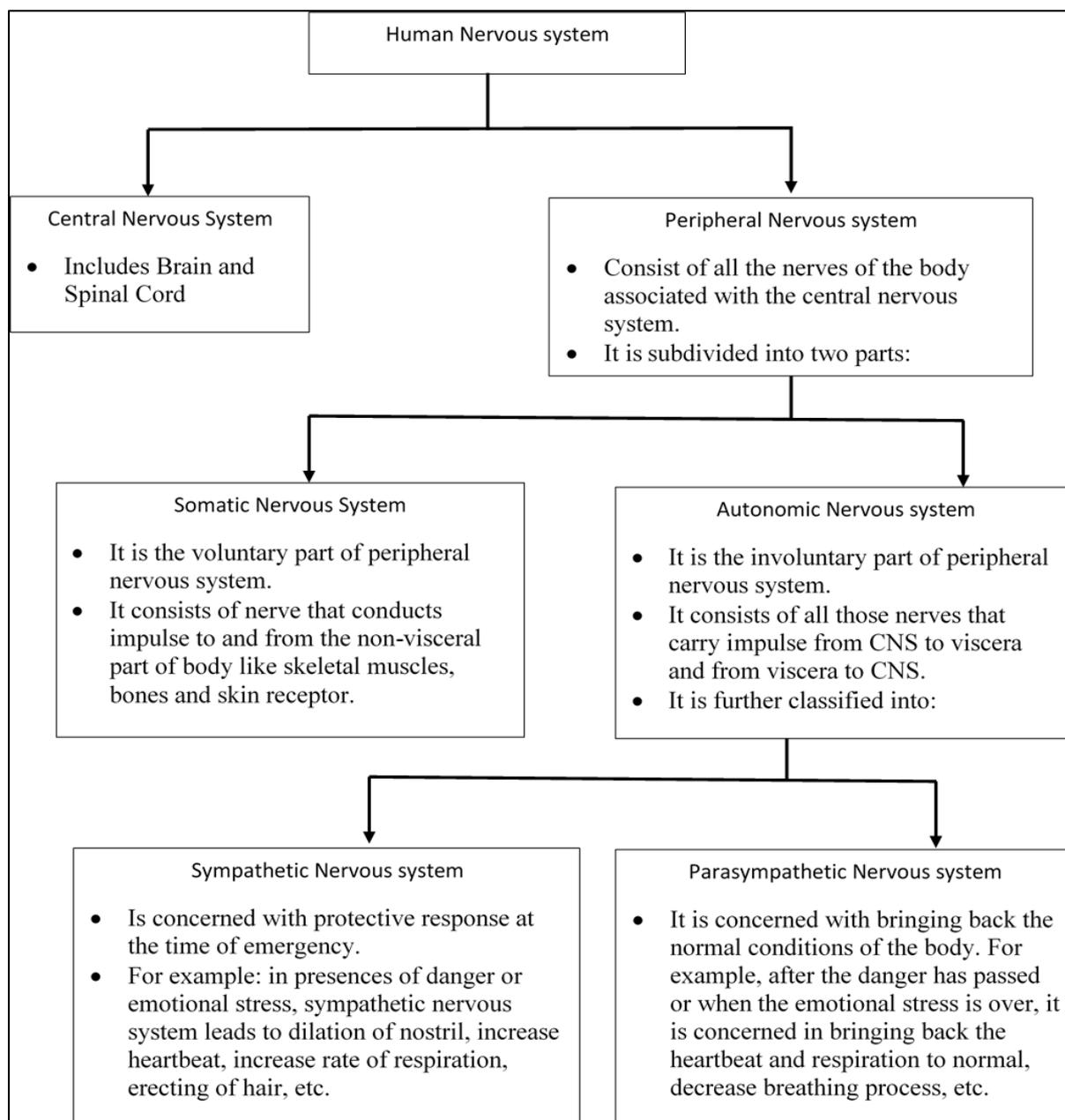


Figure: Division of Human Nervous System

Nerve Fibres and Nerve

Axon of nerve cell covered with one or two sheath is called **Nerve fibre**.

If nerve fibres are surrounded by neurilemma (membrane covering neuron) alone then is called **non-myelinated or non-medullated nerve fibre**.

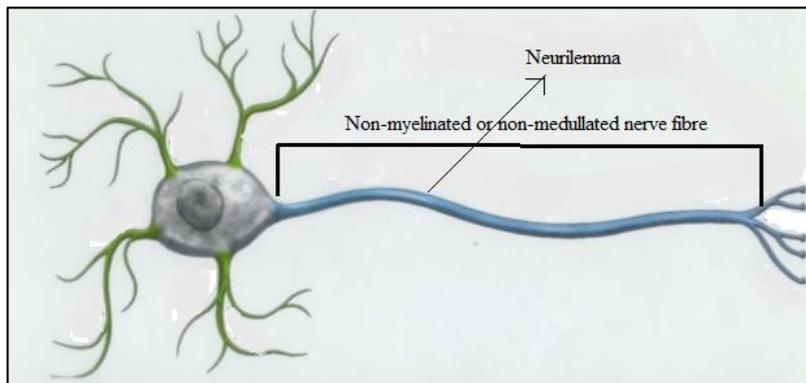


Figure: Non-Myelinated Nerve Fibre

Sometimes a nerve fibres might be covered by an additional insulating sheath know as myelin sheath, then the nerve fibre is known as **myelinated or medullated nerve fibre**. Myelin sheath is not continuous. It is constricted at regular intervals. The area of myelinated nerve fibres which does not have myelin sheath is a called Node of Ranvier.

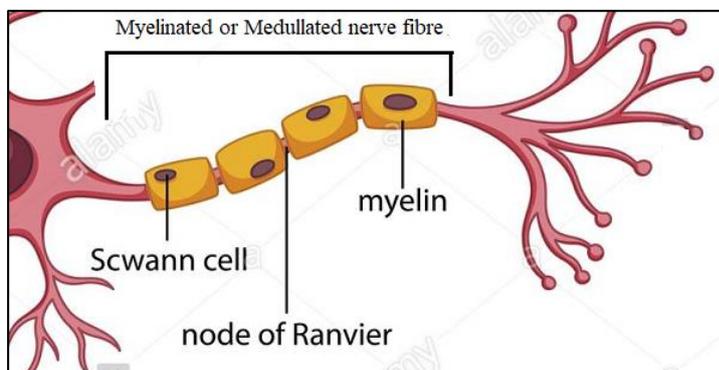


Figure: Myelinated Nerve Fibre

Nerves are bundles of nerve fibres present in peripheral nervous system.

Generation and conduction of nerve impulse: Nerve impulse is a wave of depolarization of the membrane of nerve fibre.

Polarisation and Resting membrane potential

- The neurilemma, i.e., membrane of resting nerve fibre has positive charge on its outer side and negative ions on inner side. The membrane is said to be **polarised**.

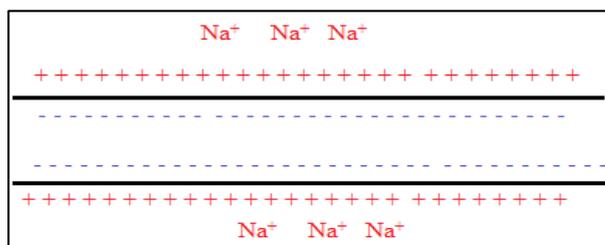


Figure: Polarised Neural Membrane

- The difference in electric charge across the neurilemma is called **resting membrane potential**. The resting potential of neurilemma is about -70mV.

Depolarisation

- Nerve fibre on being stimulated by any kind of stimulus, the Na^+ gate opens and the permeability of neurilemma for Na^+ ion increases.

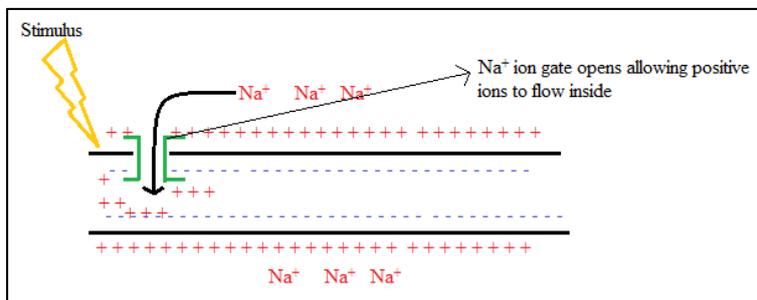


Figure: Change in the Permeability of Membrane when Stimulated

- More Na^+ ion moves into the cytoplasm of nerve fibre making the inner surface of neurilemma more positive and outer side negative. The membrane is now said to be **depolarised** and this results in the generation of **action potential**.

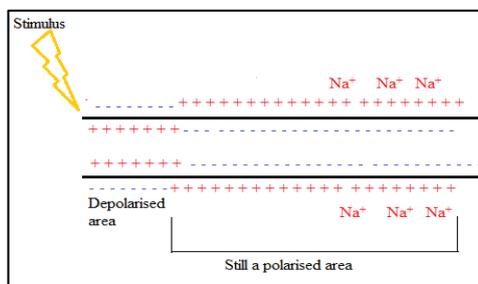


Figure: Depolarised Neural Membrane

- Depolarisation occurs only at the point where nerve fibre is stimulated. The point adjacent to depolarised area is still in polarised state (meaning the adjacent area still have positive ions outside and negative on inner side). We will discuss more on how the wave of depolarisation is conducted along nerve fibre in next topic.

Repolarisation

- With increase inflow of positive ions inside the nerve fibre, further entry of Na^+ ions is stopped. The permeability of membrane decreases and Na^+ ions are pumped out by sodium-potassium pump.

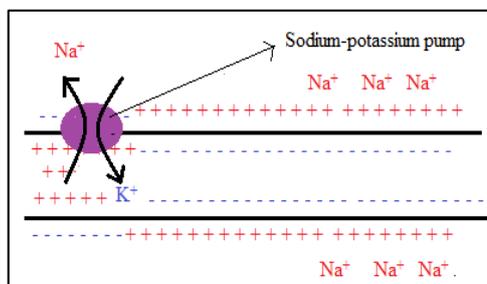


Figure: Sodium Potassium Pump Restoring the Resting Potential of Membrane

- The membrane restores its original resting potential. This is called **repolarisation**.

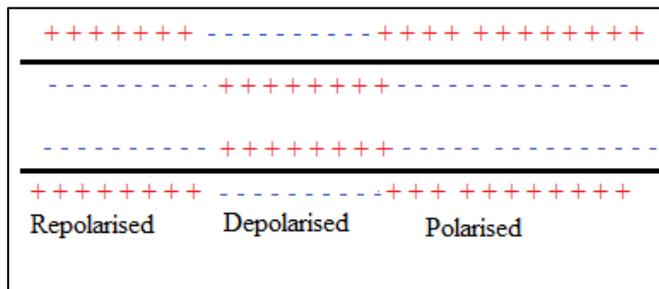


Figure: Repolarised, Depolarised and polarised three Phases of Nerve Transmission.

Conduction of nerve impulse

a) Conduction of nerve impulse in non-myelinated nerve fibre

During conduction of nerve impulse, negative ions on the outer side of depolarised area attracts the positive charge from the outer side of next polarised area.

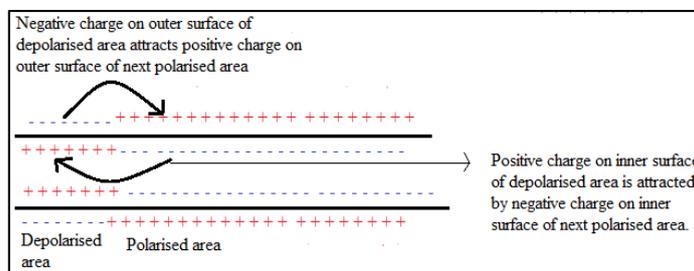


Figure: Conduction of Action Potential along Nerve Fibre

- While the positive ions from the inner surface of depolarised area is attracted by negative charge on the inner side of next polarised area. So, the depolarised area become polarised and the next polarised area becomes depolarised.

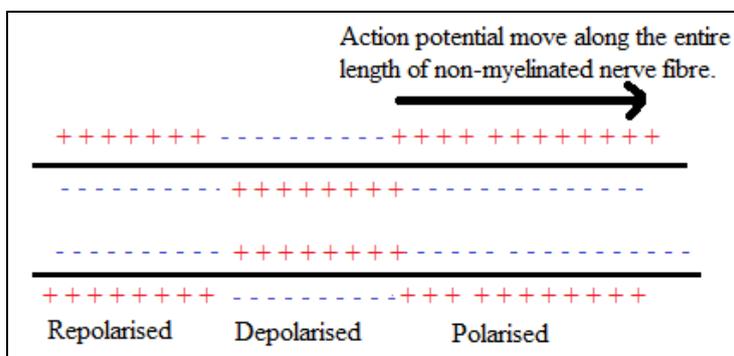


Figure: Conduction of Nerve Impulse in Non-myelinated Nerve Fibre

In non-myelinated nerve fibre, the wave of depolarisation or action potential flows all along the entire length of nerve fibre.

b) Conduction of nerve impulse in myelinated nerve fibre

- In myelinated nerve fibre, the myelin sheath insulates the nerve fibre and prevents depolarisation.
- In such case, the ionic exchange and depolarisation takes place only at node of Ranvier (which is without myelin sheath). Hence the action potential jumps from one

Node of Ranvier to next. Such mode of transmission of nerve impulse is known as **saltatory conduction** of nerve impulse.

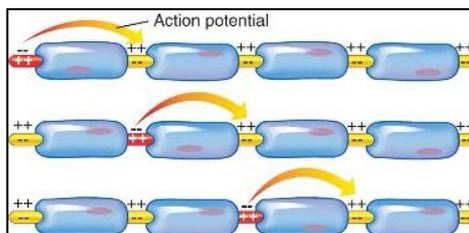


Figure: Saltatory Conduction of Nerve Impulse in Myelinated Nerve Fibre



Summary

- Human nervous system is divided into Central Nervous system and peripheral nervous system.
- Central nervous system consist of brain and spinal cord.
- Peripheral nervous system consist of all the nerves associated with central nervous system.
- Neuron is the structural and functional unit of nervous system.
- Neuron have three parts cyton, dendrites and axon.
- Axon of nerve cell when covered with one or more sheath it is called nerve fibres.
- Nerve fibres could be myelinated or non-myelinated.
- Nerve impulse travels along the entire length of non-myelinated nerve fibre.
- In myelinated nerve fibre impulse jump from one node of Ranvier to another. Such conduction of nerve impulse is called saltatory conduction.



Self-check for Learning

Answer the following questions in your notebook.

1. Why a nerve impulse is often described as an electrochemical change?
2. Why is the conduction of nerve impulse in myelinated nerve fibre faster compared to non-myelinated nerve fibre?
3. Why is the flow of nerve impulse unidirectional?
4. In case the cell membrane potential shifts from -70mV to -50mV , how would this change the permeability of membrane to K^+ and Na^+ ions?
5. The sympathetic and parasympathetic nervous system is antagonistic in their action. Give two example in support of the statement.
6. Hyperkalaemia is a higher than normal level of potassium in the blood and therefore in the extracellular fluid. What effect would hyperkalaemia have on the resting membrane potential of nerve cells? (source: <https://home.plc.wa.edu.au>)

2. CHEMISTRY

2.1. ELECTRONEGATIVITY

Learning Objectives



- Explain coordinate bonding.
- Define electronegativity.
- Define dipole moment.

Introduction

Chemical bond is the force of attraction that holds atoms together in molecules and compounds. Chemical bond is formed either by mutual sharing of electrons or by transfer of electrons between the combining atoms.

In ionic bond, transfer of electrons takes place from one atom to the other which results in the formation of oppositely charged ions. Ionic bond is formed due to the attraction between oppositely charged ions. Covalent bond is formed by mutual sharing of electrons between the combining atoms.

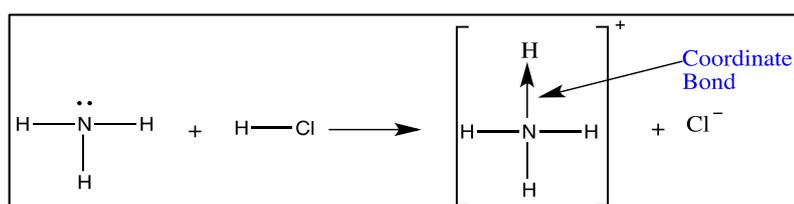
Coordinate Bond

It is a type of bond in which the shared electron pair is completely contributed by one of the combining atoms.

Example: The reaction between ammonia and hydrogen chloride.

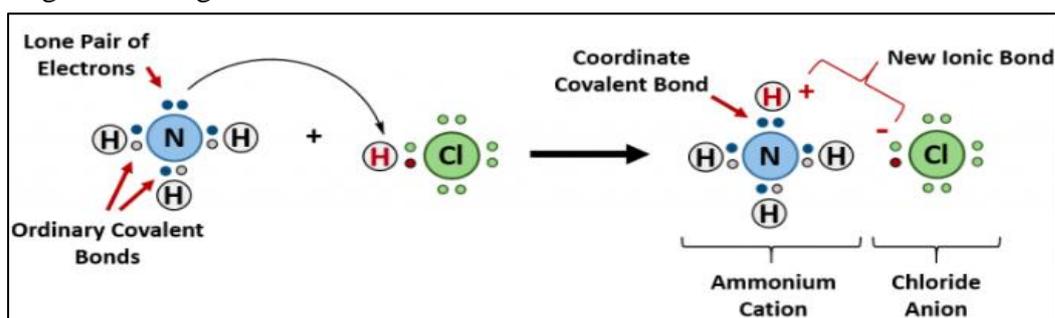
When these gases are mixed, a thick white smoke of solid ammonium chloride is formed.

The ammonium ion is formed by coordinate bond between nitrogen and one of the hydrogen atoms.



Nitrogen atom contributes a pair of electron to be shared with hydrogen atom.

To observe the electron movement during the reaction, we will make use of electron dot configuration diagram.



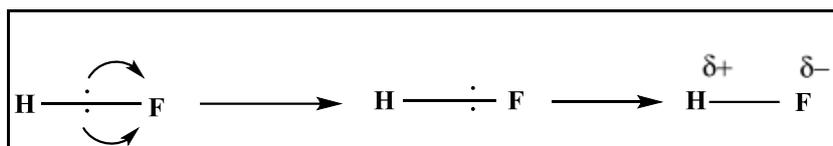


ACTIVITY 1

1. Draw and explain the electron dot configuration for the formation of hydronium ion from water and hydrogen chloride.

Bond Polarity and Electronegativity

Electronegativity is the tendency of an atom to pull the shared pair of electrons closer towards itself.



In HF molecule, fluorine being more electronegative than a hydrogen atom pulls the shared electron pair closer towards itself. This leads to the development of partial positive charge on H-atom and partial negative charge on the F-atom. The molecule as a whole will have a polarity of charges and is known as bond polarity.

Bond polarity, therefore, is a measure of how equally or unequally the electrons in any covalent bond are shared.

A polar covalent bond is the one in which one of the atoms exerts a greater attraction for the bonding electrons than the other due to difference in their electronegativity. Compound with such polar covalent bonds is called polar compounds. Other examples of polar compounds include H_2O , NH_3 etc.

A nonpolar covalent bond is the one in which the electrons are equally shared due to equal electronegativity between the combining atoms. Examples of non-polar compounds include H_2 , O_2 , Cl_2 etc.

Is HCl molecule polar or non-polar? Explain.

Dipole Moment (μ)

Dipole moment is a measure of the polarity of a molecule.

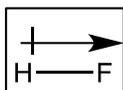
If two equal and opposite charges $q+$ and $q-$ are separated by a distance ' r ' the magnitude of the dipole moment is the product of q and r .

$$\mu = qr$$

It is expressed in the units of Debye (D).

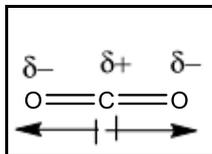
Is a vector quantity and is represented by a small arrow with tail at the positive end and head pointing towards a negative centre.

For example: The dipole moment of HF molecule is 1.91D.



For a nonpolar molecule such as F_2 , the dipole moment is zero because there is no charge separation.

Those compounds and molecules with zero net dipole moment are non-polar in nature. For example: CO_2 molecule is non-polar in nature.



The CO_2 molecule has a linear structure. The two dipole moments in the molecule are equal in magnitude but opposite in direction. The dipole moment on one side of the molecule cancels the dipole moment on the other side, resulting in the net dipole moment of zero.



ACTIVITY 2

1. Differentiate between polar and non-polar covalent bond.



Summary

- Coordinate bond is the special type of covalent bond in which the shared electron pair is contributed by one of the combining atom.
- Electronegativity is the tendency of an atom to attract the shared electron pair closer towards itself in a molecule.
- Covalent bond formed between the atoms having different electro negativities is called polar covalent bond.
- Covalent bond formed between the atoms of same electro negativities is called non-polar covalent bond.
- Dipole moment is the measure of polarity in molecules.
- Those molecules with zero dipole moment are non-polar in nature.



Self-check for Learning

1. Is CH_4 molecule polar or non-polar? Justify.
2. Differentiate between a covalent bond and a coordinate bond.
3. What are the conditions necessary for the formation of a coordinate bond?
4. Compare the polarity of HF and HCl .
5. Why are Cl_2 and O_2 molecules non-polar in nature?

2.2. ISOMERISM

Learning Objectives

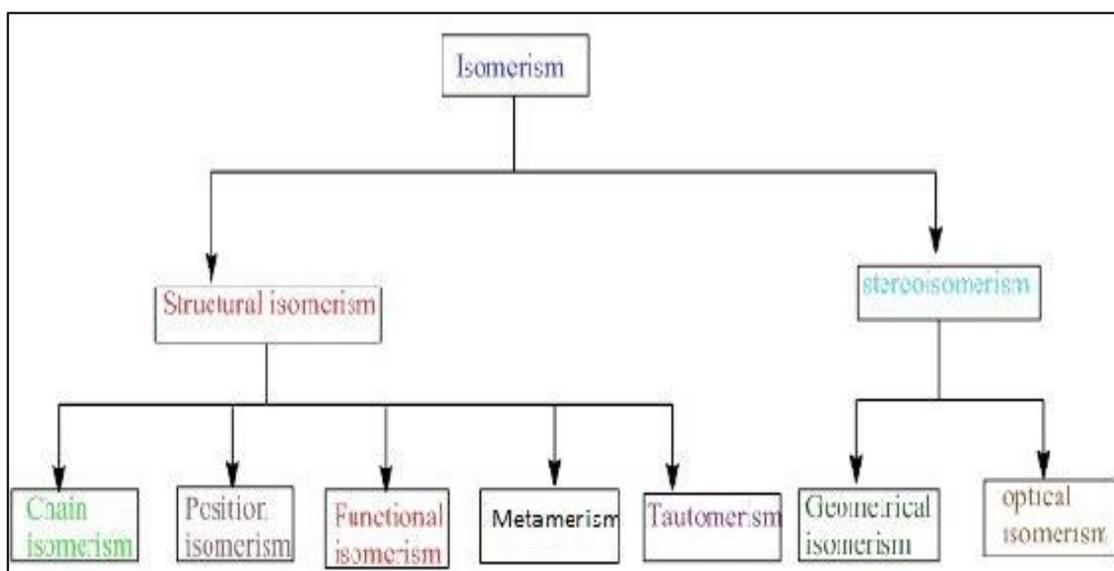


- Define isomerism.
- Classify isomerism.
- Differentiate between structural isomerism and optical isomerism.
- Write the applications of isomers in our day to day life.

Introduction

Isomerism is the phenomenon in which two or more compounds have the same molecular formula but differ in physical and chemical properties. Due to the difference in certain properties isomers have a wide range of applications in our day to day life. The difference in chemical structure gives rise to structural isomerism whereas the difference in spatial arrangement gives rise to stereoisomerism.

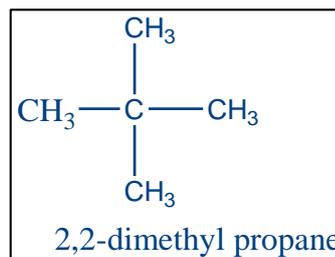
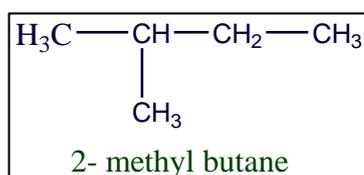
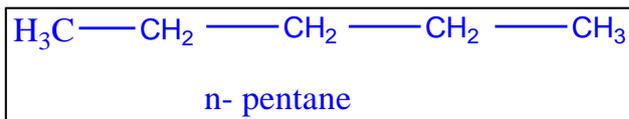
Classification of Isomerism



A. Structural Isomerism

(a) **Chain Isomerism:** It is the phenomenon in which the compounds have the same molecular formula but possess different arrangement of carbon atoms in the main chain.

For example: The molecular formula C_5H_{12} has the following chain isomers.





ACTIVITY 1

2.1.1.1. Draw all the possible chain isomers for the molecular formula C_4H_{10} and name the isomers.

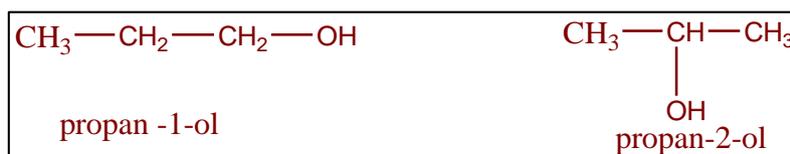
(b) **Position Isomerism:** It is the phenomenon in which the compounds have the same molecular formula but differ in the position of a double bond, triple bond or functional group.

For example: The molecular formula C_4H_8 has the following position isomers.



The above isomers differ in the position of the double bond.

For C_3H_8O the following position isomers are possible.



ACTIVITY 2

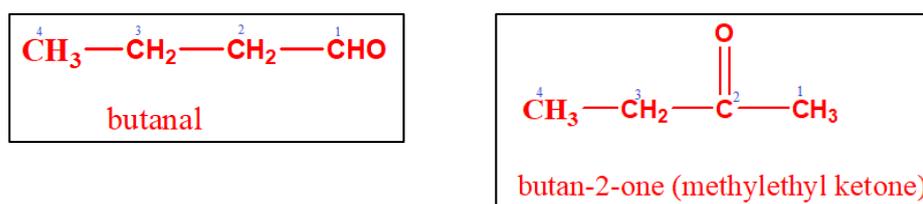
1. Draw all the possible position isomers for the molecular formula C_3H_7Cl and name the isomers.

(c) **Functional Isomerism:** It is the phenomenon in which the compounds have the same molecular formula but a different functional group.

For example: the common molecular formula C_2H_6O can have the following functional isomers



Similarly, the molecular formula C_4H_8O can have the following functional isomers.

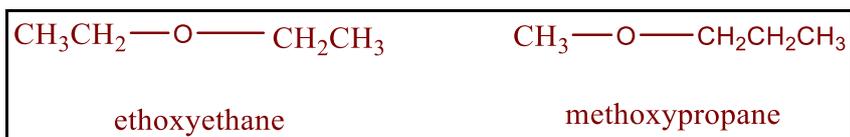


**ACTIVITY 3**

1. Draw all the possible functional isomers for the molecular formula C_3H_6O and name the isomers.

(d) **Metamerism:** It is the phenomenon in which the compounds have the same molecular formula and the functional group but have different alkyl groups attached on both the sides of the functional group. The isomers are called metamers.

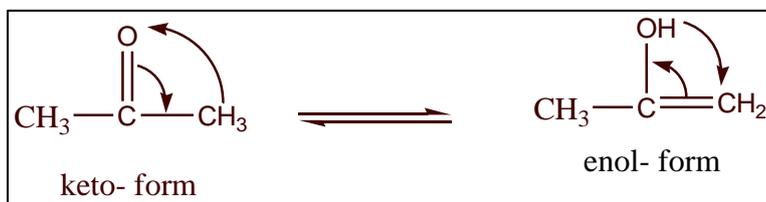
For example: The molecular formula $C_4H_{10}O$ can have the following three isomers of ethers.

**ACTIVITY 4**

1. Draw the third metamer for the above molecular formula.

(e) **Tautomerism:** It is the special type of isomerism in which a single compound exists in two readily interconvertible forms which differ markedly in the relative position of usually hydrogen. The isomers are called tautomers.

For example: Keto- Enol Tautomerism.



These two isomers exist simultaneously in dynamic equilibrium with each other.

**ACTIVITY 5**

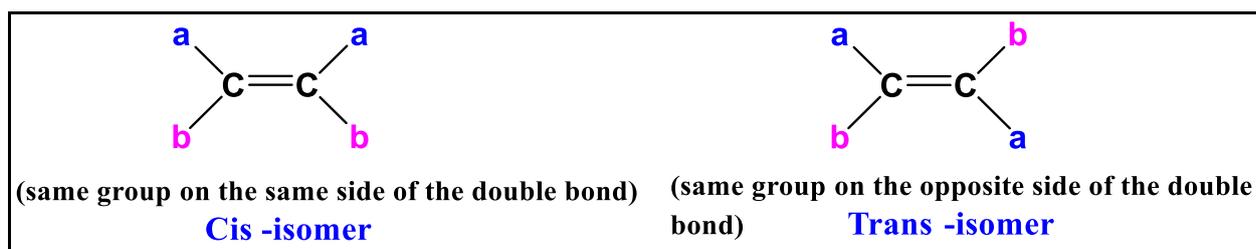
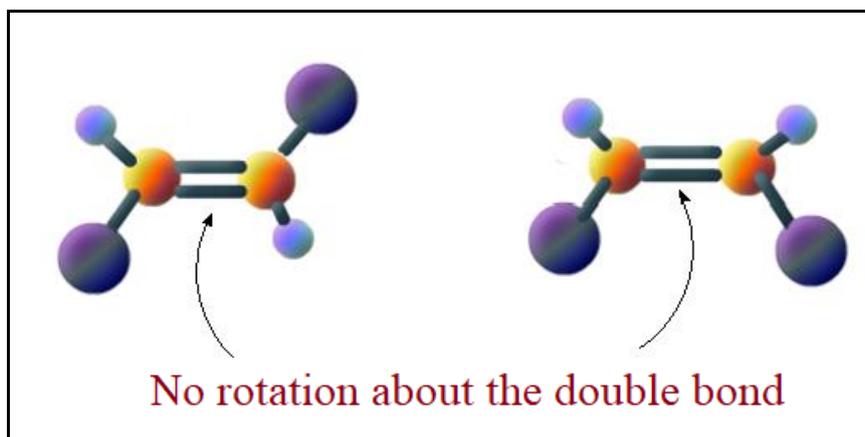
1. Draw the tautomers for nitroethane ($CH_3CH_2NO_2$)

B. Stereoisomerism

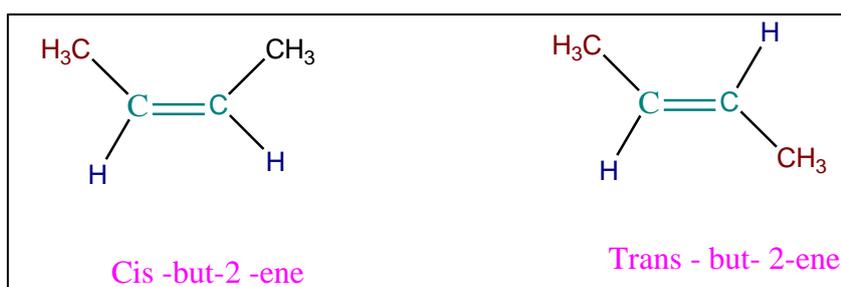
It is the phenomenon in which two or more compounds have the same molecular formula and similar chemical structures but possess different arrangement of atoms or groups in three-dimensional space. It is of two types.

(a) Geometrical Isomerism

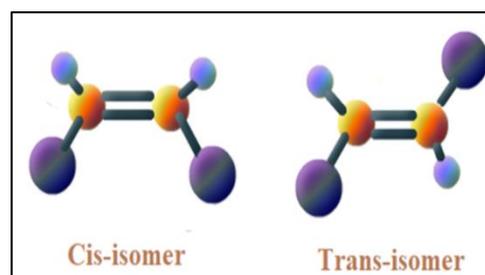
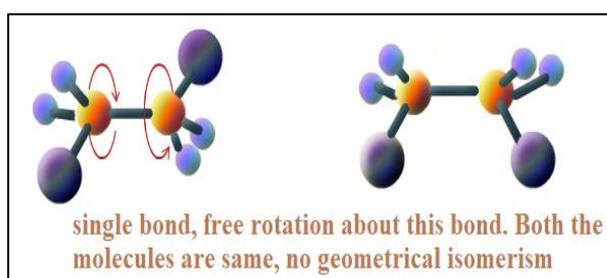
Geometrical isomerism is shown by those compounds containing carbon-carbon double bond which is incapable of rotation. Due to restricted rotation of the double bonds, the positions of an atom or the groups attached to these carbon atoms are fixed and the molecule has a definite orientation. If the two similar atoms or groups are on the same side of the double bond, they are called cis-isomers and if on the opposite side, they are called trans-isomers.



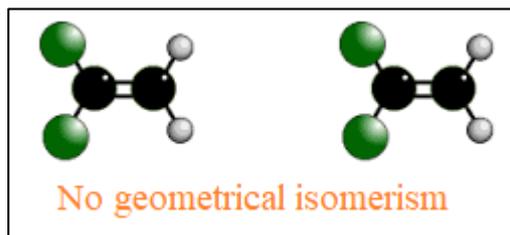
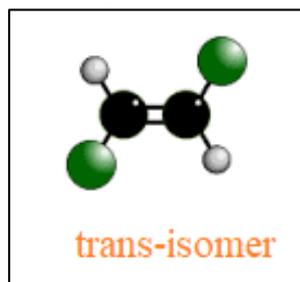
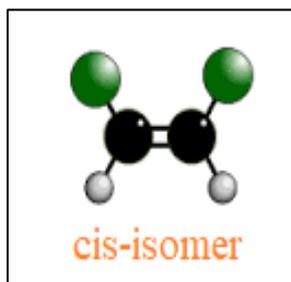
Example:

**Conditions for Geometrical Isomerism**

- a. The molecule must have carbon-carbon double bond.



- b. The molecule should be of the type $abC = Cab$, $axC = Cax$.



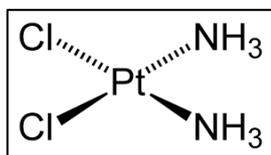
ACTIVITY 6

1. Draw a pair of geometrical isomers for each of the following.



Application of Geometrical Isomers of Chemical Compounds

Cis-platin: A coordination compound is used as chemotherapy drug in the treatment of cancer.



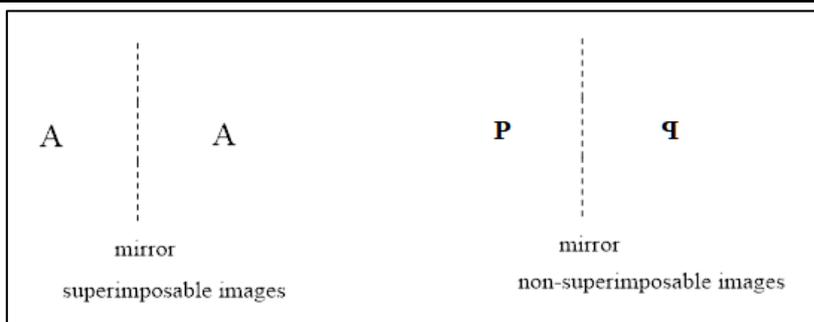
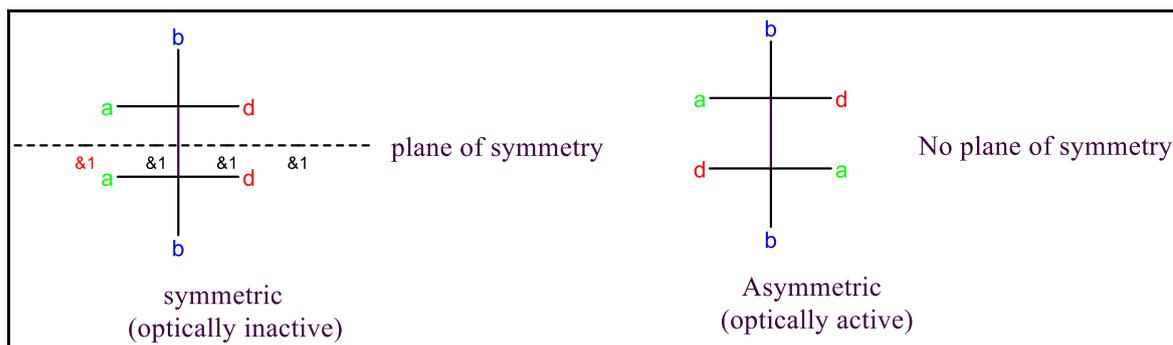
(b) Optical Isomerism

It is the phenomenon of two or more compounds having the same molecular formula and similar chemical structures *but rotates the plane of polarized light in different directions*.

If the isomer rotates in clockwise directions, it is known as **dextrorotatory** (*d*) and if in an anticlockwise direction it is known as **laevorotatory** (*l*).

Conditions for Optical Isomerism

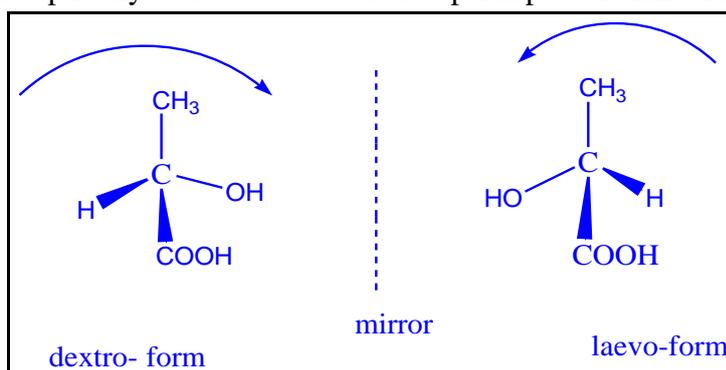
- i. The molecule must be chiral (i.e. the molecule must not possess plane of symmetry).
- ii. The molecule must not superimpose (overlap) on its mirror image.
- iii. The molecule is said to be chiral or dissymmetric when it does not possess plane of symmetry.



Optical Activity of Some of the Organic Compounds

Optical activity of lactic acid ($\text{CH}_3\text{CHOHCOOH}$)

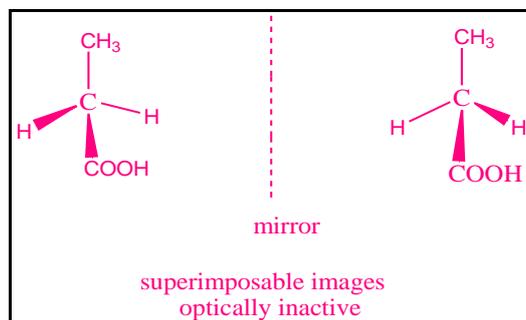
Lactic acid is optically active due to its non-superimposable mirror images.



Two forms of lactic acids are non-superimposable to each other i.e one form of it does not overlap with the other.

Optical Activity of Propanoic Acid ($\text{CH}_3\text{CH}_2\text{COOH}$)

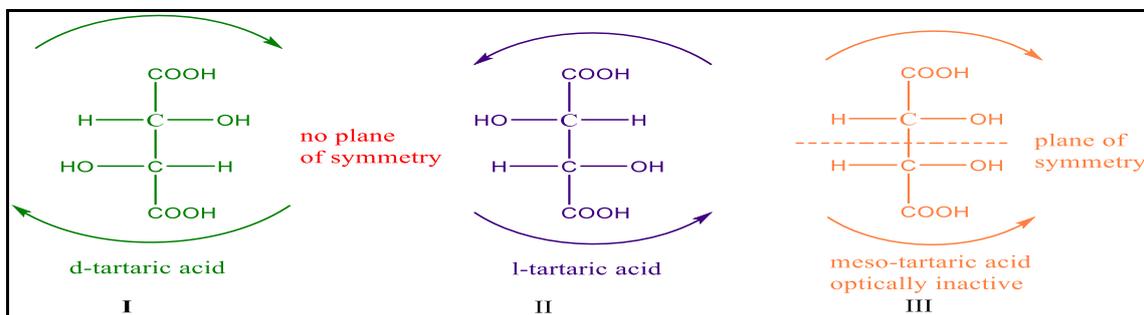
Propanoic acid is optically inactive as its mirror images are superimposable.



ACTIVITY 7

- Which of the following molecules would you expect to be optically active?
 - CCl_2F_2
 - 2-methyl butane
 - Butan-2-ol
- Draw the optical isomers of the ones which are optically active.

Optical Isomerism of Tartaric Acid



The structure I and II of tartaric acid are non-superimposable to each other and are optically active.

Structure III is the meso- tartaric acid which is optically inactive due to plane of symmetry in the molecule where the rotation caused by the upper half of the molecule is exactly balanced by the lower half of the molecule. This phenomenon is known as internal compensation.

Applications of Optical Isomers

- Carvone is the chemical compound which has two optical isomers. The dextro (+) isomer is found in spearmint oil and smells like mint whereas laevo (-) isomer is found in caraway seeds which have a different smell.
- Certain glycolipid has several optical isomeric forms but only one form of it is useful for the body immune system against pathogens.
- The only D-glucose is digested by the human body and not the L-glucose.



Summary

- Isomerism is the phenomenon in which the compounds have the same molecular formula but differ in certain physical and chemical properties.
- In structural isomerism, the compounds have the same molecular formula but have different chemical structures.
- In position isomerism, the compounds differ in terms of position of carbon atoms in the main chain.
- In position isomers, the compounds differ in terms of position of multiple bonds and the functional group along the carbon chain.
- Functional isomers have same molecular formula but different functional groups.
- Metamers have same functional group but differ in the alkyl group attached to both sides of the functional group.
- Tautomers are readily interconvertible compounds markedly differing in the position of atoms such as hydrogen.
- Stereo isomers differ in the position of atoms or group of atoms in three dimensional space.
- In geometrical isomerism, the cis - isomer has the two similar atoms or group of atoms on the same side of the double bond and trans- isomer has the same atoms or group of atoms on the opposite side of the double bond.
- Optical isomers rotate the plane of plane polarized light either in clockwise direction or in anti- clock wise direction.



Self-check for Learning

1. Draw the possible isomers of $C_3H_6O_2$ and name the type of isomer.
2. Differentiate between geometrical isomerism and the optical isomerism
3. Why is the mixture of an equimolar solution of dextro and laevo form of a compound optically inactive?

2.3. HOMOLOGOUS SERIES AND NOMENCLATURE OF ORGANIC COMPOUNDS

Learning Objectives



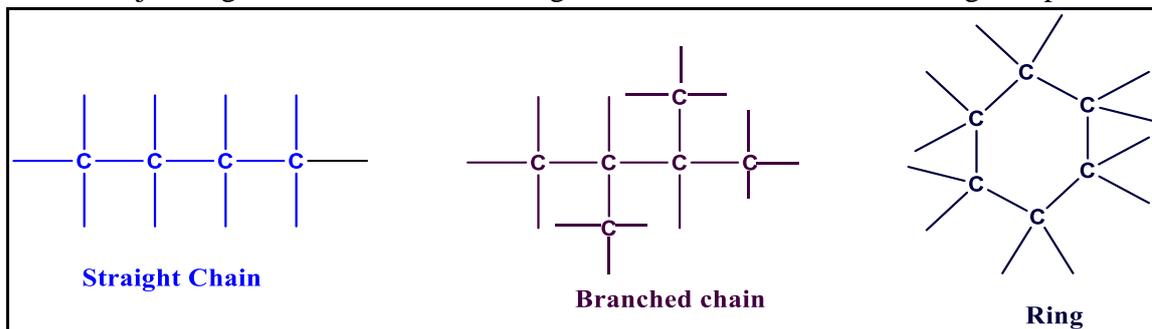
- Define organic compound.
- Classify organic compound.
- Define homologous series.
- Apply the rules to write the IUPAC names of organic compound.

Introduction

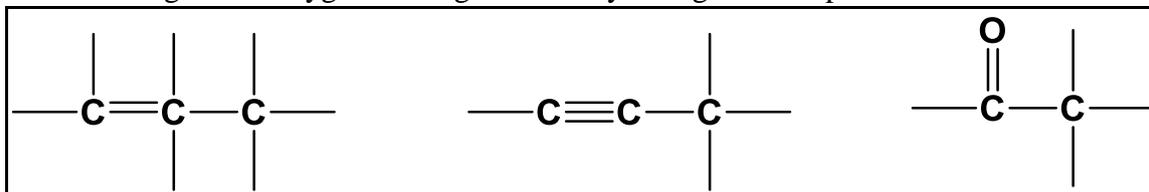
Organic compounds are those compounds containing carbon and hydrogen along with nitrogen and oxygen. Organic compounds differ markedly from inorganic compounds in composition, structure and properties. There are a comparatively large number of organic compounds.

The reasons for the existence of a large number of organic compounds are as follows.

- Catenation:** Carbon atom due to its greater strength of carbon-carbon bond and its tetra-covalency, has the unique property of linking with other carbon atoms to form very long chains. This property is known as catenation. A large number of carbon atoms join together to form either straight-chain, branched-chain or ring compounds.



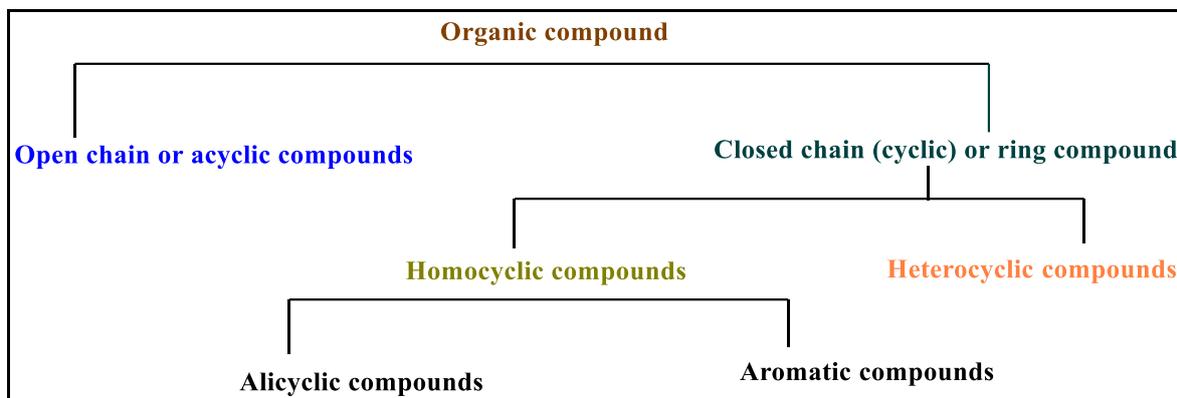
- Multiple bonds:** Carbon atom due to its small size and four valence electrons, can form multiple bonds with some other carbon atoms as well as with other atoms such as nitrogen and oxygen leading to a variety of organic compounds.



- Isomerism:** Organic compounds can exhibit the phenomenon of isomerism (the phenomenon in which compounds have the same molecular formula but the different chemical structure or a different arrangement of atoms in space) which also helps to increase in the variety and the number of the compounds.

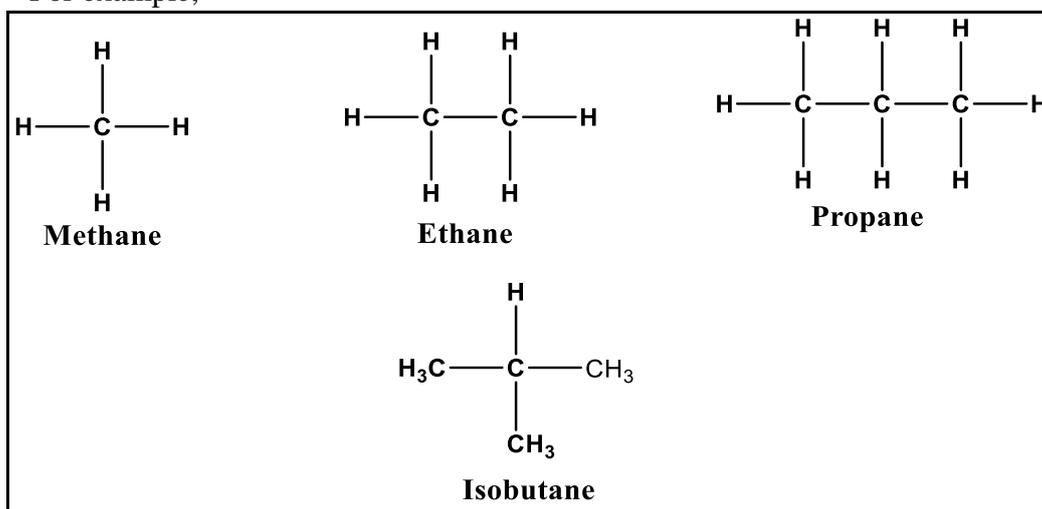
Classification of Organic Compounds

Organic compounds are broadly classified as follows.



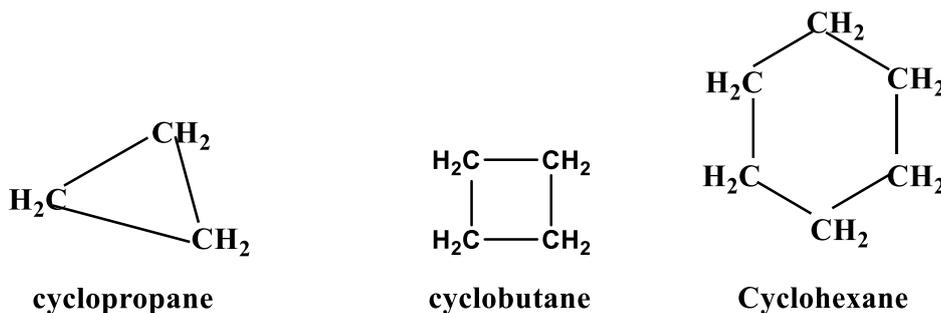
1. **Open chain or acyclic compounds:** This group of organic compounds contains an open chain of carbon atoms. They are also known as aliphatic compounds.

For example,

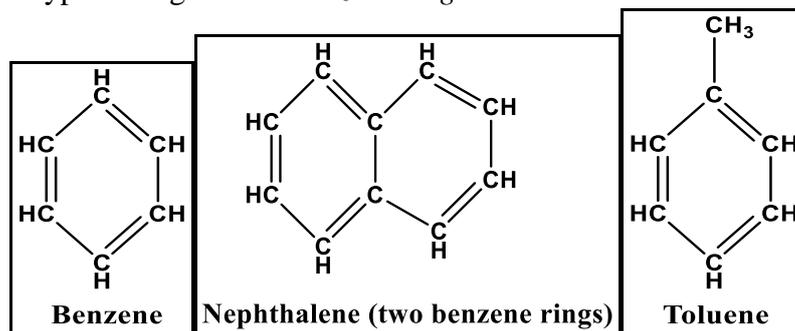


2. **Closed chain or cyclic compounds:** These compounds contain a closed ring of carbon atoms. These group of compounds are further classified as;

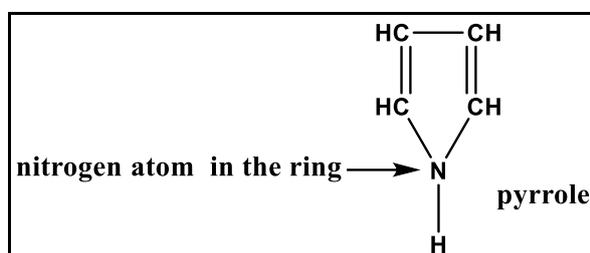
- i. **Homocyclic compound:** This class of compounds contains a ring of only carbon atoms. It is of the following two types.
 - a. **Alicyclic compounds:** These compounds contain a ring of three or more carbon atoms. For example:



- b. **Aromatic compound:** These are the organic ring compounds containing one or more special type of rings called *benzene ring*.



- ii. **Heterocyclic compounds:** These are also cyclic compounds but the ring contains one or more atoms other than carbon. For example,



Homologous Series

Organic compounds can also be classified into various families. The members of a particular family are represented by a general molecular formula and have almost similar chemical properties. Homologous series may be defined as series of similarly constituted organic compounds in which the members have the same functional group, have almost same chemical properties, represented by same general formula and the two consecutive members differ by $-\text{CH}_2$ group in their molecular formula.

For example: The members in the homologous series of alcohol are as follows.

differ by $-\text{CH}_2$	CH_3OH	methyl alcohol
	$\text{CH}_3\text{CH}_2\text{OH}$	ethyl alcohol
differ by $-\text{CH}_2$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	propyl alcohol
	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	butyl alcohol
	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	pentyl alcohol



ACTIVITY 1

- Write the homologous series of alkane up to six carbons.

Nomenclature of Organic Compounds

There are two systems of naming the organic compounds, trivial system and the IUPAC system.

In the trivial system, organic compounds are named after the source from which they are obtained.

For example, formic acid is derived from formica (meaning red ant) because the acid was obtained from sting of red ant.

However, with the increase in the number of organic compounds and the advancement of organic chemistry, the trivial system did not serve the purpose.

The International Union of Pure and Applied Chemistry (IUPAC) is the latest system of naming organic compounds adopted and accepted by the entire scientific community all over the world.

IUPAC Nomenclature of Organic Compound

In the IUPAC system, the name of an organic compound consists of the following parts:

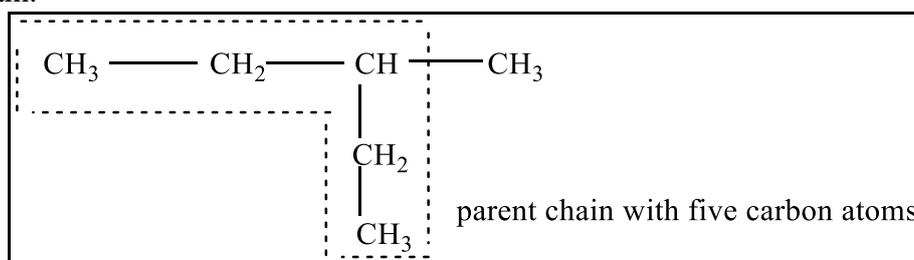
- i. Root word
- ii. Primary suffix
- iii. Secondary suffix
- iv. Prefix

The different parts in the name of an organic compound are arranged as follows.

Prefix + root word + primary suffix + secondary suffix.

The IUPAC names of all the organic compounds will consist of root word and the primary suffix though they may or may not have the prefix and the secondary suffix.

Parent Chain: It is the longest possible continuous chain of carbon atoms in the molecule. The first step involved in IUPAC system of naming the organic compound is the selection of parent chain.



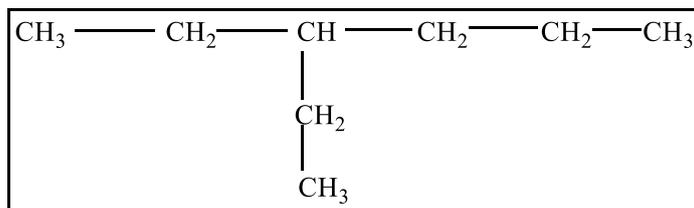
The carbon atoms in the parent chain should be numbered as 1, 2, 3 ...



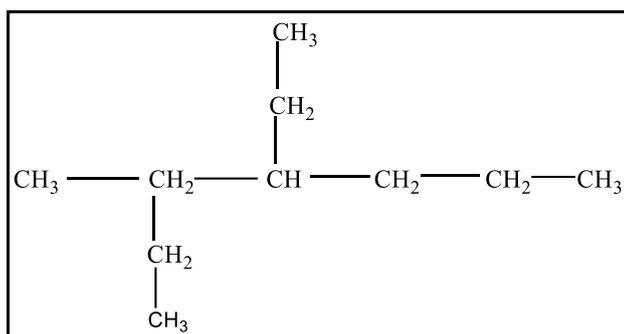
ACTIVITY 2

1. Select the parent chain in the following compounds.

i.



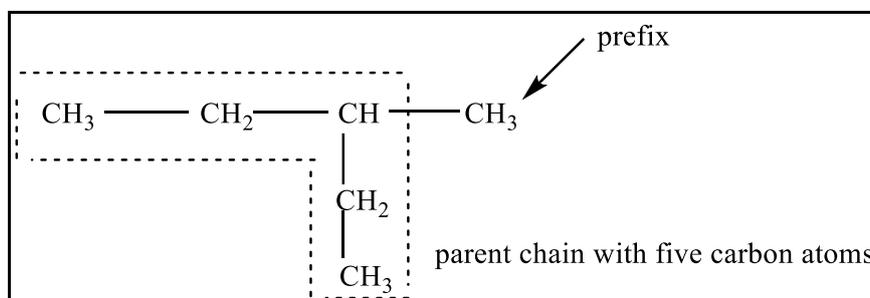
ii.



Root Word: The root word in the name of an organic compound represents the number of carbon atoms in the parent chain.

Number of carbon atoms in the parent chain	Root word
1 (C ₁)	Meth-
2 (C ₂)	Eth-
3 (C ₃)	Prop-
4 (C ₄)	But-
5 (C ₅)	Pent-
6 (C ₆)	Hex-
7 (C ₇)	Hept-
8 (C ₈)	Oct-
9 (C ₉)	Non-
10 (C ₁₀)	Dec-

For example:



Root word: pent –

Prefix: It represents the alkyl group or atom or group of atoms attached to carbon atoms of the parent chain. Such alkyl group, atom or group of atoms is regarded as substituents or side chains. Prefix is added before the root word.

Examples of few alkyl groups:

Alkyl group	Name
CH ₃ –	Methyl
CH ₃ CH ₂ – (or –C ₂ H ₅)	Ethyl
CH ₃ CH ₂ CH ₂ – (or –C ₃ H ₇)	Propyl
CH ₃ CH ₂ CH ₂ CH ₂ – (or –C ₄ H ₉)	Butyl

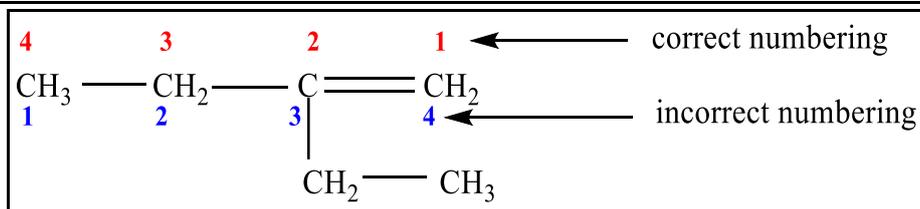
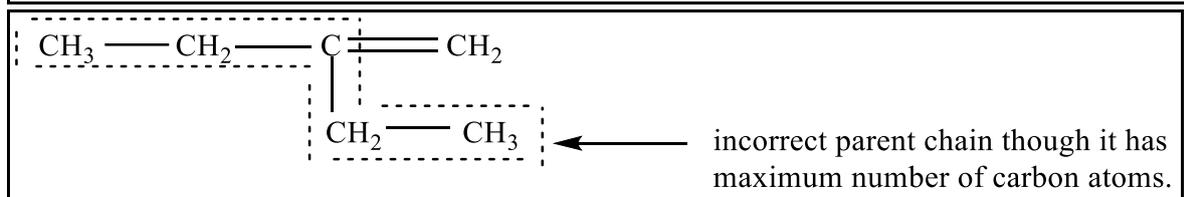
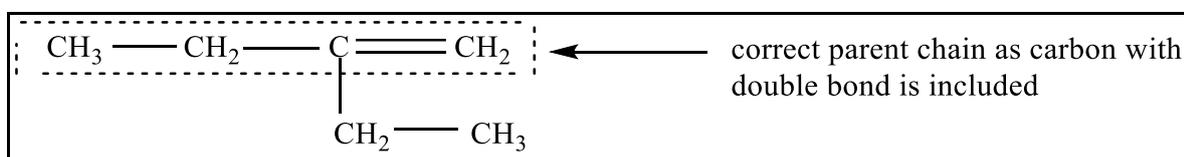
Primary suffix:

It is added to the root word which represents the saturation and unsaturation of carbon atoms in the parent chain.

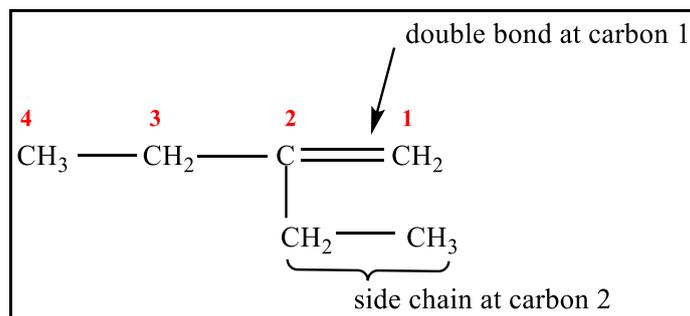
Nature of carbon chain	Primary suffix	General name
Saturated (C–C single bond)	-ane	alkane
Unsaturated (C = C, double bond)	-ene	alkene
Unsaturated (C≡C), triple bond)	-yne	alkyne

While selecting the parent chain, the carbon atoms with a double bond and a triple bond must be included though it may not be the longest chain and the numbering of carbon atoms in the parent chain must be done in such a way that the carbon with the double bond or the triple bond gets the lowest possible number.

For example:



The positions of side chains, double bond or the triple bond on the parent chain are indicated by the carbon number.

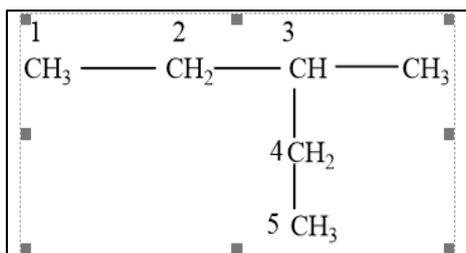


Root word: but-

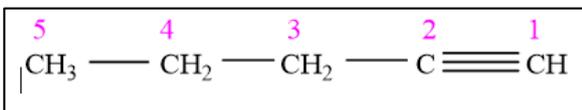
Primary suffix: -ene

Prefix: -ethyl at position 2

Complete name: 2-ethyl + but + 1-ene = **2-Ethylbut-1-ene or 2-ethylbutene.**



Root word: pent-
 Primary suffix: -ane
 Prefix: methyl at position 3
 Complete name: **3-Methylpentane**

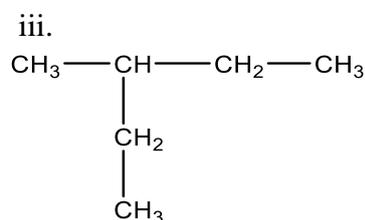
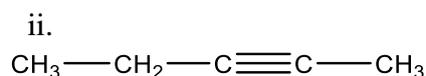
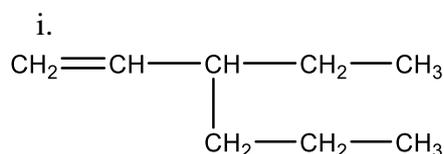


Root word: pent -
 Primary suffix: -yne
 Prefix: nil
 Complete name: **Pent-1-yne or 1-pentyne 1.**



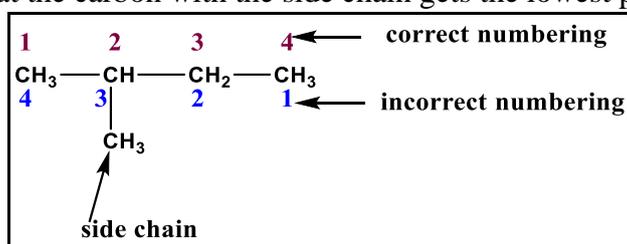
ACTIVITY 3

1. Write the IUPAC name of the following compounds.



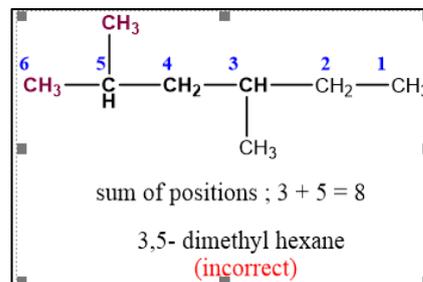
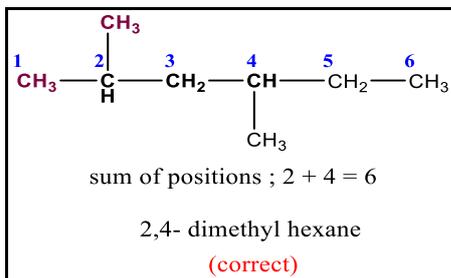
Naming of Alkanes with side chains/substituents

In alkanes with a side chain, the numbering of carbon atoms on the parent chain should be done in such a way that the carbon with the side chain gets the lowest possible number.



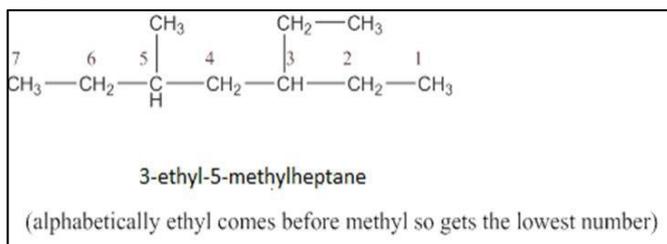
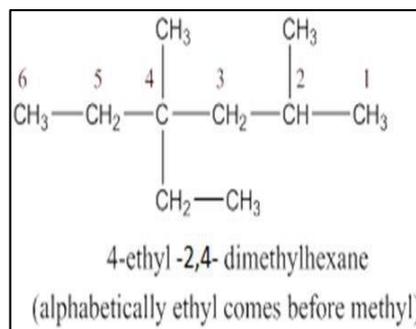
2-Methylbutane

If the same side chains are present at different positions on the parent chain, the numbering is done using the lowest **sum rule** in which sum of the positions of the side chains/substituents is minimum.



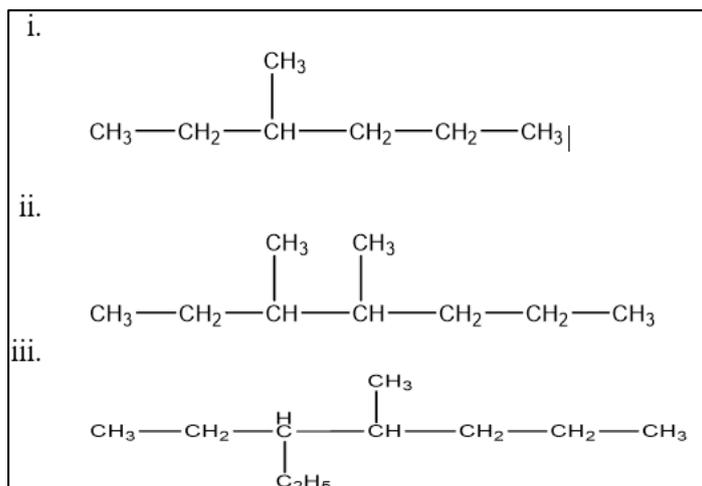
If there are two different side chains/substituents on the parent chain, numbering is done according to the lowest **sum rule** and their names are written according to the alphabetical order.

If the two different side chains/substituents are present at the equivalent position from both the ends of the parent chain, then the numbering of carbon atom is done in such a way that the substituent which comes first in the alphabetical order gets the lowest possible number.



ACTIVITY 4

1. Write the IUPAC name of the following compounds.



Secondary Suffix

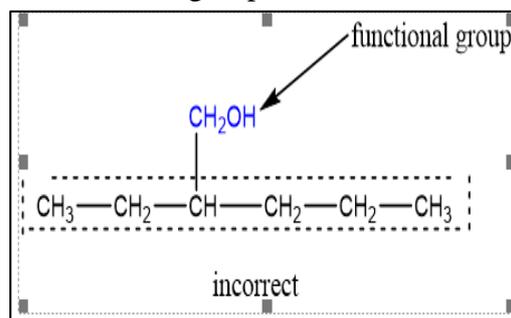
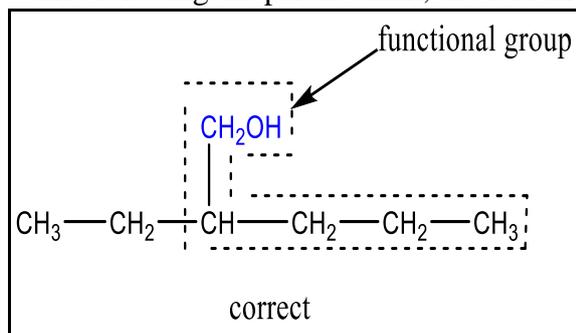
The secondary suffix in the IUPAC name of the organic compound represents the type of functional group in the compound. It is added after the primary suffix. But in some cases, it is prefixed to the name of corresponding parent hydrocarbon. – NO₂ is such group and the compound CH₃NO₂ is named as nitromethane.

Some of the common functional group and their suffix are as follows.

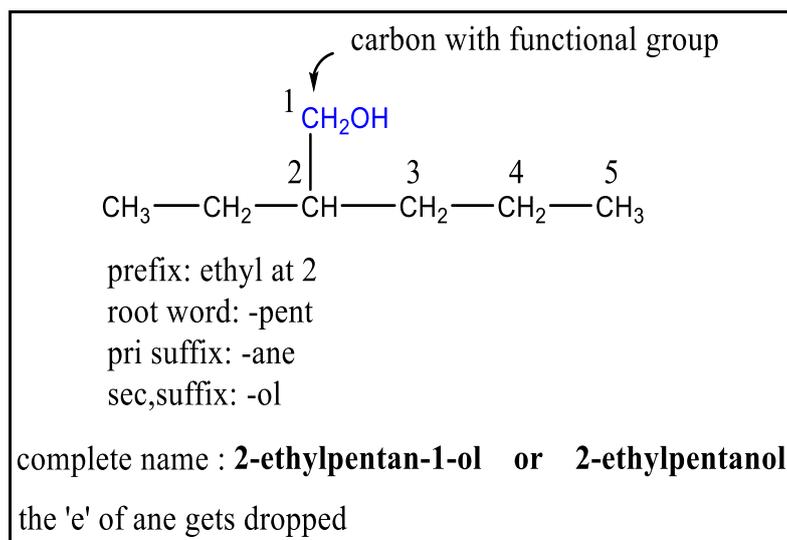
Class of compound	Functional group	Suffix
Alcohol	-OH	-ol
Aldehyde	-CHO	-al
Ketone	>C=O	-one
Carboxylic acid	-COOH	-oic acid
Amine	-NH ₂	-amine
Amide	-CONH ₂	-amide
Halide	-X (F,Cl,Br,I)	-halo, (fluoro, chloro, bromo, iodo,...)
Ether	-OR (R= alkyl group)	-alkoxy (methoxy, ethoxy,...)

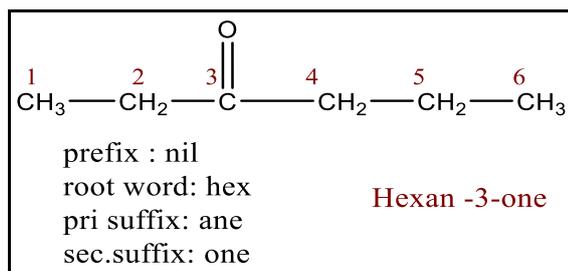
Compounds Containing only one Functional Group

While selecting the parent chain, the carbon with the functional group must be selected.

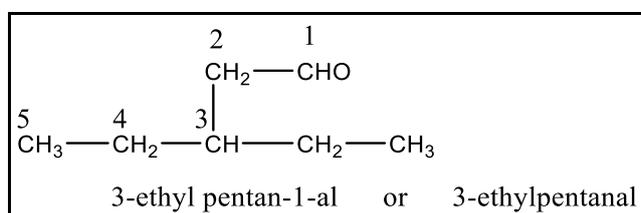
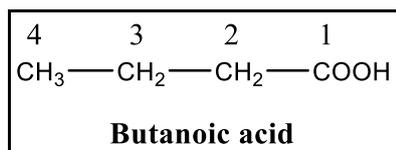


The numbering of the carbon atoms in the parent chain is done in such a way that, the carbon with a functional group gets the lowest number.

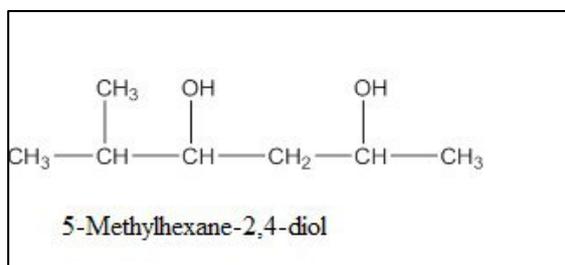




If the functional group contains a carbon atom ($-\text{COOH}$, $-\text{CHO}$, $-\text{CONH}_2$, $-\text{CN}$), it must be included in the parent chain and given the lowest number while numbering.



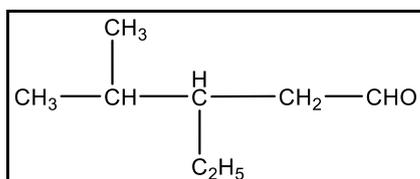
If there are more than one same functional group present in the molecule, the prefix di, tri, tetra etc. are added.



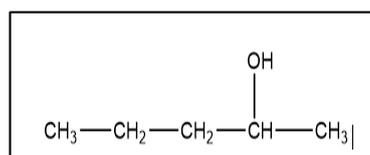
ACTIVITY 5

1. Write the IUPAC name of the following compounds.

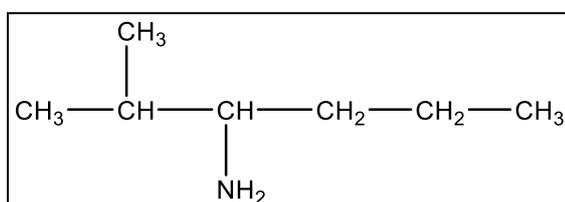
i.



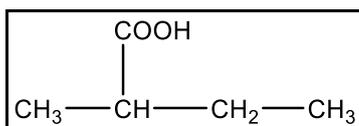
ii.



iii.

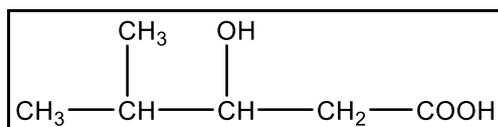


iv.



If the compound contains more than one functional group, one of them is considered as a principal functional group and named accordingly and the rest are considered as substituents. The identification of the principal functional group is done based on the position in the seniority table. The group lying above the other in the seniority table will be considered as the principal functional group.

For example,



The $-\text{COOH}$ group lies above $-\text{OH}$ group in the seniority list. Therefore $-\text{COOH}$ acts as the principal functional group in preference to $-\text{OH}$ group. The $-\text{OH}$ group is considered as a substituent.

The IUPAC name of the compound is **3-hydroxy-4-methylpentanoic acid**.



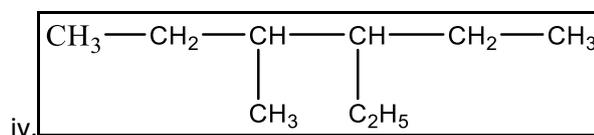
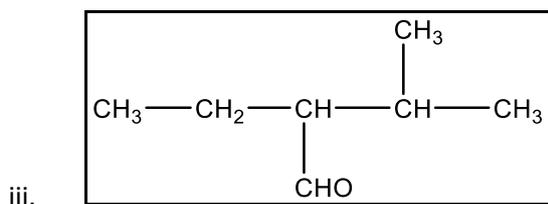
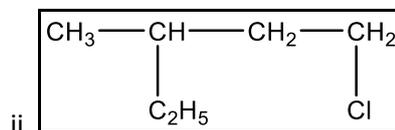
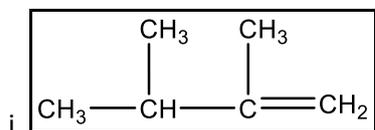
Summary

- Organic compounds are group of compounds, consisting of carbon and hydrogen as the main components along with other atoms such as oxygen, nitrogen etc.
- In trivial system of naming the compounds, the compounds are named according to the source from which they are obtained.
- Organic compounds are broadly classified under open chains compounds and closed chain or cyclic compounds.
- Homologous series is a series of similarly constituted organic compounds in which the members have the same functional group, have almost same chemical properties, represented by same general formula and the two consecutive members differ by $-\text{CH}_2$ group in their molecular formula.
- The IUPAC names of organic compounds consists of prefix, root word, primary suffix and secondary suffix.
- Parent chain is the longest continuous chain of carbon in the molecule.
- In the IUPAC name, the root word indicates the number carbon atoms, in the parent chain.
- The primary suffix, indicates the presence of type of covalent bond between the carbon atoms in the parent chain.
- The secondary suffix indicates the presence of functional group in the molecule.
- The prefix indicates the side chains or substituents attached to parent chain.



Self-check for Learning

Write the IUPAC names of the following compounds.



2.4. AMINES

Learning Objectives

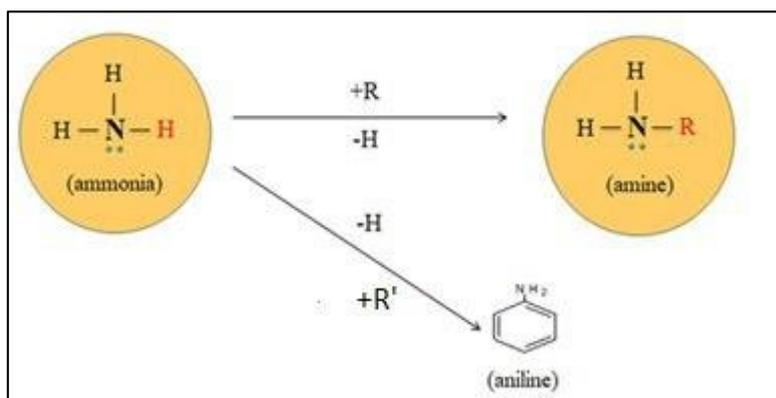


- Define amines.
- Compare different types of amines.
- Write IUPAC names of amines.
- Explain the general methods of preparation of amines.
- Compare the basicity of different amines.

Introduction

In organic chemistry, amines are compounds having functional groups that contain a basic nitrogen atom with a lone pair. The nitrogen atom in an amine has a lone pair of electrons and has three bonds with other atoms, either carbon or hydrogen. Primary aromatic amines are used as a material for the manufacture of azo dyes.

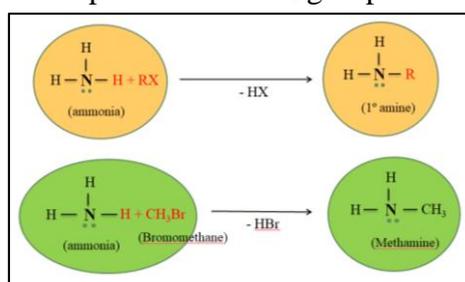
Structurally amines resemble ammonia. In an amine, one or more of the hydrogen atoms from ammonia are replaced by organic substituents like alkyl/R (alkane chain) and aryl (R' - is called aromatic ring) group.



Classification of Aliphatic Amines

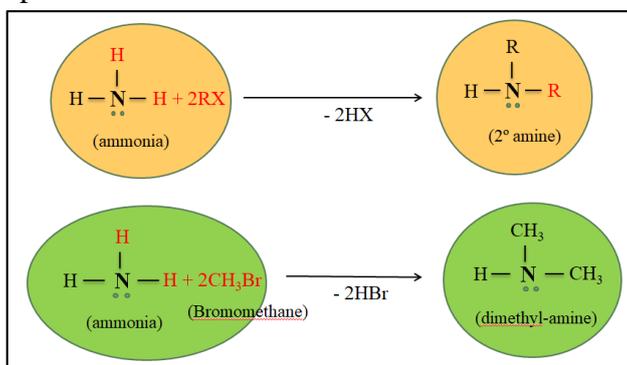
Based on the number of carbon atoms bonded directly to the nitrogen atom, amines are classified into three types, namely Primary (1^0) amine, Secondary (2^0) amine and Tertiary (3^0) amine.

1. *Primary (1^0) amines*- Amines in which one hydrogen atom of ammonia is replaced by one alkyl group. This organic compound has $-\text{NH}_2$ group as the functional group.



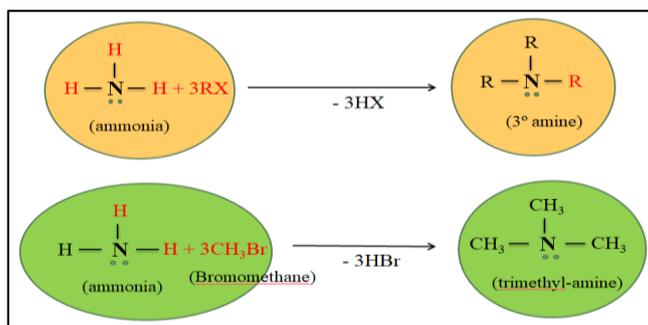
The above compounds have the general formula: $\text{R} - \text{NH}_2$

2. *Secondary (2^o) amine*- Amines in which two hydrogen atoms of ammonia are replaced by two alkyl groups (same or different). This organic compound contains –NH group as the functional group.



The above compounds have the general formula: (R)₂NH.

3. *Tertiary (3^o) amine*- Amines in which all three hydrogen atoms of ammonia are replaced by three alkyl groups. Organic compounds contain –N– (tertiary nitrogen) as the functional group.



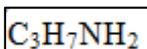
The above compounds have the general formula: R₃N



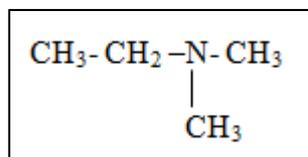
ACTIVITY 1

1. Classify the following amines into primary, secondary and tertiary amines:

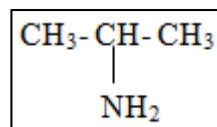
a.



b.



c.

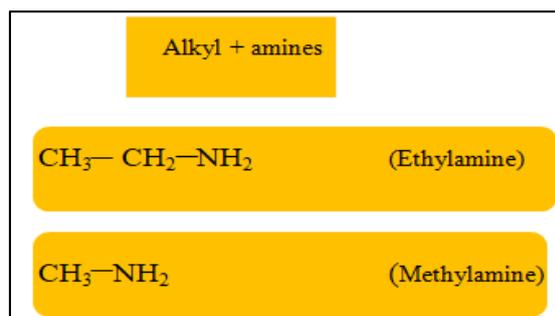


Nomenclature of Aliphatic Amines

The naming of amines is done in two ways:

1. Common System

- i. *Primary amines*: Suffix amine is added to the alkyl group attached to the nitrogen atom of the –NH₂ group.



- ii. *Secondary and Tertiary amines:* If two or more different alkyl groups are linked to the same N atom in an amine, then alkyl groups are listed in the order of increasing size and then the word amine is added at the end.



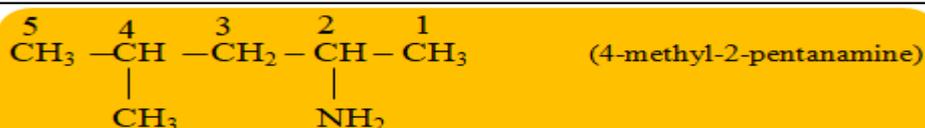
If the same alkyl group occurs twice or thrice on the same N-atom, then prefixes such as di- or tri- is placed before the name of the alkyl group.



2. IUPAC System

The IUPAC name is named by replacing the 'e' of the Parent alkane by the suffix amine.

Alkan + amine



Secondary Amines

They are named as N-alkylalkanamine with largest alkyl group forming the alkanamine part, while the smaller alkyl group forming the substituent.

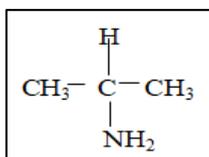




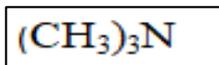
ACTIVITY 2

1. Write the IUPAC name of the following compounds.

a.



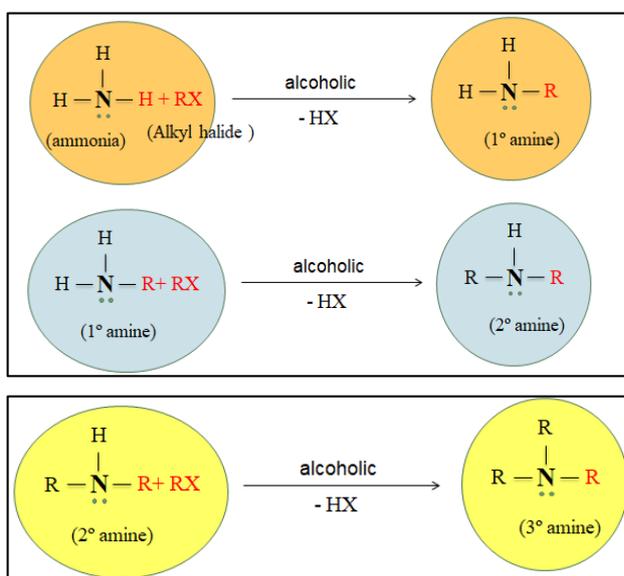
b.



General Methods of Preparation of Amines

1. By heating alkyl halide with an alcoholic solution of ammonia

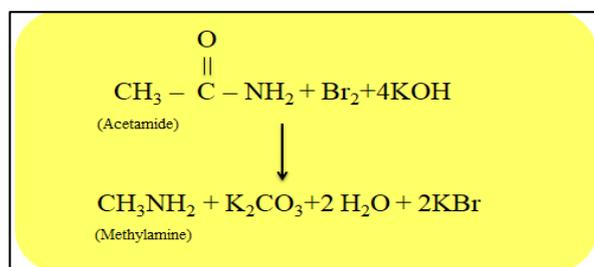
The reaction of ammonia with an alkyl halide leads to the formation of a primary amine. The primary amine formed can also react with the alkyl halide, to form secondary amine which can further react with an alkyl halide to form tertiary amine.



2. By Hoffmann's degradation method

It is also known as Hoffmann's bromamide reaction.

In this method, the carboxylic amide is converted into primary amines with one less carbon atom.

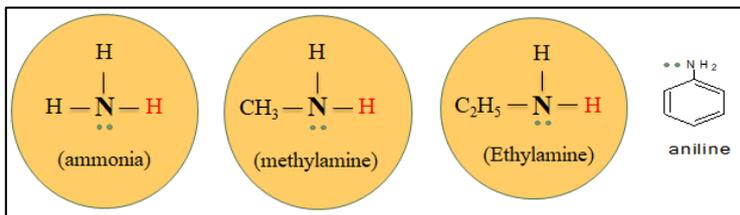


Amine is an organic compound which is made up of one or more nitrogen atoms which are bonded to alkyl groups. Amide is an organic compound or molecules that contain nitrogen atoms connected to the carbon atom of carbonyl group.

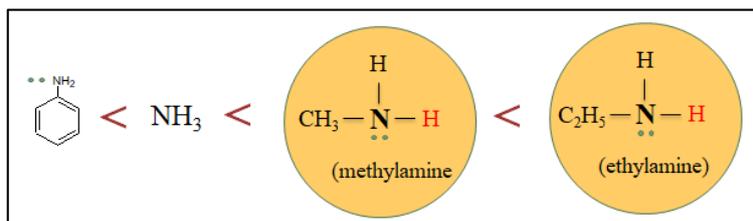
Chemical Properties of Amines

1. Basic nature of Amines

Since N-atom of amines has a lone pair of electrons, amines have the tendency to donate the lone pair of electrons to electron deficient species, and thus amines show the basic nature.



The basicity of amines is in the order:



Following are the reasons:

- Aniline is less basic than ammonia and other aliphatic amines because the lone pair of electrons present in nitrogen atom is delocalized into the benzene ring. Hence it will be less available for protonation.
- Ammonia is less basic than other aliphatic amines because it does not contain any electron releasing group attached to a nitrogen atom.
- Methylamine is more basic than ammonia because it contains electron releasing methyl group. This makes the donation of lone pair present on nitrogen atom easier.
- Ethylamine is more basic than methylamine because as the size of alkyl group increases, the electron releasing power also increases (+ I effect). Hence lone pair of electrons present on nitrogen atom of ethylamine can be donated more easily than the lone pair of electrons present on the nitrogen atom of methylamine.

Comparison of Basicity of Primary, Secondary, Tertiary Amines and Ammonia

The order of basic strength of amine is:

Secondary Amine > Primary Amine > Tertiary Amine > Ammonia

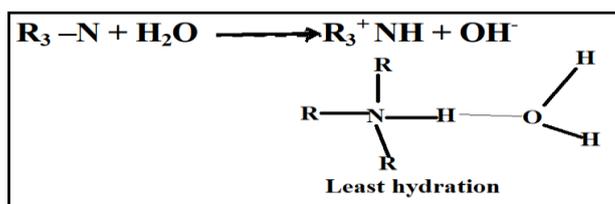
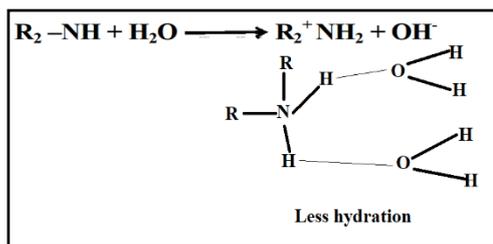
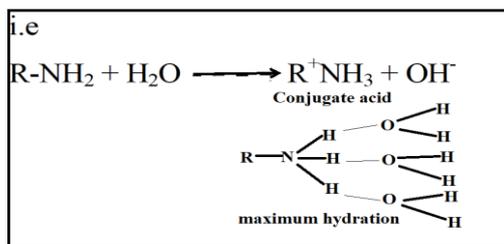
This is due to the following factors:

1. Steric Factor

- The presence of bulky group (alkyl) attached to nitrogen hinders the protonation of amines and thus decreases the basic strength of amine. This effect is called steric hindrance.
- Tertiary alkyl amine is least basic as it has the maximum steric hindrance.

2. Hydration of ions

- On the basis of the stabilization of the conjugate acids, the basic strength is in the order of:
Ammonia > Primary amine > Secondary amine > Tertiary amine
- Hydration requires the formation of hydrogen bond with water molecules which are formed through hydrogen atom attached to the nitrogen atom.
- Larger the number of hydrogen atom attached to the nitrogen atom, more is the extent of hydration and greater is the stability of conjugate acids that is greater the basic strength.

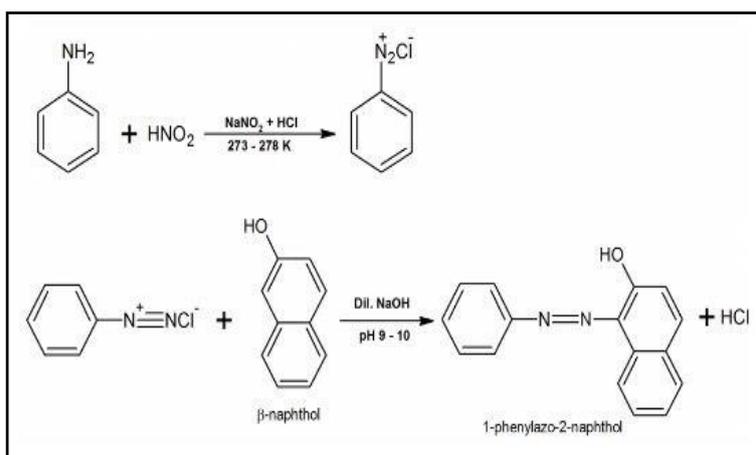


Combining the above factors, the observed order of the basic strength of amine is in the order:

Secondary Amine > Primary Amine > Tertiary Amine > Ammonia

Test to distinguish primary aliphatic amine from primary aromatic amine

- Azo dye test:** Primary aromatic amine reacts with acidic sodium nitrite solution to form benzene diazonium salt. This benzene diazonium salt reacts with β -naphthol to give brilliant orange-red dye. Primary aliphatic amine will not give this test. This test is used to distinguish between aniline ($\text{C}_6\text{H}_5\text{NH}_2$) and ethyl amine ($\text{C}_2\text{H}_5\text{NH}_2$).





Summary

- In amines, one or more of the hydrogen atoms from ammonia are replaced by organic substituents.
- Amines are classified into Primary, Secondary and Tertiary amines based on the number of carbon atoms bonded directly to the nitrogen atom.
- In the common nomenclature of amines, the suffix 'amine' is added to the alkyl group attached to the nitrogen atom of the -NH_2 group.
- In the IUPAC nomenclature of amines, the suffix amine is replaced to the parent alkane (removing 'e' from the alkane)
- In Hoffmann's method for the preparation of amines, the carboxylic amide is converted into primary amines with one less carbon atom.
- The basicity of amine is due to the presence of its lone pair of electron.
- The basicity of amines is in the order:
Secondary amine > Primary amine > Tertiary amine > Ammonia
- Azo dye test is used to distinguish primary aliphatic amine from primary aromatic amine.



Self-check for Learning

Answer the following questions in your notebook.

1. Why does the basicity of amines increase in the following order?

Secondary amine > Primary amine > Tertiary amine > Ammonia > Aniline

2. State any two applications of amines.

2.5. ACID BASE EQUILIBRIA

Learning Objectives



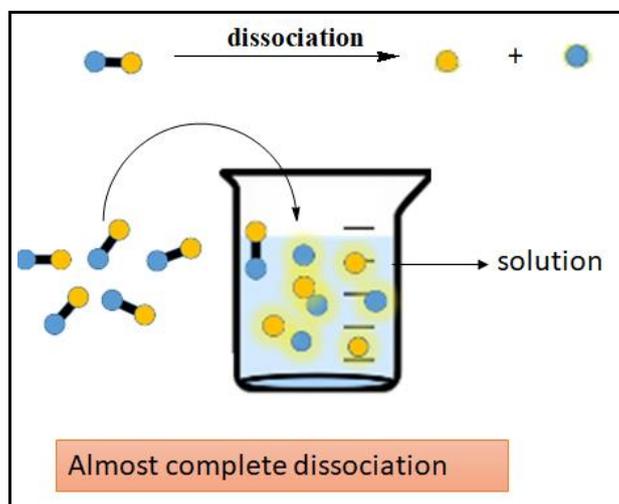
- Explain strong electrolyte and weak electrolyte.
- Define acid- base equilibria.
- State Ostwald's dilution law.
- Calculate the pH of solution.
- Explain buffer solution.

Introduction

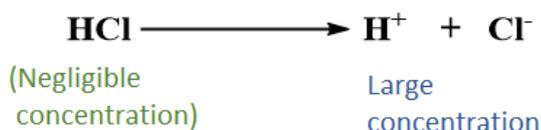
There are certain solutions which allow to pass through them. Such solutions are called electrolytic solutions. The conduction of electric current through the solution is due to the presence of ions. The properties of the electrolytic solutions are decided by the number and the nature of ions present in it.

Certain types of chemical substances dissociate to produce ions in their aqueous solutions and are known as electrolytes. Some electrolytes dissociate completely to give a large number of ions while other electrolytes dissociate partially to give fewer numbers of ions. Depending upon the extent of dissociation, electrolytes are classified as follows.

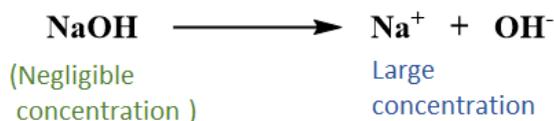
- Strong electrolyte:** It is the electrolyte which dissociates almost completely when dissolved in water. The solution of such electrolyte will have a large concentration of ions compared to the concentration of un-dissociated molecules.



Example : strong acid

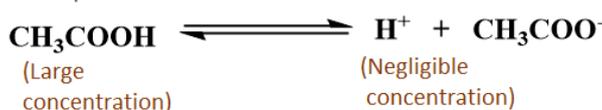


Example : strong base

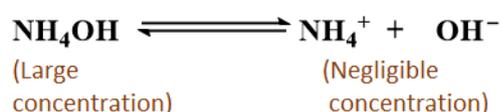


- ii. **Weak electrolyte:** Electrolyte which dissociates partially in its aqueous solution. Solution of such electrolyte will contain fewer ions than the un-dissociated molecule.

Example : weak acid



Example : weak base



Acid base equilibria are therefore, the equilibrium between the dissociated ions and the un-dissociated molecules of weak electrolyte.

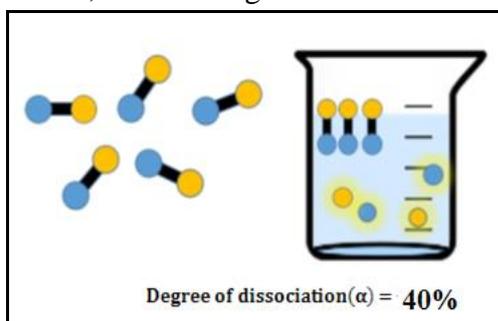
Degree of dissociation (α)

Degree of dissociation is the extent to which an electrolyte dissociates in its aqueous solution. *Mathematically:*

$$\text{Degree of dissociation}(\alpha) = \frac{\text{number of moles of electrolyte which dissociate}}{\text{total number of moles of electrolyte}}$$

For example: If 1.5 moles of acetic acid is taken and 0.3 moles of it dissociates in the solution, then the degree of dissociation is

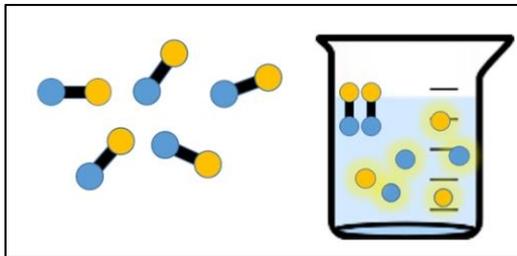
$$\text{Degree of dissociation}(\alpha) = \frac{0.3}{1.5} = 0.2 \text{ or } 20\%$$





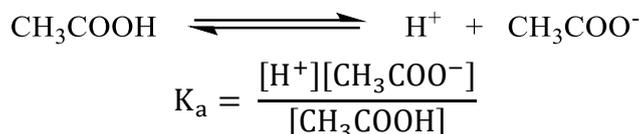
ACTIVITY 1

1. What would be the degree of dissociation of the electrolyte in a solution given below?

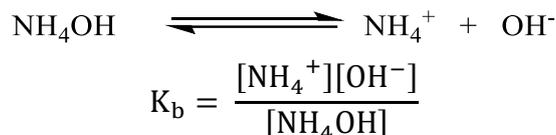


- What would be the degree of dissociation of HCl?
- Will there be acid–base equilibrium for HNO₃?

Dissociation/Ionization Constant of Acid and Base



K_a = dissociation/ ionization constant of acid



K_b = dissociation/ ionization constant of base

Strength of Acid and Base

Strength of Acid: It is the capacity of an acid to give H⁺ ions in its aqueous solution.

Larger the value of ionization constant (K), greater is the strength of acid.

For Example:

K_a value of CH₃COOH = 1.8 X 10⁻⁵

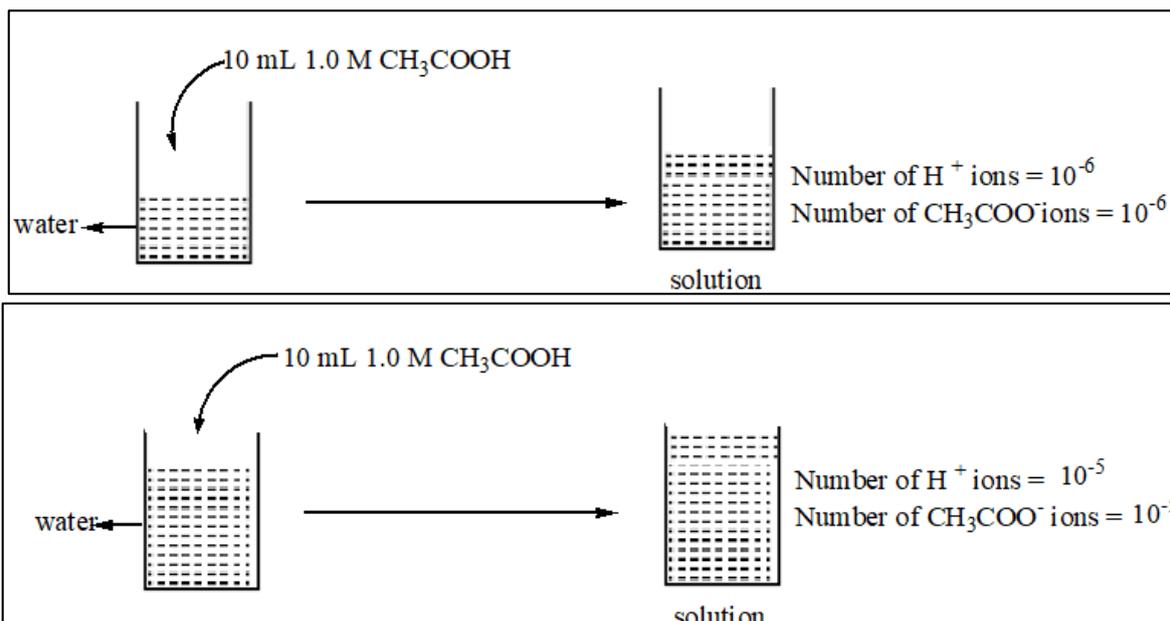
K_a value of HCN = 7.1 X 10⁻¹⁰ (CH₃COOH is stronger than HCN)

Strength of Base: It is the capacity of a base to give OH⁻ ions in its aqueous solution.

NaOH is a stronger base than NH₄OH.

Ostwald's Dilution Law

Study the following figures which show the result of the addition of the same volume of acetic acid to different volumes of water. Display the following illustrations and explain the difference in the extent of dissociation of a weak acid in relation to number of ions and volumes of the solutions.



The two solutions contain the same amount of acetic acid but they contain different number of ions due to different volumes. Ostwald's dilution law explains the extent of dissociation of weak electrolyte in relation to number of ions and volumes of the solutions. The degree of dissociation of a weak electrolyte increases with the increase in dilution volume.

Mathematical form of Ostwald's Dilution Law

Let AB be the weak electrolyte which dissociates as follows:



Suppose 1.0 mole of this electrolyte is dissolved in 'V' litre of solution and ' α ' be its degree of ionization, the concentrations of ions and the undissociated molecules in the solution can be expressed as follows.

	AB	\rightleftharpoons	A^+	+	B^-
Initial amount:	1.0		0		0
Amount at equilibrium:	$(1 - \alpha)$		1α		1α
concentration $\left(\frac{\text{mole}}{\text{L}}\right)$:	$\frac{1 - \alpha}{V}$		$\frac{\alpha}{V}$		$\frac{\alpha}{V}$

We know:

$$K = \frac{[\text{A}^+][\text{B}^-]}{[\text{AB}]}$$

$$K = \frac{\frac{[\alpha]}{V} \times \frac{[\alpha]}{V}}{\frac{[1-\alpha]}{V}}$$

$$K = \frac{\alpha^2}{[1-\alpha]V}$$

For a dilute solution, ' α ' is very small and $(1-\alpha)$ is almost equal to 1

$$K = \frac{\alpha^2}{v}$$

$$\alpha^2 = KV$$

$$\alpha = \sqrt{KV}$$

In terms of concentration 'c'

$$\alpha = \sqrt{\frac{K}{c}}$$

Based on the mathematical form of Ostwald's dilution law, it can be stated as follows.

Ostwald's dilution law states that the degree of dissociation of a weak electrolyte at a particular temperature is directly proportional to the square root of dilution volume or inversely proportional to square root of concentration.



ACTIVITY 2

- To which of the following compounds, the Ostwald's dilution law is not applicable? Why?

HCl, H₂CO₃, KOH, NH₄OH

Concept of Acid and Base

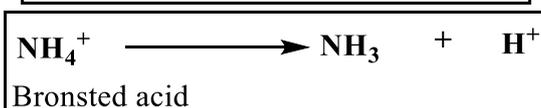
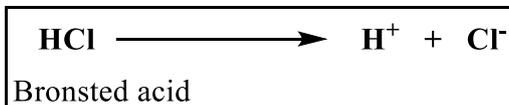
Arrhenius concept:

Acid: It produces H⁺ ions or H₃O⁺ ions in aqueous solution. (HCl, H₂SO₄, H₂CO₃, CH₃COOH, etc. are some of the examples of acid)

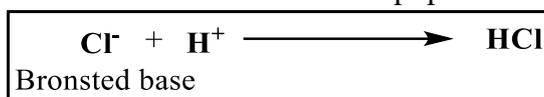
Base: It produces OH⁻ ions in aqueous solution. (NaOH, NH₄OH, KOH, etc. are some of the examples of base)

Bronsted Concept (Protonic Concept)

ACID: Acids are those chemical substances which produce protons (proton donor).



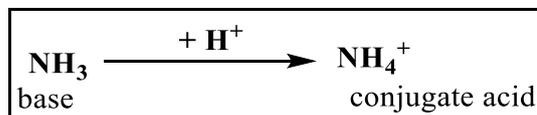
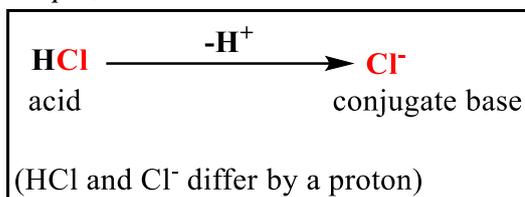
BASE: Bases are those chemical substances which accept protons.



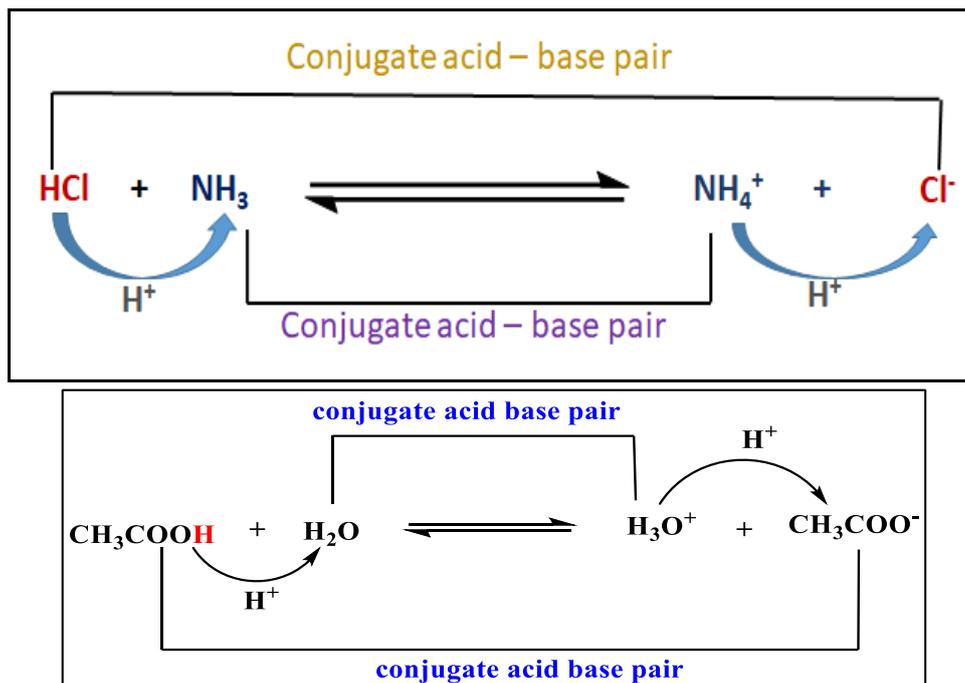
Conjugate Acid–Base Pair

These are pair of chemical species which differ by a proton.

For example,



Neutralization Reaction



ACTIVITY 3

- Write the conjugate base of the following.
 - H₂CO₃
 - HCO₃⁻
 - H₂S
- Write the conjugate acid of the following.
 - OH⁻
 - HSO₄⁻
 - SO₄²⁻
- Complete the following and indicate the conjugate acid-base pairs in each case.
 - CH₃COOH + NH₃ →
 - HCl + H₂O →

Ionic Product of water (K_w)

Water being a very weak electrolyte, dissociates to a small extent as shown below.



$$K = \frac{[\text{H}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$$

$$K \times [\text{H}_2\text{O}] = [\text{H}^+][\text{OH}^-]$$

The degree of dissociation of water is extremely small, therefore the concentration of water tends to remain constant. $[\text{H}_2\text{O}] = \text{constant}$

$$K \times \text{constant} = [\text{H}^+][\text{OH}^-]$$

$$K_w = [\text{H}^+][\text{OH}^-] \quad ; \quad (K \times [\text{H}_2\text{O}] = K_w)$$

K_w = ionic product of water

Thus, the ionic product of water is defined as the product of hydrogen ion concentration and the hydroxyl ion concentration at a particular temperature.

At 25°C, the ionic product value of water is found to be 10^{-14} .

The dissociation of water produces an equal number of H^+ and OH^- ions, therefore,

$$10^{-14} = [\text{H}^+][\text{OH}^-]$$

$$10^{-14} = [10^{-7}] \times [10^{-7}]$$

$$[\text{H}^+] = 10^{-7} \text{ mole/litre}$$

$$[\text{OH}^-] = 10^{-7} \text{ mole/litre}$$

$$10^{-14} = [\text{H}^+][\text{OH}^-]$$

The ionic product value of water in the solution remains constant at 25°C and increases with the increase in the temperature due to the increase in the degree of dissociation of water.

The concentration of H^+ ions and the OH^- ions in the solution changes, depending on the nature of solution, but the ionic product value remains the same at that temperature.

For example, a solution has $[\text{H}^+] = 10^{-3}$ mole / litre at 25°C.

$$[\text{OH}^-] = ?$$

$$10^{-14} = [\text{H}^+][\text{OH}^-]$$

$$[\text{OH}^-] = \frac{10^{-14}}{[\text{H}^+]}$$

$$[\text{OH}^-] = \frac{10^{-14}}{[10^{-3}]}$$

$$[\text{OH}^-] = 10^{-11} \text{ mol/lit}$$

Nature of solution depends upon relative concentrations of H^+ and OH^- ions.

$$[\text{H}^+] > [\text{OH}^-] \text{ -acidic}$$

$$[\text{H}^+] < [\text{OH}^-] \text{ -basic}$$

$$[\text{H}^+] = [\text{OH}^-] \text{ -neutral}$$

**ACTIVITY 4**

1. A solution has 1.58×10^{-5} mole /L of hydrogen ions at 25°C . Determine the concentration of OH^{-} ions in the solution.

The pH of Solution

The pH of solution represents the hydrogen ion concentration in the solution. It is defined as negative logarithm of H^{+} ions concentration in the solution.

$$\text{pH} = -\log [\text{H}^{+}]$$

$$[\text{H}^{+}] = 10^{-\text{pH}}$$

For example, if a solution contains 10^{-2} mole/L of H^{+} ions, then:

$$\text{pH} = -\log [\text{H}^{+}]$$

$$= -\log 10^{-2}$$

$$= 2$$

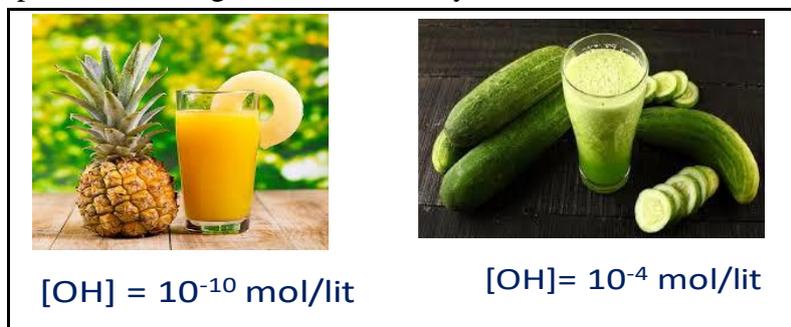
Nature of solution depends on pH

$[\text{H}^{+}]$ mol /litre	$\text{pH} = -\log [\text{H}^{+}]$	Nature of the Solution
10^{-0}	0	Acidic
10^{-1}	1	
10^{-2}	2	
10^{-3}	3	
10^{-4}	4	
10^{-5}	5	
10^{-6}	6	Neutral
10^{-7}	7	
10^{-8}	8	Basic
10^{-9}	9	
10^{-10}	10	
10^{-11}	11	
10^{-12}	12	
10^{-13}	13	
10^{-14}	14	



ACTIVITY 5

In the modern times, acidity is one of the major health issues among the people who tend to be least concerned about the type of food they consume. Which of these drinks would you recommend to a person suffering from acute acidity?

**Buffer Solution**

Buffer is a solution whose pH value does not change appreciably either on keeping for a long duration or on adding a small amount of water or acid or base to it.

Types of Buffer solution*i. Solution of a single salt*

This buffer solution is prepared from salt of a weak acid and weak base.

Example: solution of $\text{CH}_3\text{COONH}_4$ (ammonium acetate)

ii. Acidic buffer.

This buffer solution is prepared by mixing equi-molar solutions of a weak acid and its salt of a strong base.

Example: mixture of equi-molar solutions of CH_3COOH (weak acid) and CH_3COONa (salt)

iii. Basic buffer.

It is prepared by mixing equimolar solutions of a weak base and its salt of a strong acid.

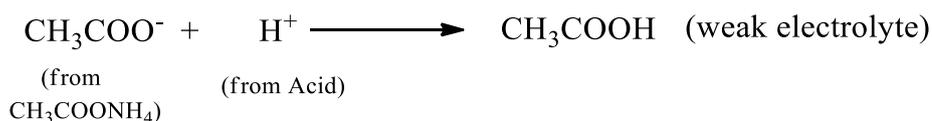
Example: mixture of equimolar solution of NH_4OH (weak base) and NH_4Cl (salt)

Buffer Action

The mechanism by which buffer solution resists the change in its pH is called buffer action.

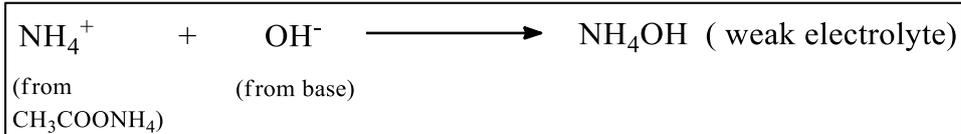
i. Buffer action of solution of $\text{CH}_3\text{COONH}_4$ (ammonium acetate)

When acid is added to this buffer solution, (for example HCl) the CH_3COO^- ions from the buffer combines with the H^+ ions from the acid to form CH_3COOH .



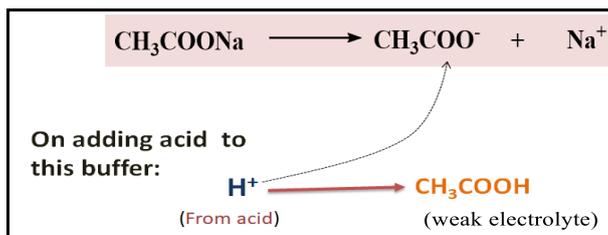
CH_3COOH being weak acid hardly dissociates in the solution. The concentration of H^+ ions in the solution does not change considerably. Hence the pH remains the same.

When a base is added to this buffer solution (for example NaOH), the NH_4^+ ions from the buffer combines with the OH^- ions from the base to form NH_4OH .

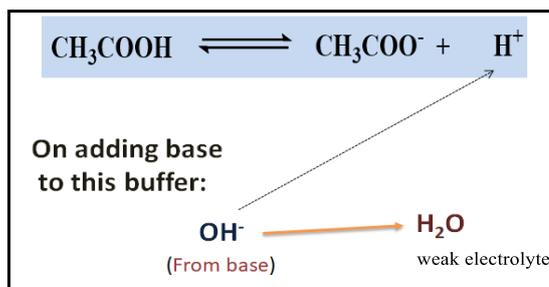


NH_4OH being weak base hardly dissociates in the solution. The concentration of OH^- ions in the solution does not change considerably. Hence the pH remains the same.

ii. Buffer action of acidic buffer ($\text{CH}_3\text{COOH} + \text{CH}_3\text{COONa}$)

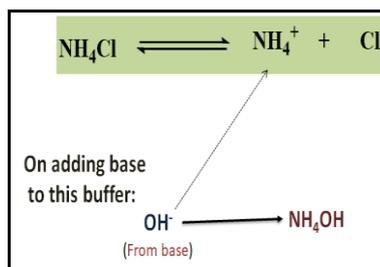
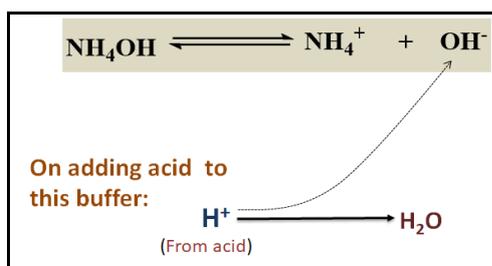


The CH_3COO^- ions from the buffer combines with H^+ ions from the acid to keep the same pH.



The H^+ ions from the buffer combine with OH^- ions from the base to keep the same pH.

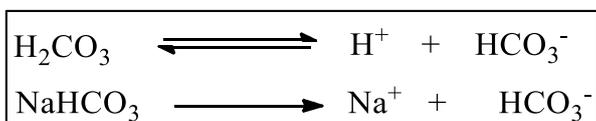
iii. Buffer action of Basic buffer ($\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$)



Blood as Buffer

Blood is the best example of a buffer solution in a biological system. It contains a solution of carbonic acid (H_2CO_3) and sodium bicarbonate (NaHCO_3) which act as buffer pair.

Buffer Action of Blood



When acid enters the blood, the bicarbonate ions (HCO_3^-) from NaHCO_3 combine with H^+ ions from the acid to form H_2CO_3 .



Carbonic acid being weak acid does not dissociate much in the solution. The concentration of the H^+ ions in the blood does not change considerably when the acid enters in it. Hence constant pH is maintained.

When the base enters the blood, the H^+ ions from the H_2CO_3 of the buffer combines with the OH^- ions from the base to form water.



Water being weak electrolyte, it hardly dissociate into ions. Therefore, the OH^- ions concentration does not change considerably when the base enters the blood. Hence, constant blood pH is maintained.



Summary

- Strong electrolytes are chemical substance which dissociates completely in aqueous solution.
- Weak electrolytes are those chemical substances which dissociates partially in aqueous solution.
- Acid – base equilibrium is the equilibrium between the dissociated ions and the remaining un-dissociated molecules of weak electrolyte in the solution.
- Degree of dissociation is the measure of extent to which the given electrolyte dissociates in aqueous solution.
- The degree of dissociation of strong electrolyte is almost 1 or 100%.
- Ostwald's dilution states that the degree of dissociation of weak electrolyte is directly proportional the square root of dilution volume.
- Conjugate acid – base pair is the pair of compounds which differ by a proton.
- Ionic product of water is the product of concentration of H^+ ions and the OH^- ions in the solution at a particular temperature.
- The ionic product of water at 25°C is 10^{-14} .
- The pH of the solution determines the H^+ ions in the solution.
- pH is equal to $-\log[\text{H}^+]$.
- Buffer is the solution that resists the change of its pH upon adding acid, base or water or keeping it for longer duration of time.
- Blood acts as buffer in the body of cold or warm blood animals.



Self-check for Learning

1. Which of the following pair of compounds cannot act as buffer?
 - a. $\text{HCl} + \text{NaHCO}_3$
 - b. $\text{H}_3\text{PO}_4 + \text{NaH}_2\text{PO}_4$
 - c. $\text{HCOOH} + \text{NaCl}$
2. Calculate the pH of the solution having 10^{-13} mole/ L of OH^- ions.

2.6. HYBRIDISATION AND SHAPES OF MOLECULES

Learning Objectives



- Explain the hybridization of atomic orbitals.
- Describe the shape of molecules based on hybridization.
- Explain the shapes and bond angles in molecules based on VSEPR theory.

Introduction

Hybridization of atomic orbitals plays an important role in studying the nature of bonding and determining the geometry of molecules. It involves the redistribution of energies among orbitals during bond formation.

Hybridization is the process of mixing atomic orbitals of different shapes and energies, to produce orbitals of equivalent shape and energy-oriented symmetrically with respect to one another. The new set of orbitals as a result of hybridization are called hybrid orbitals. Only those orbitals of the same energy level can undergo hybridization. The orbitals of the central atom undergo hybridization during the formation of a bond with other atoms.

The shape of any hybrid orbital is different from the shapes of the original atomic orbitals. The geometries of the molecules are explained through hybridization.

Types of Hybridization

1. *sp or diagonal hybridization*

Consider beryllium in the BeF_2 molecule:

In its ground electronic state, it would not be able to form bonds because it has no singly occupied orbitals.

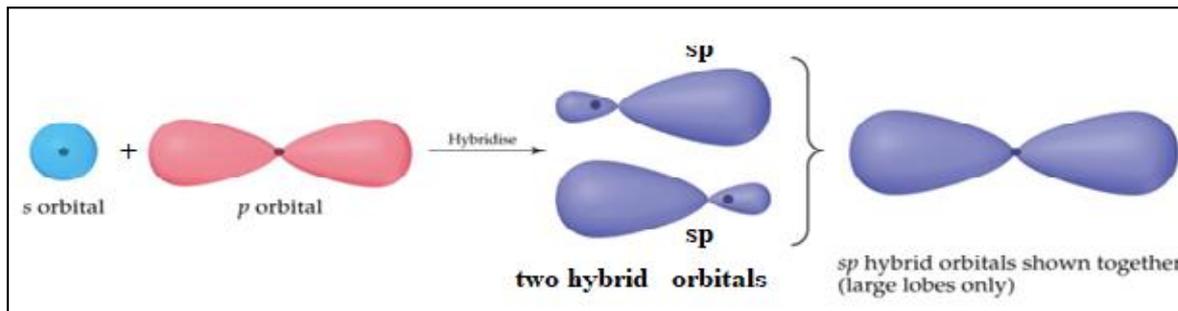


BUT if it absorbs a small amount of energy needed to promote an electron from the $2s$ orbital to the $2p$ orbital, it can form two bonds with F atoms.

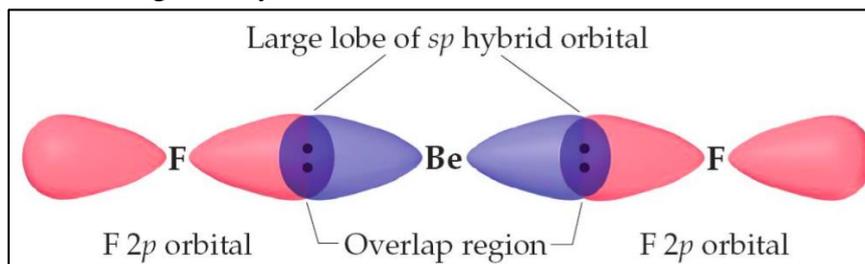


Mixing the $2s$ and $2p$ orbitals yields **two degenerate (of equal energy) orbitals** that are hybrids of the two orbitals. Each of the new hybrid orbitals is called sp -orbital.

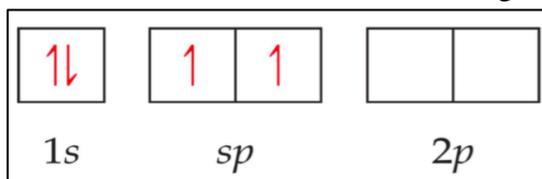
The sp hybrid orbitals have two lobes like a p – orbital. One of the lobes is larger and more rounded.



These two degenerate orbitals would align themselves in 180° from each other. Therefore, the observed geometry of BeF_2 is linear.



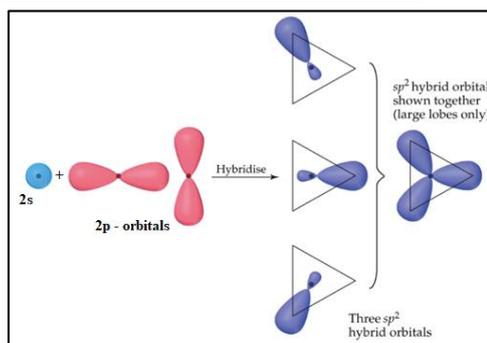
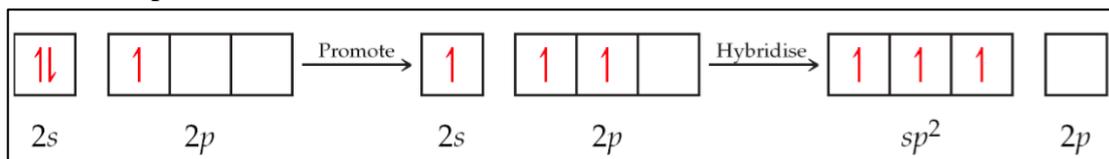
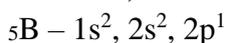
The orbital diagram for **Be** atom of BeF_2 would look like the one given below.



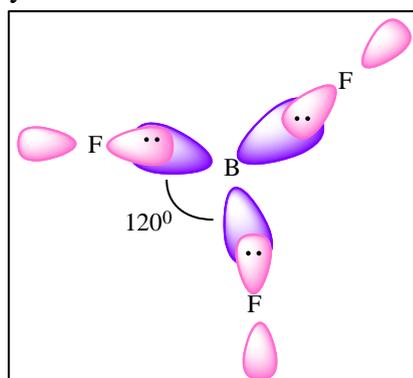
The electrons in the sp hybrid orbitals can form bonds with the two fluorine atoms. The sp orbitals are higher in energy than the 1s orbital but lower than the 2p orbitals.

2. sp^2 or Trigonal Hybridization

In such type of hybridization, one s- orbital and the two p – orbitals (p_x and p_y) undergo hybridization to give three new hybrid orbitals called sp^2 orbitals. For example, in BF_3 molecule, the central boron atom is sp^2 – hybridized.

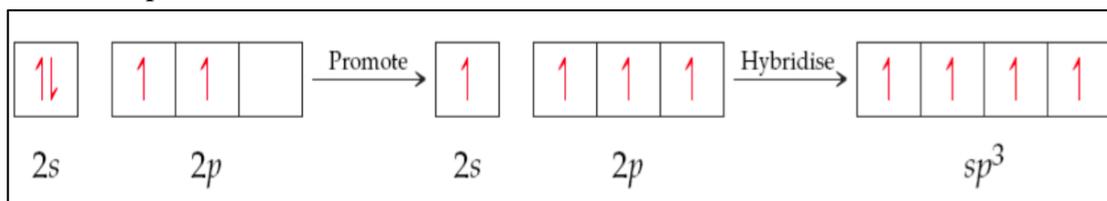


The three sp^2 hybrid orbitals lie in the same plane, 120° apart from one another. They are used to make three equivalent bonds with the three F-atoms, leading to the **trigonal planar** molecular geometry of BF_3 .

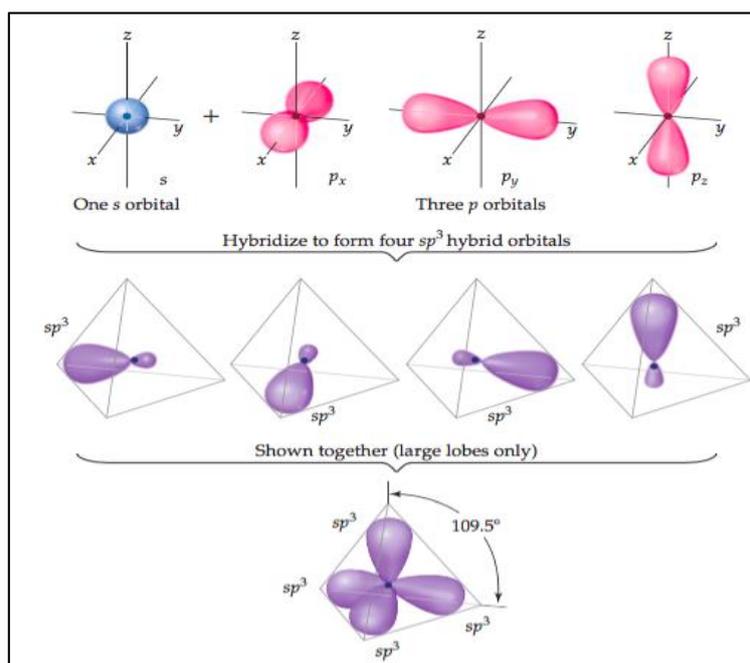


3. sp^3 or Tetrahedral Hybridization

In such type of hybridization, one s -orbital and the three p -orbitals undergo hybridization to give four new hybrid orbitals called sp^3 orbitals. For example, the central carbon atom in CH_4 undergoes sp^3 hybridization to form four equivalent hybrid orbitals each of which is called sp^3 hybrid orbital. The carbon atom forms four bonds with the four hydrogen atoms.
 ${}_6C - 1s^2, 2s^2, 2p^2$



$(1 \times s) + (3 \times p) = 4 \times$ degenerate sp^3 orbitals



The molecule therefore has tetrahedral geometry with bond angle of 109.5°

Steps to predict the type of hybridization in simple molecules

1. Add the valence electrons of all the atoms in the molecule.
2. If the total number of electrons is 8 or less than 8, divide it by 2. Add quotient and the remainder to get the type of hybridization.
3. For cation subtract the positive charge from the valence electrons and for anion add the negative charge to the valence electron.
4. If the total number of electrons is more than 8, divide it by 8. Consider Q_1 as quotient and R_1 as remainder of this division.
5. Divide R_1 if left, by 2 and find the second quotient Q_2 and R_2
6. Now add $Q_1 + Q_2 + R_2$ to get the type of hybridization.

Examples:**BeF₂**

Valence electrons = Valence electron of **Be** + 2 × valence electron of F

Valence electrons = 2 + 2 × 7 = 2 + 14 = 16

(Since the total valence electron is greater than 8, divide it by 8) $16/8 = 2$

Therefore, BeF₂ undergoes sp – hybridization.

H₂O

Valence electrons = 2 × valence electron of H + valence electron of O

Valence electrons = 2 × 1 + 6 = 8

(Since the total valence electron is equal to 8, divide it by 2) $8/2 = 4$

H₂O undergoes sp³- hybridization

**ACTIVITY 1**

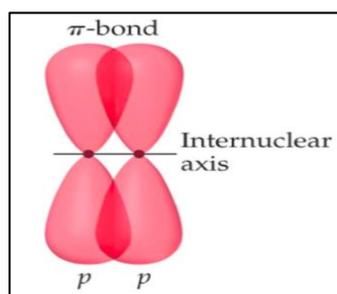
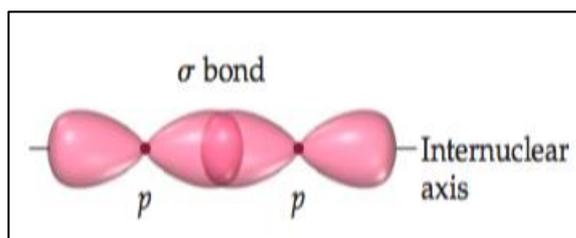
1. Predict the hybridization of the following.
 - S in SO₂ molecule
 - N in NH₃ molecule
 - N in NO₂⁻

Multiple Covalent Bonds

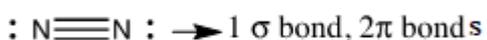
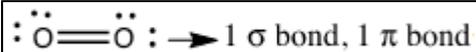
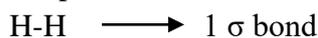
Depending upon the nature of overlap of atomic orbitals, covalent bond is of two types.

- Sigma (σ) bond** – It is formed due to overlapping of two orbitals along the internuclear axis (head to head overlap)
- Pi (π) bond** – It is formed due to sideways overlapping of two orbitals.

In the molecule with multiple covalent bonds, there can be only one sigma bond. The rest of the covalent bonds are pi – bonds.

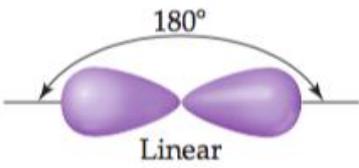
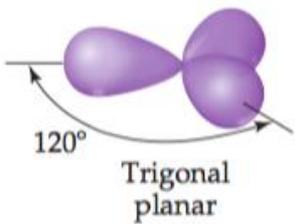
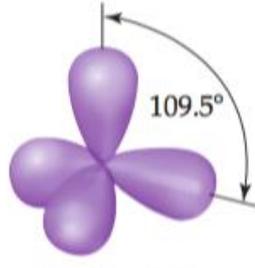


For example;



Factors Affecting Shapes of Molecules

1. Type of hybridization

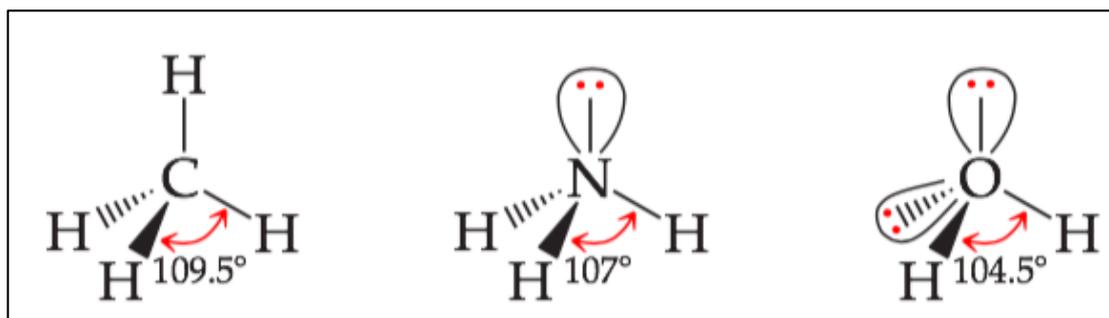
Atomic Orbital Set	Hybrid Orbital Set	Geometry	Examples
s, p	Two sp	 <p>Linear</p>	$\text{BeF}_2, \text{HgCl}_2$
s, p, p	Three sp^2	 <p>Trigonal planar</p>	BF_3, SO_3
s, p, p, p	Four sp^3	 <p>Tetrahedral</p>	$\text{CH}_4, \text{NH}_3, \text{H}_2\text{O}, \text{NH}_4^+$

2. Valence Shell Electron Pair Repulsion Theory or VSEPR Theory

- Molecular geometry also depends on the lone pair and bond pair of electrons on the central atom. The repulsion between such pairs of electrons accounts for the different geometry of the molecules.
- The extent to which the repulsion between the pairs of electrons take place, determines the bond angles in the molecules

The order of repulsion between the electrons is as follows:

- Lone pair – lone pair > lone pair – bond pair > bond pair – bond pair
- Greater the number of lone pair of electrons on the central atom, greater is the distortion produced in the normal bond angle or shape.
- For example, methane, ammonia and water have a tetrahedral geometry, but their bond angles differ.



Water has the lowest bond angle which is due to greater repulsion between the lone pair and lone pair. The bond angle decreases as the number of non-bonding (lone) electron pairs increases.



ACTIVITY 2

1. Answer the following questions.
 - i. How many pi bonds does $O = C = O$ have?
 - ii. Predict the shape of ethene and sulphur dioxide molecule using hybridization and VSEPR theory.



Summary

- Hybridization is the process of mixing atomic orbitals of different shapes and energies, to produce orbitals of equivalent shape and energy-oriented symmetrically with respect to one.
- Only those orbitals of same energy level undergo hybridization.
- sp hybridization involves one 'p' and one 's' orbital of a given energy level.
- The molecules with ' sp ' hybridization have linear geometry.
- Molecules with sp^2 hybridization have usually trigonal planar geometry.
- Molecules with sp^3 hybridization have usually tetrahedral geometry.
- VSEPR theory is useful in explaining the different geometries of molecules.



Self-check for Learning

1. Define hybridization.
2. Predict the hybridization and geometry of C_2H_2 and BF_3 molecules.
3. Why is the bond angle of ammonia higher than that of water?
4. Differentiate between pi-bond and sigma bond.

2.7. RADIO ACTIVITY

Learning Objectives



- Define radioactivity and half-life.
- Explain causes of radioactivity.
- Explain n/p ratio with the help of Serge chart.
- Solve numerical problems with respect to half-life.

Introduction

Henri Becquerel, a French scientist, discovered the phenomenon called radioactivity, though it was a purely accidental discovery. He kept uranium salts on the top of black paper containing photographic film/plate. He had his setup in a drawer. Later, when he developed a photographic plate, he noticed dark spots on it. He, therefore, concluded that uranium salts emitted invisible radiations which affected photographic plate.

Later, Marie Curie along with her husband took intensive study for substances emitting radioactive rays and discovered two radioactive substances such as polonium and radium. Since her body was constantly exposed to harmful rays, she, unfortunately, passed away after diagnosing with a disease called aplastic leukaemia (Cancer).

Their discoveries didn't go in vain. It helped other new scientists to discover many radioactive substances.

- The phenomenon of spontaneous emission of certain invisible radiations by elements like uranium is called radioactivity. The substances which emit these rays are called radioactive substances.
- The element changes into another element due to radioactivity. It is a spontaneous and irreversible self-disintegrating process (no conditions like temperature, pressure or presence of catalyst are required).
- Radioactive substances are unstable. They emit the rays in the form of alpha and beta particles and also in the form of gamma rays.

Causes of Radioactivity

1. Even and odd number of protons and neutrons

Sl. no	No. of protons (p)	No. of neutrons (n)	No. of stable nuclides or isotopes	Stability of nuclide
1	Even	Even	160	Stable
2	Even	Odd	56	Less stable
3	Odd	Even	52	Less stable
4	Odd	Odd	4	Least stable

2. Strong Nuclear Force

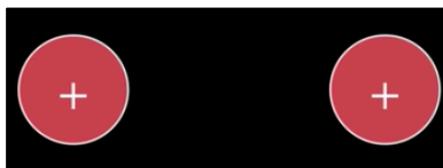


Figure: Two protons experiencing repulsive electromagnetic force

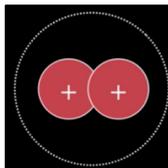


Figure: Two protons experiencing an attractive nuclear force

There are many natural forces that operate in nature like gravitational force, electromagnetic force, etc. The nuclear force is a typical force of attraction which is strongest of all. But it comes into existence only when nucleons (neutron and proton) are very close in a distance of fermi ($1 \text{ fermi} = 1 \times 10^{-15} \text{m}$). Usually, when nucleons like protons are close, they experience an electromagnetic force of repulsion due to same positive charge (Figure A) but if the distance between the two protons is narrowed beyond limiting range, they experience a nuclear force (Figure B). This nuclear force holds the nucleons in tiny nuclear space of an atom. This statement remains true for small nucleons. However, for atoms with a larger number of nuclides, the nuclides break due to weak nuclear force leading to radioactivity.

3. n/p ratio

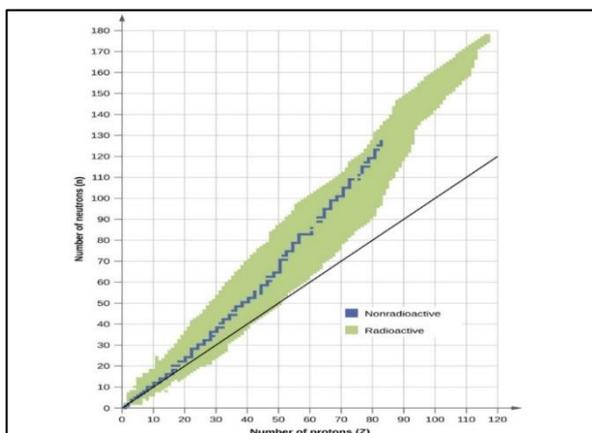


Figure: Stability belt of radioactive substances

The neutron-proton ratio (N/Z ratio or nuclear ratio) of an atomic nucleus is the ratio of its number of neutrons to its number of protons.

The fundamental particles spontaneously disintegrated (mode of decay) by radioactive substance and the changes it brings on parent nuclide are as follows.

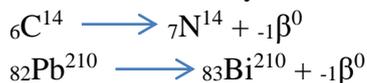
Sl. No	Alpha Particle	Beta Particle	Gamma Particle
1.	Known as helium nuclei	Known as electron	Secondary emission
2.	Represented as ${}_2\text{He}^4$	Represented as ${}_{-1}\beta^0$ / ${}_{-1}e^0$	${}^0\gamma^0$
3.	The new product formed has an atomic mass number less by four units and atomic number by two units. Eg.	The new element formed has the same mass number but the atomic number will be increased by one unit. Eg.	Emission of γ rays will not produce a new element
	${}_{88}\text{Ra}^{226} \longrightarrow {}_{86}\text{Rn}^{222} + {}_2\text{He}^4$ ${}_{84}\text{Po}^{210} \longrightarrow {}_{82}\text{Pb}^{206} + {}_2\text{He}^4$	${}^6\text{C}^{14} \longrightarrow {}^7\text{N}^{14} + {}_{-1}\beta^0$ ${}_{82}\text{Pb}^{210} \longrightarrow {}_{83}\text{Bi}^{210} + {}_{-1}\beta^0$	

Interpretation of Stability belt of radioactive substance

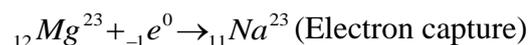
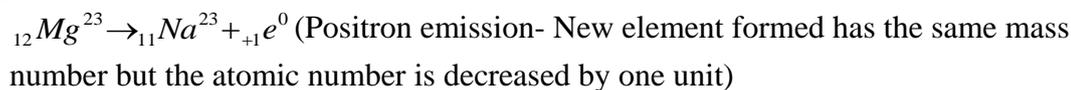
The blue line shows stable nuclides also known as stability zone.

The green region shows unstable nuclides.

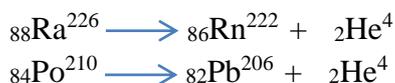
Nuclides present above stability zone, are unstable. It contains more number of neutrons leading to higher n/p ratio. Since they are unstable, they undergo disintegration by emitting beta- particles, thus lowering the number of neutrons and n/p ratio. As a result, they tend to come closer to the stability zone, making nuclides stable.



Nuclides present below stability zone, are unstable as well. They contain more number of protons leading to lower n/p ratio. Since they are unstable, they undergo disintegration by either emitting positron or undergoing a process called electron capture thus lowering a number of protons and n/p ratio. As a result, they tend to come closer to the stability zone, making nuclides stable.



Nuclides containing more of both neutrons and protons undergo alpha decay to become stable.



Note: An unstable nuclide generally decays in a mode that shifts its N / Z ratio towards the band of stability.



ACTIVITY 1

- For each of the decay type, complete the table showing the effect on the nucleus.

	Type of decay	Change in Mass number	Change in Atomic number
1	α decay	Reduced by 4 units	Reduced by 2 units
2	β decay		
3	β^+ emission		
4	Electron capture		

Half-life

The half-life of a radioactive nucleus is one of its main features which determines how quickly it will decay and for how long we need to worry about its radiations. Half-lives can range from a fraction of a second to billions of years. The **half-life** is defined as the amount of time it takes for a given isotope to lose half of its radioactivity. The longer the half-life of a nucleus, the lower the radioactive activity.

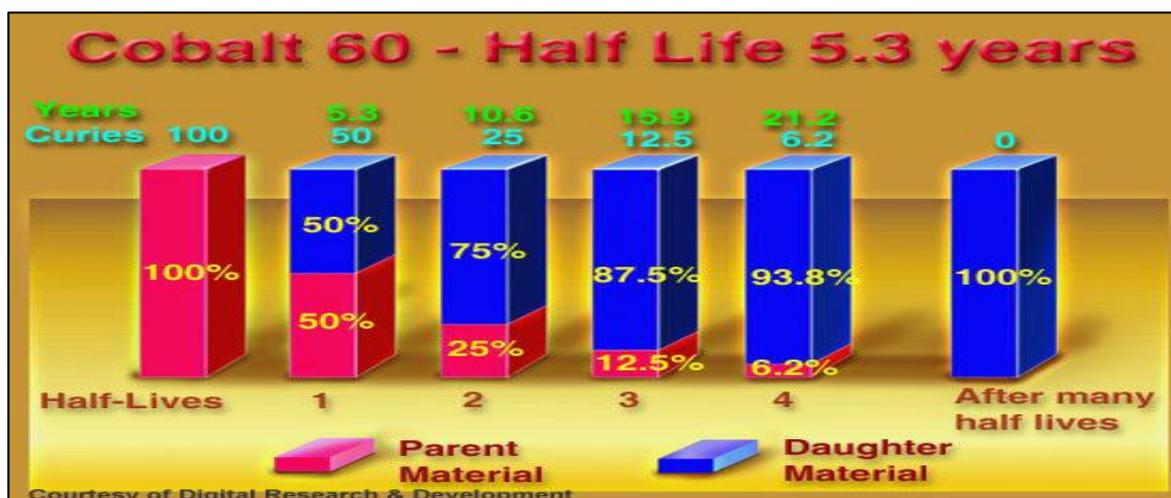


Figure: Graphical Representation of half-life of Cobalt 60.

Each radionuclide has its own particular half-life that never changes, regardless of the quantity or form of the material (i.e., solid, liquid, gas, element or compound). If a radioisotope has a half-life of 14 days, half of its atoms would have decayed within 14 days. In 14 more days, half of that remaining half will decay, and so on.

Calculations based on Half-life

The formula for calculating the amount of radioactive substance (N) left after 'n' number of half-life is

$$N = N_0 \left(\frac{1}{2} \right)^n$$

N = final concentration or amount of radioactive sample

N_0 = initial concentration or amount of radioactive sample

$$n = \frac{t}{t_{\frac{1}{2}}}$$

n = number of half-life

Example 1:

- Calculate the amount of iodine isotope left after 180 days when 4 gram of radioisotope was taken initially. $t_{1/2}$ = 60 days

N = ? N_0 = 4gm, t = 180 days, $t_{1/2}$ = 60 days

$$N = N_0 \left(\frac{1}{2} \right)^n$$

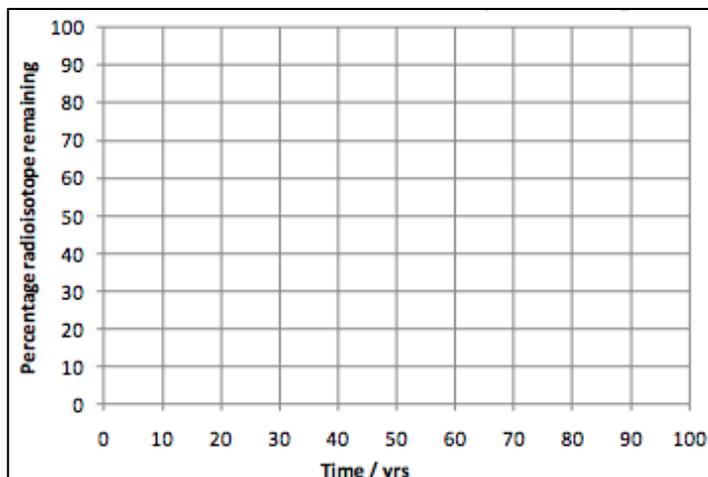
$$n = \frac{t}{t_{\frac{1}{2}}} = \frac{180}{60} = 3$$

$$N = 4 \times \left(\frac{1}{2} \right)^3 = 0.5gm$$



ACTIVITY 2

1. If a radionuclide has a half-life of 10 years, complete the graph below.



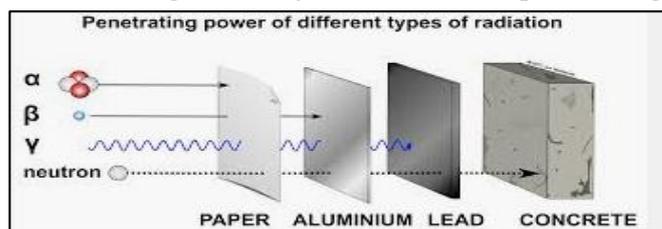
Summary

- The phenomenon of spontaneous emission of certain invisible radiations by elements is called radioactivity. The substances which emit these rays are called radioactive substances.
- The radioactivity of the elements results into the formation of isotopes of new element or the same element.
- The radioactive elements emit rays such as alpha rays, beta-rays and gamma rays.
- n/p ratio of elements determines the stability of their nucleus.
- Lighter elements with n/p ratio 1 are more stable.
- Those elements with n/p ratio lying above belt of stability emit beta-rays and become stable.
- Those elements with n/p ratio lying below the belt of stability become stable either by emitting positron or by electron capture process.



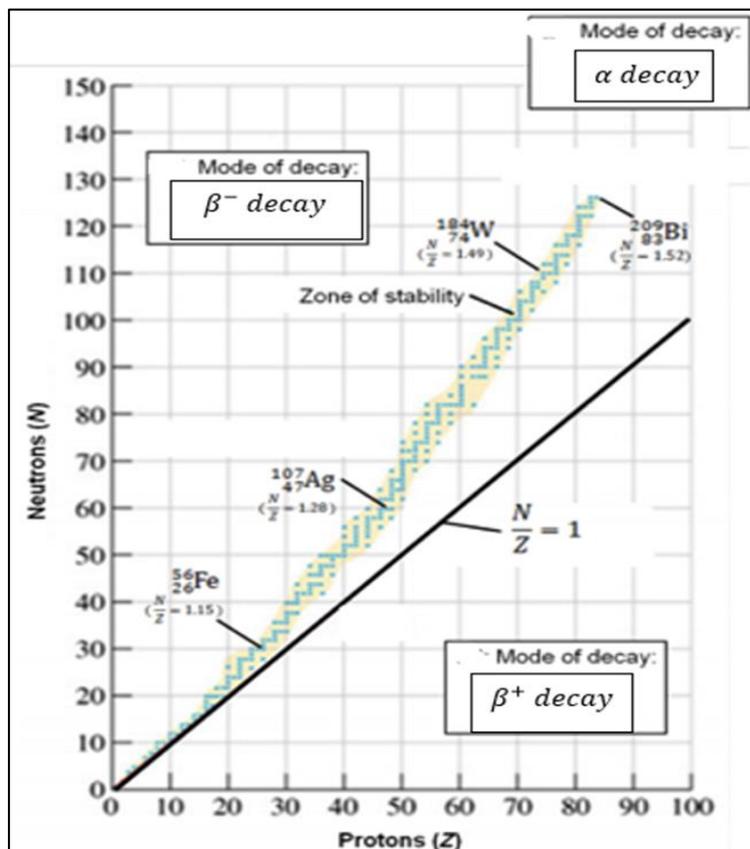
Self-check for Learning

1. In what different ways are we exposed to radiation in our day to day life? List down two advantages and disadvantages each.
2. Differentiate alpha, beta and gamma rays based on their penetrating power.



3. Half-life of polonium is 140 days. Find the mass of polonium left after 5 days if 16gm was taken initially.
4. Sketch each of the following nuclides on the figure, calculate their N/Z ratios and hence predict their stability. For the unstable (radioactive) nuclides, predict the mode(s) of nuclear decay they are likely to undergo.

- a) ${}^5_3\text{B}^{12}$
- b) ${}^{92}_{92}\text{U}^{234}$
- c) ${}^{57}_{57}\text{La}^{127}$
- d) ${}^{63}_{63}\text{Eu}^{153}$



3. PHYSICS

3.1. RESOLUTION OF VECTORS

Learning Objectives



- Explain resolution of vectors.
- Resolve a single vector into its perpendicular components.
- Determine the magnitude of perpendicular components of a vector.
- Compare addition and resolution of vectors.
- State examples of resolution of vectors in real life situations.

Introduction

The process of resolution of vectors is just opposite to that of the process of addition of vectors. When we add vectors, we get a single vector i.e. the resultant vector from two vectors but when we resolve a vector, we get two vectors from a single vector.

Resolution of Vectors

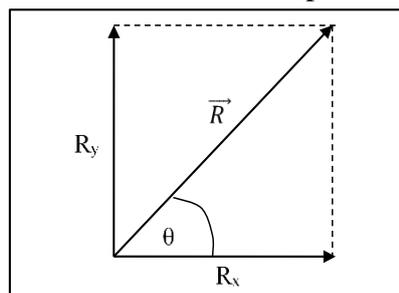
The resolution of vectors is a process of splitting a single vector into its component vectors which when combined according to the law of vector addition, produce the given vector. Suppose a single vector \vec{R} is resolved or splitted into two vectors \vec{A} and \vec{B} . The resolved vectors \vec{A} and \vec{B} are called the component vectors of vector \vec{R} . When these two component vectors are combined according to triangle's law of vector addition, then we get a resultant vector whose magnitude and direction are equal to that of the given vector \vec{R} taken initially.



Resolution of Vector into its Rectangular Components

When a vector is resolved into two components perpendicular to each other, such components of the given vector are called rectangular components of the vector.

The component along X-axis is called horizontal component or x-component denoted by R_x and the component along Y-axis is called vertical component or y-component denoted by R_y .



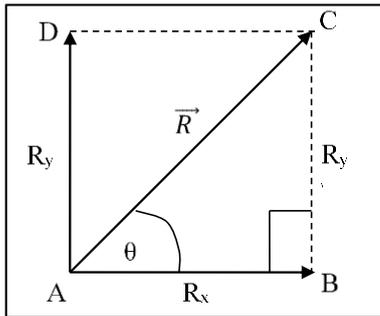
We can find the magnitude of perpendicular components of a vector by applying the following formulas.

$$R_x = |\vec{R}| \cos \theta$$

$$R_y = |\vec{R}| \sin \theta$$

Here, θ is the angle between the given vector (R) and the x-axis taken in counter-clockwise direction.

Now, let us derive the formulas for horizontal component and vertical component of given vector.



In right angled triangle ABC,

$$\cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\cos \theta = \frac{AB}{AC}$$

$$\cos \theta = \frac{R_x}{|\vec{R}|}$$

On cross multiplication we get,

$$R_x = |\vec{R}| \cos \theta$$

This is the formula for horizontal component of the given vector.

Again, in same right angled triangle ABC,

$$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\sin \theta = \frac{BC}{AC}$$

Here, $BC = R_y$ because $BC = AD$ as they are opposite sides of rectangle ABCD.

$$\sin \theta = \frac{R_y}{|\vec{R}|}$$

On cross multiplication we get,

$$R_y = |\vec{R}| \sin \theta$$

This is the formula for vertical component of the given vector.

Example

A force of magnitude 100 N makes an angle of 30° with x-axis. Find the magnitudes of its perpendicular components.

Given: $|\vec{R}| = 100 \text{ N}$ and $\theta = 30^\circ$

Solution:

$$R_x = |\vec{R}| \cos \theta = 100 \times \cos 30^\circ = 86.6 \text{ N}$$

$$R_y = |\vec{R}| \sin \theta = 100 \times \sin 30^\circ = 50 \text{ N}$$

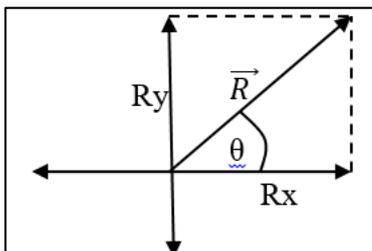


ACTIVITY 1

- Take a vector of any magnitude (say 100N) making an angle of 45° with the x-axis in positive direction. Calculate the magnitude of its horizontal component and vertical component. What is your observation?
- Keep the magnitude of the vector same as in Step 1 but take the value of θ less than 45° . Calculate the magnitude of its horizontal component and vertical component. Note down your observation.
- Keep the magnitude of the vector same as in Step 1 but take the value of θ greater than 45° . Calculate the magnitude of its horizontal component and vertical component. Note down your observation.
- Write down the relationship between the value of angle θ and the magnitudes of the horizontal and vertical components of the vector.

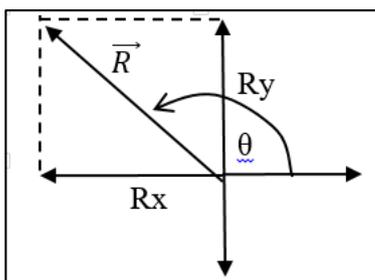
Different Cases of Resolution of Vectors

i.



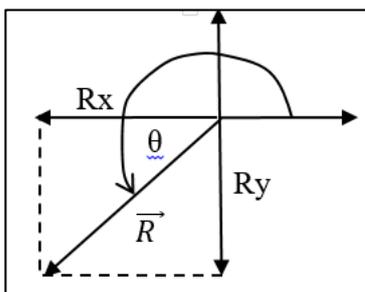
When the given vector is in the first quadrant of co-ordinate axes, both the components R_x and R_y are positive. The value of angle θ lies between 0° and 90° .

ii.



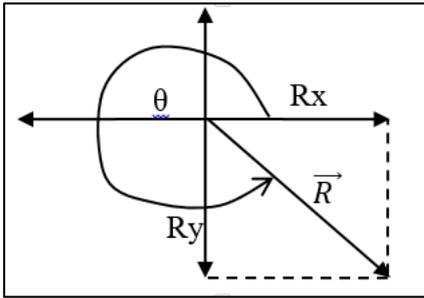
When the given vector is in the second quadrant of co-ordinate axes, the component R_x is negative and the component R_y is positive. The value of angle θ lies between 90° and 180° .

iii.



When the given vector is in the third quadrant of co-ordinate axes, both the components R_x and R_y are negative. The value of angle θ lies between 180° and 270° .

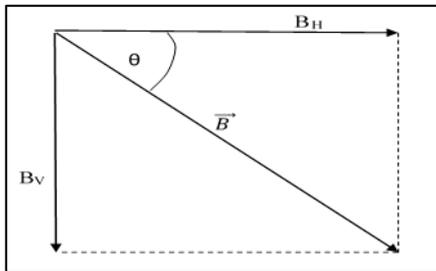
iv.



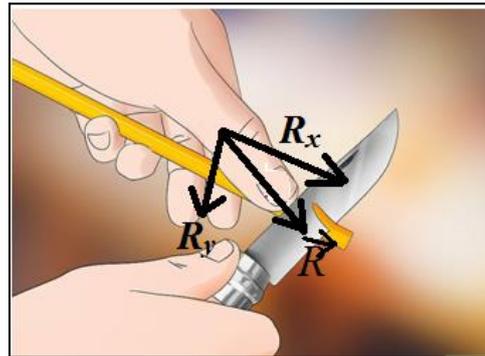
When the given vector is in the fourth quadrant of co-ordinate axes, the component R_x is positive and component R_y is negative. The value of angle θ lies between 270° and 360° .

Examples of Resolution of Vectors from Real Life Situation

Earth's magnetic field denoted by \vec{B} has two components B_V and B_H . B_V is perpendicular to the Earth's surface and B_H is parallel to the Earth's surface.



When we sharpen pencil with a blade, we cut the pencil at an angle. The component of force in the direction perpendicular to pencil cuts the pencil. The component of force in the direction parallel to pencil removes the thin wooden part.



Summary

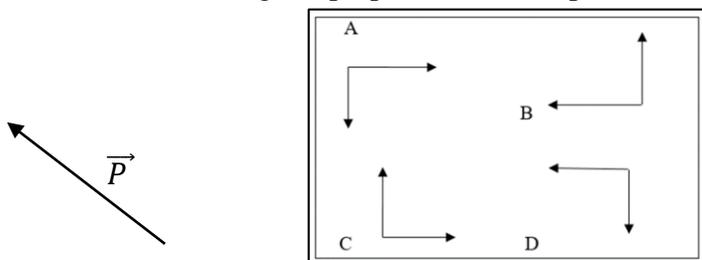
- Vectors can be resolved by placing them on a Cartesian Co-ordinate system.
- Resultant vector can be resolve into x-component and y-component which are known as rectangular components.
- In rectangular components, we can find resultant vector, x-component, y-component, the angle, and also the position of the vector that is in which quadrant the vector is lying.



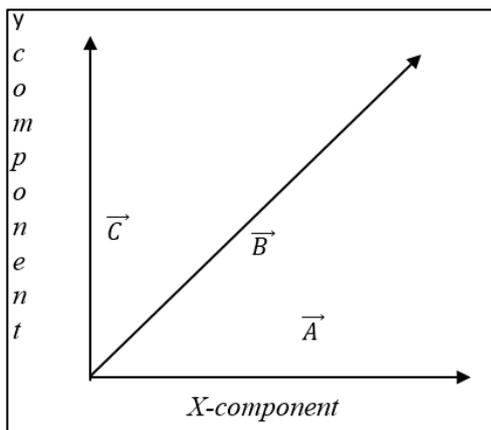
Self-check for Learning

Answer the following questions in your notebook.

1. Which of the following are perpendicular components of vector \vec{P} ?



2. Find the magnitude of horizontal and vertical components of a velocity vector of magnitude 50 m/s inclined at an angle of 30° with the positive direction of x-axis taken in the counterclockwise direction.
3. The angle between vectors A and B is 60° . Find the magnitudes of x- component and y- component if the magnitude of given vector B is 16 units.



4. The resultant of two forces perpendicular to each other is same as that of either of the two forces. What is the angle between one of the forces and the resultant?

3.2. KINEMATIC EQUATION

Learning Objectives



- Explain displacement-time graph and acceleration-time graph.
- Calculate velocity, acceleration and other quantities from the graphs which are related to slope.
- Derive kinematics relations by graphical method.
- Interpret the symbols used in these equations.
- Solve the problems based on these three formulas.

Introduction

A branch of science that deals with the motion of bodies is called kinematics. To derive the kinematics relations, we need to understand the different types of graphs given below.

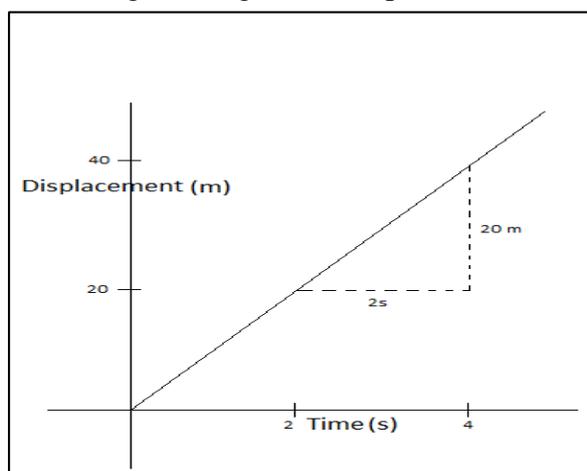
Displacement-time Graph

The graphs of displacement along y-axis and time along x-axis give the displacement-time graphs.

On a displacement-time graph, slope is equal to velocity.

$$\begin{aligned} \text{Slope} &= \frac{\text{rise}}{\text{run}} \\ &= \frac{\text{change in } y\text{-value}(\Delta y)}{\text{change in } x\text{-value}(\Delta x)} \\ \text{Slope} &= \frac{20}{2} \\ &= 10\text{m/s} \end{aligned}$$

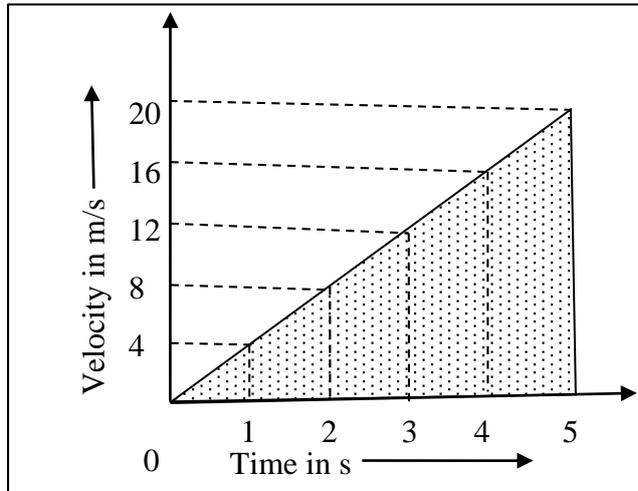
Where 10m/s is the velocity.



Velocity-time Graph

The graph drawn with velocity along the y-axis and time along the x-axis is known as a velocity-time graph. Velocity is defined as the rate of change of displacement. It can be determined from the given displacement-time graph. The slope of the graph is equal to acceleration.

The area under the velocity-time graph is equal to displacement.



$$\begin{aligned} \text{Slope} &= \frac{12-8}{3-2} \\ &= \frac{4}{1} \end{aligned}$$

$$= 4 \text{ m/s}^2 (\text{acceleration})$$

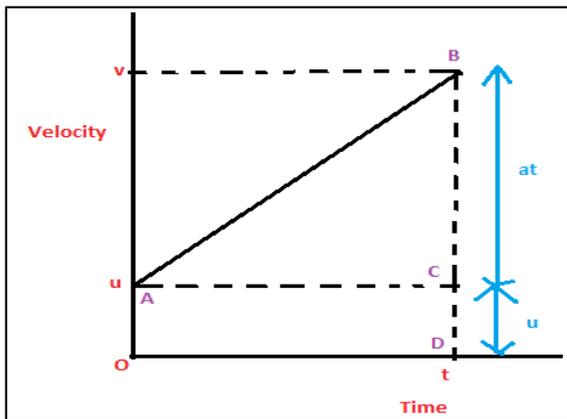
$$\text{Area} = \frac{1}{2} \times \text{base} \times \text{height} = \frac{1}{2} \times 5 \times 20$$

$$\text{Area} = 50 \text{ m}$$

\therefore Displacement, $x = 50 \text{ m}$

Equation of Kinematics (Graphical Method)

For uniformly accelerated motion, the equations which relate displacement, time taken, initial velocity, final velocity and acceleration is known as the equation of kinematics.



Assumption

In order to derive these relations using the velocity-time curve, let us assume that an object is moving in a straight line with uniform acceleration 'a'. Let 'u' be the initial velocity of the object at time $t = 0\text{s}$ and 'v' be the final velocity of the object after time 't'. Distance travelled by the object in time t is x.

We know that the acceleration of an object is equal to the slope of the v-t graph shown in the figure. Therefore, acceleration = slope of line AB,

$$a = \frac{BC}{AC}$$

$$a = \frac{BD - CD}{OD}$$

$$a = \frac{v - u}{t}$$

$$v = u + at \text{-----(1)}$$

We also know that the area under the velocity-time graphs represents a displacement of the object in a given instant of time.

So, we get acceleration = slope of line AB

From diagram find the value of the side BC in terms of acceleration (a) and time (t).

$$a = \frac{BC}{AC} = \frac{BC}{OD} = \frac{BC}{t}$$

$$\therefore BC = at \text{-----(2)}$$

Displacement of the object, from the graph is given by

$$x = \text{area of rectangle OACD} + \text{area of triangle ABC}$$

$$x = OA \times OD + \frac{1}{2} \times AC \times BC$$

Substituting the values, we get,

$$x = ut + \frac{1}{2} \times t \times at$$

$$x = ut + \frac{1}{2} at^2 \text{-----(3)}$$

Again, the displacement of the object is also equal to the area of the trapezium OABD.

Therefore, x = area of trapezium OABD,

$$x = \frac{1}{2} \times (BD + OA) \times OD$$

$$x = \frac{1}{2} \times (BD + CD) \times OD$$

Find OD from the diagram above by using the triangle ABC.

$$a = \frac{BC}{AC} = \frac{BD - CD}{OD}$$

On cross-multiplication,

$$\therefore OD = \frac{BD - CD}{a} \text{-----(4)}$$

Substituting this value of OD in the above equation, we get

$$x = \frac{1}{2} \times (BD + CD) \times \frac{(BD - CD)}{a}$$

$$= \frac{1}{2a} \times [(BD)^2 - (CD)^2]$$

$$= \frac{1}{2a} \times (v^2 - u^2)$$

$$\therefore v^2 - u^2 = 2ax$$

**ACTIVITY 1**

Jigme is waiting at a stoplight. When it finally turns green, Jigme accelerated from rest at a rate of 6.00 m/s^2 for a time 4.10 seconds. Determine the displacement of Jigme's car during this time.

Hint: $u = 0 \text{ m/s}$, $t = 4.10 \text{ s}$, and $a = 6.00 \text{ m/s}^2$

The value of 'v' is not in the equation. Therefore, select the formula that will help you to calculate 'x' using the values of u, t and a. Ans: 50.43m.

**Summary**

- The slope of the displacement-time graph gives the velocity.
- The slope of the velocity-time graph gives the acceleration.
- The area under the velocity-time graphs gives the displacement of the moving object.
- The three kinematics relations are

$$v = u + at$$

$$x = ut + \frac{1}{2}at^2$$

$$v^2 - u^2 = 2ax$$

**Self-check for Learning**

Write answer in your notebook.

1. A particle moving with uniform acceleration along a straight line covers distances D_1 and D_2 in successive intervals of time t_1 and t_2 respectively. What is the acceleration of the particle?

3.3. COULOMB'S LAW

Learning Objectives



- Explain Coulomb's law.
- Define electric current, potential difference and electric resistance.
- Analyse Kirchhoff's laws.
- Solve questions based on Kirchhoff's law.

Introduction

The great Greek philosopher, Thales observed that when a piece of amber is rubbed with wool, amber acquires the property of attracting light bodies. Since it happened about 2500 years back, this observation was not given any importance. Later it was found that several other materials like glass, ebonite and sulphur on being rubbed attract light bodies. When a balloon is rubbed against a woollen cloth, it becomes negatively charged and the woollen cloth becomes positively charged. This shows that the two neutral objects get electrified, which means they acquire 'charge'.

Electric Charge

The intrinsic property of materials that makes it possible for them to exert electrical force and respond to electric force is known as electric charge. It is denoted by Q .

$$\text{Charge} = \text{electric current} \times \text{time}$$

$$Q = I \times t$$

SI unit of electric charge is the coulomb (C)

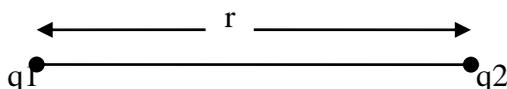
$$1C = 1A \times 1s$$

It is a scalar quantity.

Now when the negatively charged balloon is placed against a neutral wall, the balloon gets attracted to the wall. This is because the negative charges on the wall get repelled and positive charges on the wall get attracted to the negatively charged balloon. Therefore, the like charges repel and unlike charges attract each other. The force of repulsion or attraction between two like or unlike charges is called coulombian force.

If we bring two like charges together, positive or negative, it exerts the force of the same magnitude in opposite direction, whereas if we bring two unlike charges together, there will be a force of attraction between two charges. The equation giving the electrostatic force of repulsion or attraction for charged particles is called coulomb's law.

Coulomb's law



According to Coulomb's law, two stationary point charges q_1 and q_2 repel or attract each other with a force 'F' which is:

Directly proportional to the product of the charges ($F \propto q_1 \times q_2$)

Increase in the magnitude of either charge increases the magnitude of the force and inversely proportional to the square of distance 'r' between them. $(F \propto \frac{1}{r^2})$.

The increase in distance between two charges decreases the magnitude of the force and vice versa.

Combining we get,

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = k \frac{q_1 q_2}{r^2}$$

where 'k' is a proportionality constant.

When the charges are placed in vacuum or air,

$$k = \frac{1}{4\pi\epsilon_0}$$

Here, ϵ_0 (pronounced as 'epsilon nought') is called the permittivity of free space i.e. vacuum. Substituting the value of k, we get,

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

Where, $\frac{1}{4\pi\epsilon_0}$ is approximately equal to $9 \times 10^9 Nm^2 C^{-2}$.

Notes:

The forces exerted by two charges on each other are equal and opposite.

$$\vec{F}_{12} = -\vec{F}_{21}$$

If a system contains a number of interacting charges, then the net force on any charge equals the vector sum of forces exerted on it by all the other charges.

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \dots + \vec{F}_{1n}$$

$$\vec{F}_1 = \frac{1}{4\pi\epsilon_0} \left(\frac{q_2 q_1}{r_{21}^2} + \frac{q_3 q_1}{r_{31}^2} + \dots + \frac{q_n q_1}{r_{n1}^2} \right)$$

Electric Current (I)

The rate of flow of charge across any cross-section of a conductor is called electric current.

In an electric circuit, if an amount of charge 'Q' flows in 't' second, then the electric current is given by;

$$I = \frac{Q}{t}$$

Unit of electric current is ampere (A)

$$1 A = \frac{1 C}{1 s}$$

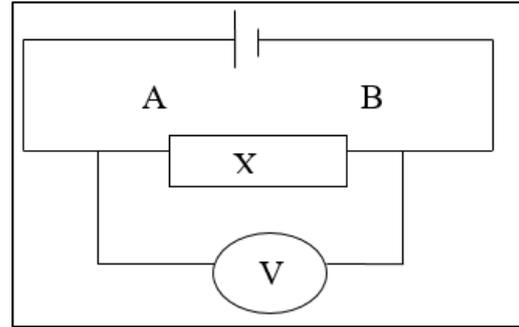
Potential Difference (V)

The difference in the amount of energy that charge carriers have between two points in a circuit is known as potential difference.

The difference in the amount of energy that charge carriers have between terminal A and terminal B of component X can be measured by using voltmeter connected parallel to it.

Potential difference, $V = I \times R$

Unit of potential difference is volt (V).



Electrical Resistance (R)

The ratio of the potential difference to the current is known as electrical resistance.

$$R = \frac{V}{I}$$

Unit of resistance (R) is the ohm (Ω)

$$1 \Omega = \frac{1 V}{1 A}$$

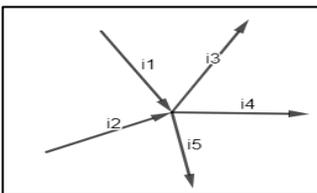
Kirchhoff's Laws

In 1842, Kirchhoff gave two laws by which we can determine the distribution of current among different conductors in complicated circuits.

1. Kirchhoff's First Law or Junction Rule

In an electric circuit, the algebraic sum of the current meeting at any junction in the circuit is zero.

$$\sum i = 0$$



According to the sign convention:

- The current entering the junction are taken as positive (i_1 and i_2).
- The current leaving the junction is taken as negative. ($-i_3$, $-i_4$, $-i_5$).

Using Kirchhoff's first law;

$$i_1 + i_2 - i_3 - i_4 - i_5 = 0$$

$$i_1 + i_2 = i_3 + i_4 + i_5$$

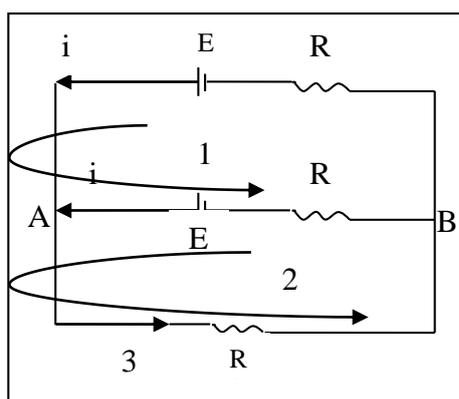
Notes: The sum of current entering the junction is equal to current leaving the junction. Kirchhoff's first law is simply a statement of conservation of charges.

2. Kirchhoff's Second Law or Loop Rule

The algebraic sum of the changes in potential around any closed resistance loop is zero.

$$\sum \Delta V = 0$$

$$\sum iR = 0$$



According to the sign convention:

Change in potential (ΔV) is taken negative when we go in the direction of the current.

Change in potential (ΔV) is taken positive when we go against the current.

If we go from negative terminal to positive terminal, $\Delta V = +E$.

If we go from positive terminal to negative terminal, $\Delta V = -E$.

Applying Kirchhoff's first law at junction A, a current flowing through R_3 i.e. i_3 is equal to $i_1 + i_2$.

Applying Kirchhoff's second law in loop 1, we get

$$-i_1 R_1 + E_1 - E_2 + i_2 R_2 = 0$$

Similarly, applying Kirchhoff's second law in loop 2, we get

$$-i_2 R_2 + E_2 - (i_1 + i_2) R_3 = 0$$

Solving these two equations we can get the values of i_1 and i_2 provided the values of R_1 , R_2 and R_3 are given.

Notes: Kirchhoff's second law is a statement of the conservation of energy.



Summary

- Electric charge is the intrinsic property of the material and can be positive or negative.
- Rate of change of charge in a conductor across any cross-section of the conductor is called the electric current.
- The voltage difference between two points in an electric circuit is the potential difference.
- Electrical resistance is the hindrance/obstruction offered by a conductor to the flow of current.

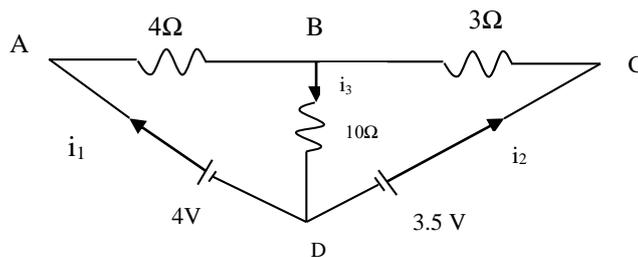
- The equation that gives the electrostatic force for charged particles is called
- Coulomb's law.
- Coulomb force between two charges is in accordance with Newton's 3rd law.
- Injunction rule, the current flowing towards the junction is taken as positive and current flowing out of the junction is taken as negative.
- The algebraic sum of current entering the junction is equal to the algebraic sum of current leaving the junction.
- Kirchhoff's first law is a statement of conservation of charge.
- Kirchhoff's second law is a statement of conservation of energy.



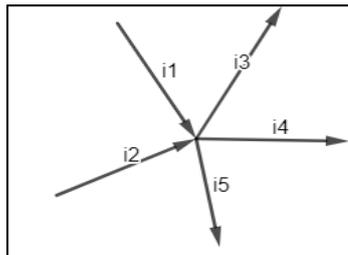
Self-check for Learning

Solve the following questions in your notebook.

1. In the circuit shown, E_1 and E_2 are the batteries having emf 4V and 3.5V respectively. Using Kirchhoff's laws, calculate current i_1 , i_2 and i_3 .



2. Calculate the current (i_5) if the currents $i_1 = 10A$, $i_2 = 7A$, $i_3 = 9A$, and $i_4 = 4A$. Also state which rule is applied in the figure on the right.



3.4. SIMPLE HARMONIC MOTION (SHM)

Learning Objectives



- Define simple harmonic motion (SHM).
- Derive velocity and acceleration in SHM.
- Explain the terms displacement, amplitude, frequency, angular frequency, and time period.
- Derive maximum velocity and maximum acceleration.
- Define and derive the relation for energy in SHM.
- Explain conservation of energy in SHM.

Introduction

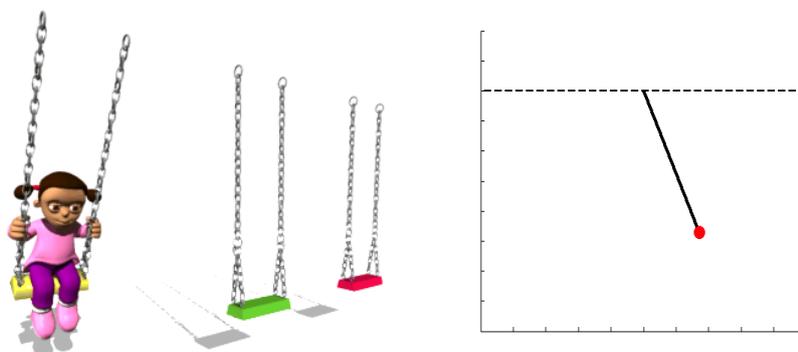
I am sure you must be fond of music? But have you ever wondered, how you hear the soothing sound when the musical instrument is played at a distance...What is the process that helps you to enjoy music?

Why do a pendulum and swing follow a repetitive path?

All the above questions are answered by a common phenomenon known as simple harmonic motion.

What is Simple Harmonic Motion?

A special type of periodic motion in which an object moves to and fro or back and forth repeatedly about a mean position under the influence of a restoring force is known as simple harmonic motion (SHM).



Oscillating Pendulum

The restoring force (a force which tries to bring the oscillating body back to its initial position) is always directed towards the mean position (position B in Figure 1) and its magnitude at any instant is directly proportional to the displacement of the particle from the mean position at that instant.

The restoring force acts in the opposite direction to the displacement of the particle which leads to oscillatory motion.

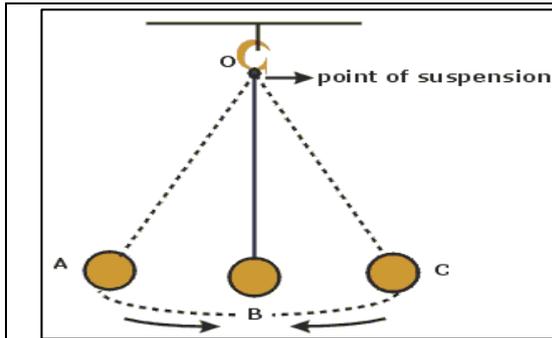


Figure: A Pendulum in Motion

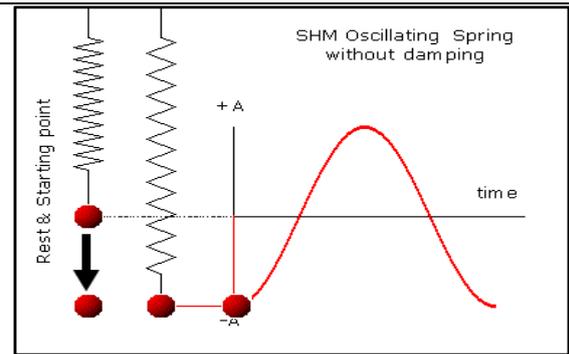


Figure: Block and Spring System

This graph shown in Figure 2 is similar to part of a sine or a cosine curve which has amplitude or the height equal to 'A'. It covers a certain distance from the mean position (rest position) at a particular instant of time which is the displacement(x) of the object in SHM. Therefore, the displacement equation for such motion can be written in terms of sine or a cosine function.

Displacement in SHM

The displacement in a simple harmonic motion is given by the equation

$$x(t) = A\cos(2\pi ft) \dots \dots \dots (1)$$

Or

$x(t) = A\sin(2\pi ft)$, where $x(t)$ is the displacement of the particle at a particular instant of time 't', 'A' is the amplitude, 'f' is the frequency and 'T' is the time.

The displacement of particles undergoing oscillatory motion can be expressed as functions of sines and cosines.

Terms Related to Simple Harmonic Motion

Displacement: It is the distance of a particle from the mean position at any instant of time while executing simple harmonic motion. Its symbol is 'x' and its unit is 'm' or 'cm' or 'mm'.

Amplitude: The maximum displacement of a particle on either side of its mean position is known as amplitude. Its symbol is 'A' and its unit is 'm' or 'cm' or 'mm'.

Frequency: The number of repetitions or oscillations made per second in periodic motion is called frequency. Its symbol is 'f' and its unit is hertz (Hz).

Time period: The time taken to complete one oscillation is known as the time. Its symbol is T and its unit is second (s).

Amplitude and Time Period

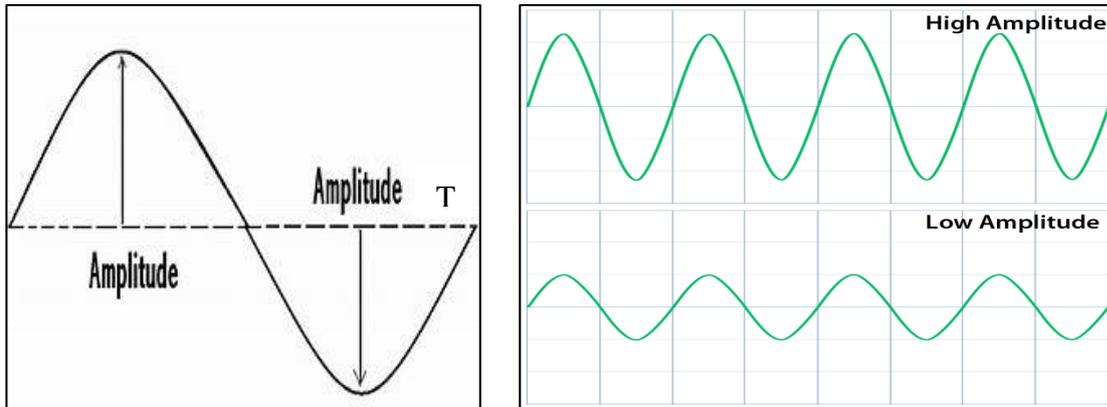


Figure: Amplitude

Angular Frequency (ω)

It is the angular displacement (circular displacement) per unit time period.

$$\omega = \frac{\text{Angular displacement}}{\text{time}}$$

Since the angular displacement made by a body in time equal to the time period 'T' is equal to 2π radian (or 360°);

$$\omega = \frac{2\pi}{T}$$

$$\text{or, } \omega = 2\pi f \quad \left(\text{Since } f = \frac{1}{T} \right)$$

Maximum Velocity (v_{\max})

The velocity of the body executing simple harmonic motion is given by the rate of change of displacement i.e.

$$v(t) = \frac{dx(t)}{dt} \quad (\text{Here } v(t) \text{ is the velocity at a particular instant of time 't', } dx(t)$$

is the small change in displacement during a very small interval of time dt.)

Now substituting the value of displacement $x(t)$ from equation (1), we get

$$v(t) = \frac{d[A \cos(2\pi ft)]}{dt}$$

$$v(t) = \frac{d}{dt} [A \cos(2\pi ft)] \frac{d}{dt} (2\pi ft)$$

$$v(t) = -A \sin(2\pi ft) \times (2\pi f)$$

$$v(t) = -(2\pi f)A \sin(2\pi ft) \text{ ---- } 2$$

Where $2\pi fA$ is known as velocity amplitude i.e. maximum velocity (v_{\max}).

When the value of $\sin(2\pi ft) = 1$ (maximum) then;

$$v_{\max} = -(2\pi f)A \times 1$$

$$\therefore v_{\max} = -2\pi fA$$

Maximum Acceleration (amax)

The acceleration of the body executing simple harmonic motion is given by the rate of change of velocity.

We have

$$a(t) = \frac{dv(t)}{dt} \text{ (Here } a(t) \text{ is the acceleration at a particular instant of time 't',}$$

$dv(t)$ is the small change in velocity during a very small interval of time dt .)

Substituting the value of $v(t)$ from equation (2), we get

$$a(t) = \frac{d[-(2\pi f)A \sin(2\pi ft)]}{dt}$$

$$a(t) = -(2\pi f)A \left[\frac{d}{dt} \sin(2\pi ft) \frac{d}{dt} (2\pi ft) \right]$$

$$a(t) = -(2\pi f)A \cos(2\pi ft) \times (2\pi f)$$

$$a(t) = -(2\pi f)^2 A \cos(2\pi ft) \text{ ----- 3}$$

Where $(2\pi f)^2 A$ is known as acceleration amplitude i.e. maximum acceleration (a_{\max}).

When the value of $\cos(2\pi ft) = 1$ (maximum) then;

$$a_{\max} = -(2\pi f)^2 A \times 1$$

$$\therefore a_{\max} = -(2\pi f)^2 A$$

On comparing equations (1) and (3), we get

$$a(t) = -(2\pi f)^2 \times x(t) \text{ ----- (4)}$$

$$\text{Or, } a(t) = -\omega^2 \times x(t)$$

In SHM, the acceleration is proportional to the displacement but opposite in sign and the two quantities are related by the square of the angular frequency (ω).

When the displacement has its greatest positive value, the acceleration has its greatest negative value. When displacement is zero, the acceleration is also zero.

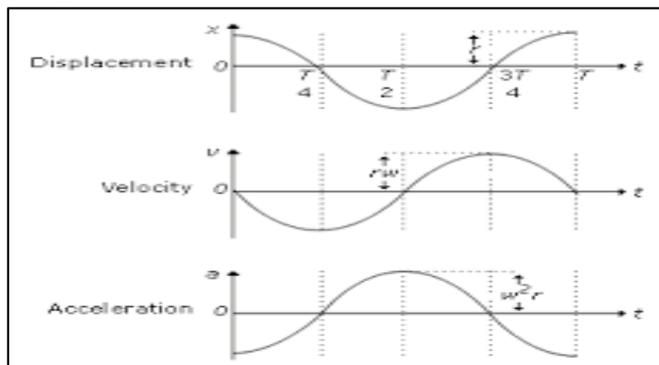
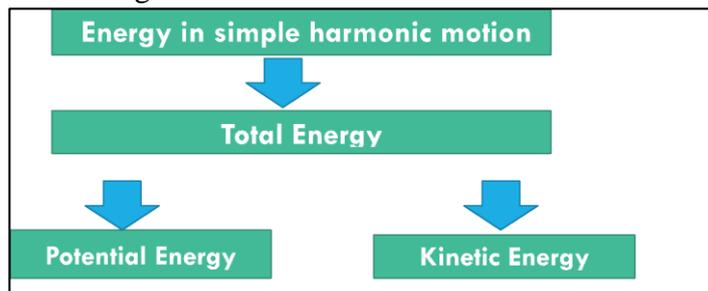


Figure: Displacement, Velocity, Acceleration Versus Time Graph

Energy in Simple Harmonic Motion

Every object possesses energy, either in motion or at rest. In the simple harmonic motion, the object moves to and fro along the same path. Do you think an object possesses energy while travelling the same path again and again?

To answer the above question, analyse the situation of an oscillating pendulum. When a pendulum swings, it possesses kinetic energy at the mean position and potential energy at the two extreme positions. Its kinetic energy is converted into potential energy as it swings from a mean position towards the extreme position. Then its potential energy is again converted into kinetic energy as it swings from an extreme position towards the mean position and then the energy continues to change in the same manner.



We all know that acceleration of particle varies with time in simple harmonic motion. Using Newton's second law we can find the force which must act on the particle to give it that acceleration i.e.

$$F = ma$$

Substituting the value of a from equation (4), we get

$$F = -m(2\pi f)^2 x \text{ -----(5)}$$

In simple harmonic motion, a restoring force that is proportional to the displacement but in opposite direction is given by Hooke's law i.e.

$$F = -kx \text{ -----(6)}$$

Substituting the value of F from equation (6) in equation (5), we get

$$-kx = -m(2\pi f)^2 x$$

$$k = m(2\pi f)^2, \text{ where } k \text{ is the spring constant}$$

Spring Constant: (k) measures how stiff and strong the spring is and is measured in N/m or dyne/cm.

Simple Harmonic Oscillator

Consider a block and spring system which forms a linear simple harmonic oscillator (i.e. linear oscillator). Let us take an example of spring in still state i.e. when no external force is applied. Attach one end of spring to a fixed point and the other end to a block which forms a simple linear oscillator, where the force (F) is proportional to displacement(x). The energy of linear oscillator transfers back and forth between kinetic energy and potential energy while the sum of these two energies i.e. mechanical energy remains constant.

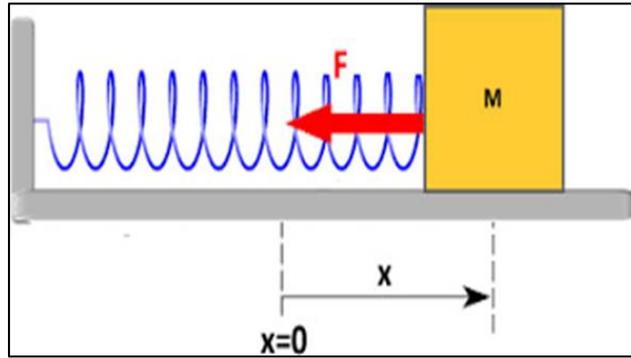


Figure: Block and Spring System

Energy of Simple Harmonic Motion

The potential energy of linear oscillator depends on how much the spring is stretched or compressed, i.e. on displacement (x).

Thus potential energy of a linear oscillator is expressed as $E_p(t) = \frac{1}{2}kx^2$

On substituting the value of x from equation (1), we get

$$\begin{aligned} \text{i.e. } E_p(t) &= \frac{1}{2}k[A\cos(2\pi ft)]^2 \\ E_p(t) &= \frac{1}{2}kA^2 \cos^2(2\pi ft) \text{-----7} \end{aligned}$$

The kinetic energy of the system depends on how fast the block is moving that is the velocity of the block i.e. v(t), thus, $E_k(t) = \frac{1}{2}mv^2$

Substituting the value of v from equation (2), we get

$$\begin{aligned} E_k(t) &= \frac{1}{2}m[(2\pi f)A\sin(2\pi ft)]^2 \\ E_k(t) &= \frac{1}{2}m(2\pi f)^2 A^2 \sin^2(2\pi ft) \\ &= \frac{1}{2}kA^2 \sin^2(2\pi ft) \text{-----8} \quad \because k = m(2\pi f)^2 \end{aligned}$$

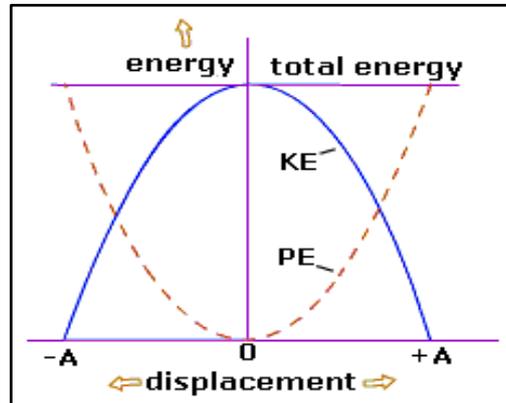
The total mechanical energy is given by sum of the potential energy (Ep) and kinetic energy (Ek). Thus adding equations (1) and (2), we get

$$\begin{aligned} E_t(t) &= E_p(t) + E_k(t) \\ &= \frac{1}{2}kA^2 \cos^2(2\pi ft) + \frac{1}{2}kA^2 \sin^2(2\pi ft) \\ &= \frac{1}{2}kA^2 [\cos^2(2\pi ft) + \sin^2(2\pi ft)] \\ &= \frac{1}{2}kA^2 \quad \because \cos^2(2\pi ft) + \sin^2(2\pi ft) = 1 \end{aligned}$$

The total mechanical energy of the linear oscillator is constant and is independent of time.

Total Energy Graph

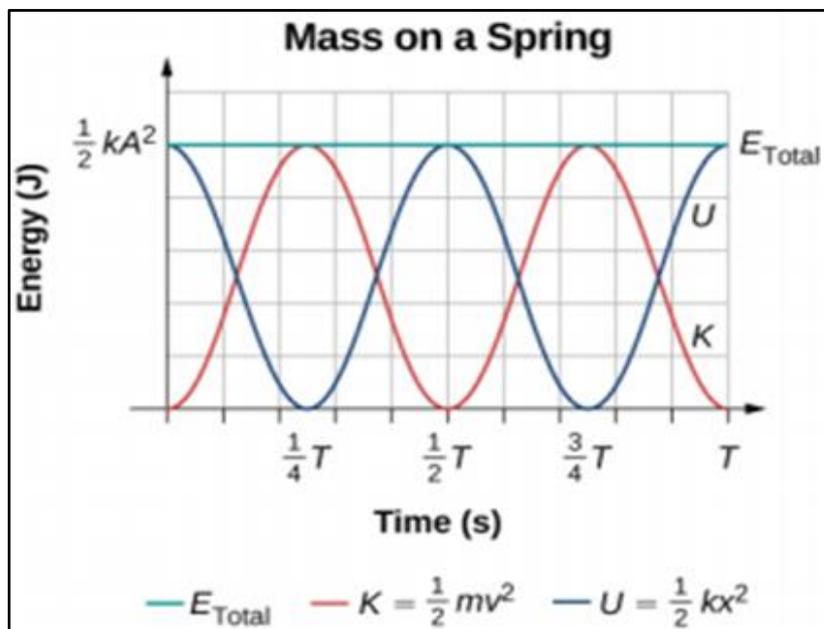
The dotted curve shows the variation in potential energy and the blue curve shows the variation in kinetic energy, with respect to the displacement of the oscillator.



The law of conservation of energy states that energy can neither be created nor destroyed. Therefore, the total energy in simple harmonic motion will always be constant. However, kinetic energy and potential energy are interchangeable. The figure represents a graph of kinetic and potential energy vs instantaneous displacement.

At the mean position, the total energy in simple harmonic motion is purely kinetic and at the extreme position, the total energy in simple harmonic motion is purely potential energy.

At other positions, kinetic and potential energies are interconvertible and their sum is equal to $\frac{1}{2} k A^2$. The nature of the graph is parabolic.





Summary

- Oscillations occur when a body is disturbed from its equilibrium position.
- Oscillatory motion is always periodic, but the periodic motion may or may not be oscillatory.
- Time period is represented by T and its unit is second.
- Frequency is reciprocal of time period.
- Angular frequency (ω) is given by $2\pi f$.
- At mean position the kinetic energy is maximum and potential energy is zero.
- At extreme position, the potential energy is maximum and kinetic energy is zero.
- Displacement of a particle is the distance of the oscillating particle from a mean position at a time 't' but amplitude is the maximum displacement on either side of the mean position.
- The sum of the potential energy and kinetic energy is mechanical energy.



Self-check for Learning

1. A spring has a spring constant of 0.1 N/m . What force is required to get an extension of 4m ? [Hint: Use relation between force, spring constant and displacement]
2. What is the maximum acceleration of a platform that oscillates at amplitude 2.20cm and frequency of 6.60 Hz ? [Hint: Find a_{max}]
3. Find the mechanical energy of block-spring system having a spring constant of 1.3N/cm and amplitude of 2.4cm . [Hint: Find total energy]

COMMERCE STREAM

1. COMMERCE

1.1. MANAGEMENT

Learning Objectives



- Study the concepts of management.
- Explain the features of management.
- State the functions of management.

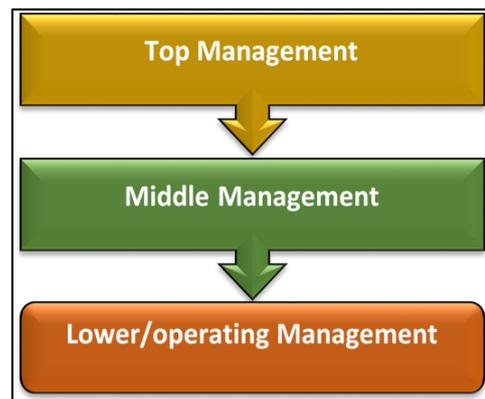
Introduction**Management**

- It is the process of planning, organising, staffing, directing and controlling the performances of an organisation to accomplish the pre-determined objectives.
- Any organization operating for profit or non-profit, management is an essential component to achieve its pre-determined objectives.
- The success of any organisation depends on the efficiency of the management.

Levels of Management

In every organization, there is a chain of command from top to bottom, which is known as levels of management.

- The top managerial positions consist of Board of Directors, Chief Executive Officer or Managing Director who gives strategic directions in terms of organisational vision, goals and to frame policies.
- Middle level positions consist of branch manager or departmental heads who are responsible for the top management for the functioning of their department. They execute the plans of the organisation per the policies and directives of the top management.
- The lower or operating level consists of supervisors or section officers. They are responsible for designing jobs and tasks to various workers.



Characteristics of Management

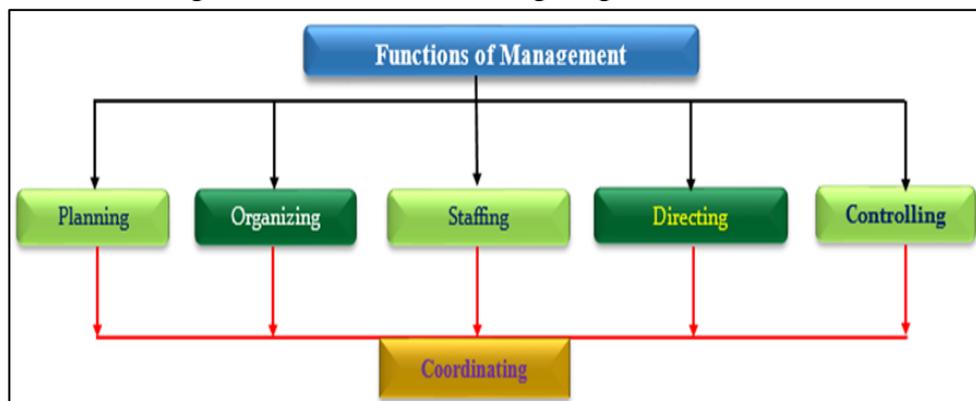
Characteristics of Management is represented diagrammatically, and explanation is provided below for a better understanding.

- Management is goal-oriented: All management activities are goal-oriented and result-oriented. Every organisation has goals to achieve and the achievement of those goals of the organisation is ensured by effective management.
- Management is a group activity: Every organisation has a group of people working together. All these people work towards a common goal. It involves teamwork and employee's skills in getting things done through group effort.
- Management is Universal: The principles and techniques of management are applicable in all types of organisations whether government, private, corporations however big or small. This technique also applies to all levels of management.
- Management has a Dynamic function: The management must change policies and practices of the organisation according to the changes in its environment so that it is easier for the management to compete in the market.
- Management is Intangible: Management is an invisible force which cannot be seen or touched but can be felt in the form of results.



Functions of Management

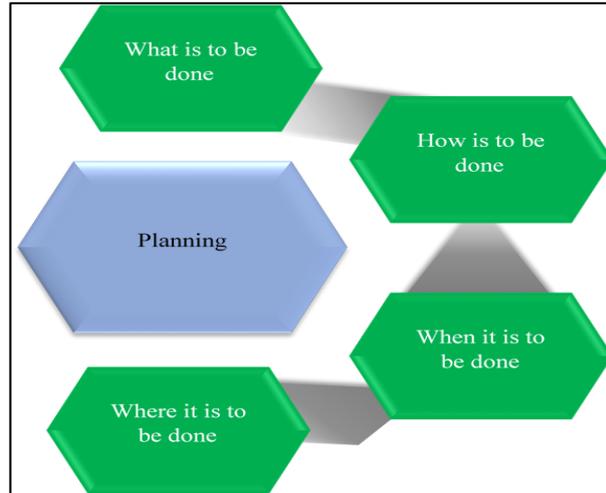
The Functions of management are shown in the figure given below.



i. Planning

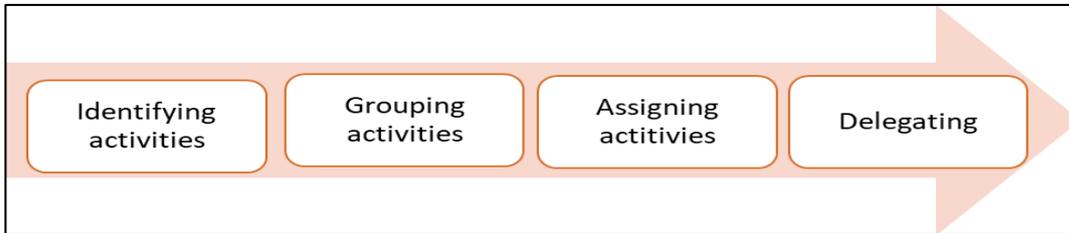
The diagram below explains the concept of planning.

Planning is a fundamental function of management. Looking ahead or thinking before acting is called planning. Nothing can be performed without planning. In simpler terms, it is today’s design for tomorrow and an outline of steps to be taken. Proper planning helps in avoiding or minimising confusion, uncertainties, risks, and resource wastage.



ii. Organising

It is the process of mobilising resources such as human, finance, technology, land, and materials for carrying out the plans and activities set in the planning stage. It also involves the development of an organisational structure to clearly define duties, communicate reporting lines, and allocate resources for the achievement of goals. Organising optimum use of human resources by matching work with talent/skills and it also encourages teamwork.



iii. Staffing

‘To staff’ means to recruit, select, develop, maintain and utilize human resources to get the most qualified personnel for the job. The sole aim of staffing is to put the right man for the right job.

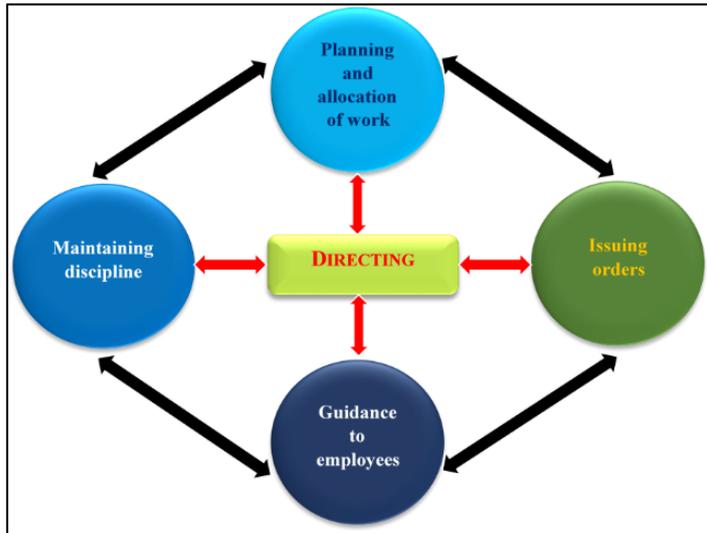
Importance:

- Discovering competent employees.
- Improves the quality and quantity of output.
- Reduces the cost of personnel.



iv. Directing

It is the process of providing direction and guidance to the employees on their roles and responsibilities in the achievement of the set goals. Directing should be in such a way that motivates individual to perform. It also facilitates the employees to work in a disciplined manner by guiding and supervising their activities.

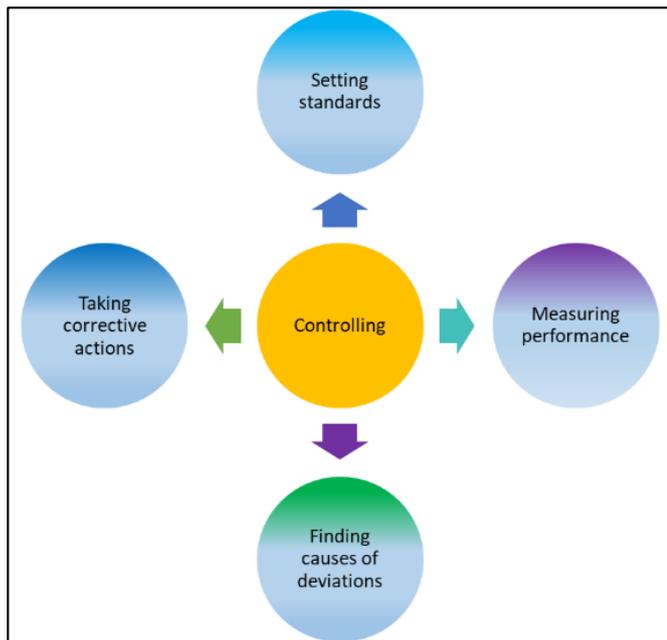


v. Controlling

Controlling pertains to evaluation of the performance of employees in meeting the set goals. An assessment of employees' actual performance against the target performance takes place in this stage. This assessment helps in gathering feedback which further helps in making proper plans.

vi. Co-ordinating

Coordination is not a separate function of management but an essence of management. It means working together of a large number of people for a common end voluntarily. It is the art of achieving harmony of individual and group effort for the accomplishment of organizational goals. Different functions of management such as planning, organising, staffing, directing and controlling are performed to achieve coordination.



ACTIVITY 1

Imagine that you are going to live on an island and you are allowed to take only three things with you. What things would you take?

To take those things, you need to plan, organize, coordinate, and make decisions. This raises the question of management.

Importance:

- It helps to reduce the gaps in performances.
- Increase the productivity of employees.
- It is the basis for future planning.

**Summary**

- Management is getting work done through others.
- Management is a continuous process.
- Managers are evaluated based on the collective performance of those they supervise.
- Managers use resources of the organisation, both physical as well as human to achieve the set goals.
- Management is the process of planning, organising, controlling, and staffing to achieve organisational goals.

**Self-check for Learning**

1. Considering your home as an organisation, write different managerial roles undertaken by each member of your family. Here is an example for you:
Mother: Manager
2. Draw the relationship of managerial roles undertaken by your family with organisational management. Here is an example for you.
Mother: Manager: - She manages the household activities and decides what needs to be purchased from the market.

1.2. COMMUNICATION AND ITS IMPORTANCE

Learning Objectives



- Explain the concepts of business communication.
- Explain the importance of communication in business.
- Relate the importance of communication in the real world of work.

Introduction

Every day we communicate with others for varied reasons through different modes. Some of us talk face to face, while some communicate through emails, phones, newspapers, television, radio and various other modern communication methods. Thus, we can classify communication as interpersonal, intrapersonal, group communication, upward, downward, lateral, diagonal, and oral/verbal, non-verbal and written.



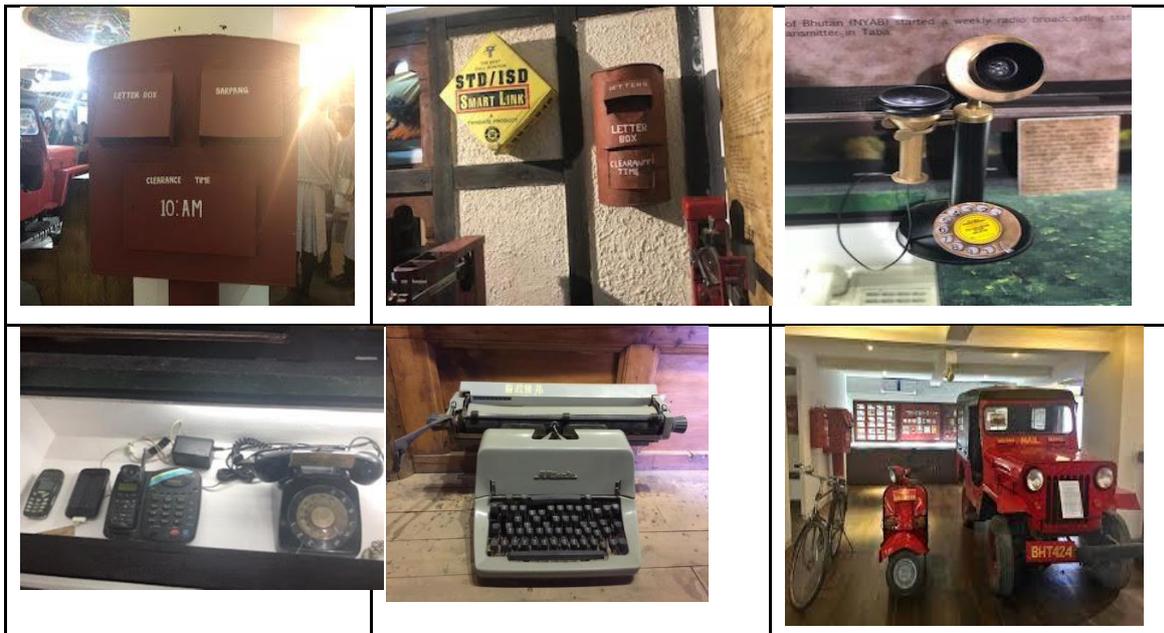
ACTIVITY 1

1. Write down your understanding about the term 'communication'.

What is communication?

Communication is an exchange and understanding of ideas, facts, and opinions, information between two or more persons. It may also be regarded as a process of meaningfully transferring information for one person to another. The success of a business depends on the effectiveness of communication.

The pictures below take us through the old modes of communication. They are the pictures from the postal museum, Thimphu.



Business Communication

Business communication refers to exchanging information between all parties involved in the operation of the business to promote business goals, objectives, aims, and activities as well as to increase the profitability by selling products to the customers. Effective business communication fosters valuable rapport among the organisation and its stakeholders, resulting in increased productivity.

1. Facilitates Sound Planning

Sound planning requires the supply of information from all the departments and stakeholders. Planners must ensure participation of every employee of the organization and seek their opinions and suggestions during the planning process. However, they must ensure the authenticity of the information received. Thus, communication plays a vital role in planning.



2. Facilitates Decision Making

A decision must be made upon a series of consultation and meeting with the employees and stakeholders. Management must even allow debates to arrive at a good decision. Effective communication enables both the management and the subordinates to identify the real problems and take appropriate decisions.

3. Facilitates Coordination

The success of an organisation depends on the coordinated efforts of all the departments and sections of an entity. To ensure a coordinated effort, a good chain of communication is a must. Coordination can be maintained among various related departments by making an exchange of information regularly.

4. Improves Morale and Mutual Trust

Effective communication creates mutual trust and confidence between the management and the employees. Management sharing idea and experience with employees facilitates in eliminating fears and help in winning their trust and confidence.

5. Maintaining Stakeholders

Stakeholders are those interested parties who are highly influential in the business decision and the success of a business depends on their participation. Therefore, stakeholders must be well informed and get the right information about them. The organisation must have a good chain of correspondences with them.

6. Improve Public Relations

To develop goodwill and public trust, true and fair information about the business must be provided at the right time which otherwise may pose various implications for the sustenance of the business. It is only through communication that management can present a good image to the outside world.

7. Enables Efficient and Smooth Operation of an Enterprise

Effective communication fosters the smooth operation of the management process. The smooth and efficient functioning of an enterprise entirely depends upon the effectiveness of the system of communication.



ACTIVITY 2

1. Reflect for a few minutes as how communication has proved to be vital in your daily life. Write them down in your notebook.



Summary

- Communication is the process of passing information and it is essentially a bridge of meaning between the people. Communication is giving and receiving information.
- Business communication refers to exchanging information between all parties involved in the operation of the business to promote business goals, objectives, aims, and activities as well as to increase the profitability by selling products to the customers.
- Communication is vital as it facilitates proper planning and coordination. It also improves morale and mutual trust, public relations and enables efficient operation of the business.



Self-check for Learning

Answer the following questions in your notebook.

1. If you are attending a job interview, what are the essential communication skills you may require?
2. The invention of the mobile network has brought tremendous change in the communication channel in the society. What are some of the implications you foresee in the use of the mobile phone for official correspondences?
3. Look at the pictures on the various modes of communication used in the past and compare what changes have happened and list down at least FIVE modern modes of communication.

1.3. PRINCIPLES OF EFFECTIVE COMMUNICATION

Learning Objectives:



- State the concepts of principles of effective communication.
- Explain various principles of effective communication.
- Apply the principle of effective communication in a real workplace.



ACTIVITY 1

Self-rating activity:

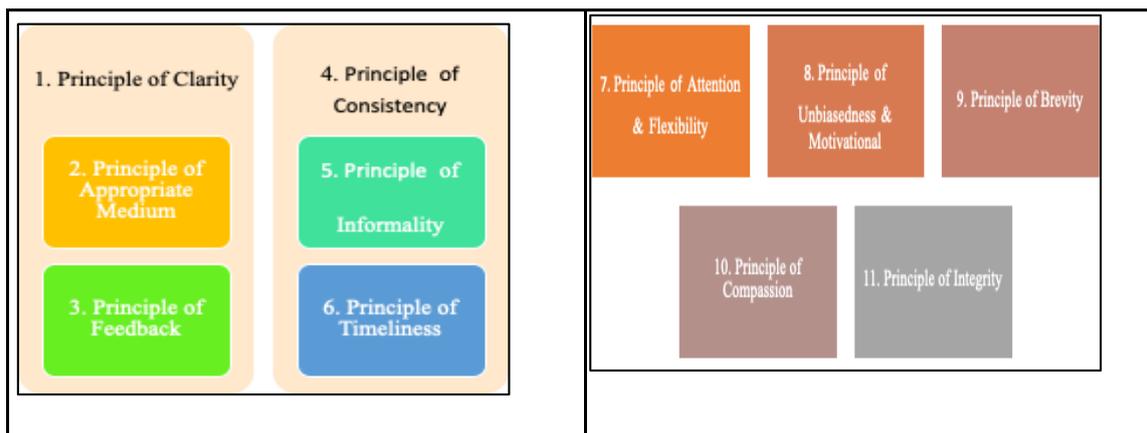
On a scale from 1 to 10, (1 being poor and 10 being excellent) how would you rate yourself as an effective communicator? Why would you rate yourself as communicator?

Introduction

In the last two lessons, we discussed about the communication, business communication and objectives of business communication. In this lesson, let us discuss how we can communicate effectively to fulfil the objectives of communication. Do you often get confused while engaging in a conversation? Have you ever felt nervous about speaking up? Have you ever felt frustrated for not being able to get your message through? Well, let us look at the meaning of principles of effective communication.

It refers to communication guidelines aimed at fostering effective business communication.

Principle of Effective Communication



1. Principle of Clarity

The communication should be clear and easily understandable by the receiver in the process of communication. It may not be possible to achieve perfect communication unless the purpose of communication is clearly defined. The ideas to be communicated should be very clear in the mind of the sender. If the message is clear, it would also evoke the same responses.

2. Principle of Appropriate Medium

The appropriateness of communication channel depends upon the nature and purpose of the information to be transmitted. The media used should be such that the message is conveyed properly and is understood rightly. There may be numbers of networks available in an organisation, but management should select one which is most suitable for a particular message.

Example: Official correspondences are sent through written letters.

3. Principle of Feedback

Feedback refers to actual response or reply of the receiver to the communicator. There should always be a follow-up action to ensure that the message is rightly understood.

Feedback enables the sender to know whether the receiver has properly understood the message and also helps in knowing the reaction of the receiver.

4. Principle of Consistency

The communication should be consistent with plans, policies and objectives of the organization and not in conflict with them. The sender should not create any gap between what he says and what he does. If the messages are inconsistent to the organizational objectives, programs etc. then these will create confusion in the minds of subordinates about their implementation.

5. Principle of Timeliness

The message should be conveyed at the right time and to the right person. The messages sent in time will help in taking timely actions. The messages sent in time will help in making and implementing decisions. Untimely messages do not have any impact and utility.

6. Principle of Attention and Flexibility

The message should be conveyed in such a way that it attracts the attention of the receiver and makes him understand the ideas in it. Each person has his or her own emotions, sentiments, and likings etc. which determine the degree of attention. The message should be conveyed in such a way that it attracts the attention of the receiver and makes him understand the ideas in it.

The communication system should be agreeable to change according to the condition of the business change. It should absorb new techniques of communication with little struggle.

7. Principle of Unbiasedness and Motivational

It should be free from personal prejudices. It must take into account the interests of the other parties. The receiver should be encouraged to express his or her reactions. It should not only be informative but also prescriptive (regulatory).

8. Principle of Brevity

To have effective communication in the business organisation, all messages must be accurate, consistent and precise. It means all communication must be brief and to the point. Irrelevant words and information tend to spoil the messages that one wants to convey.

9. Principle of Compassion

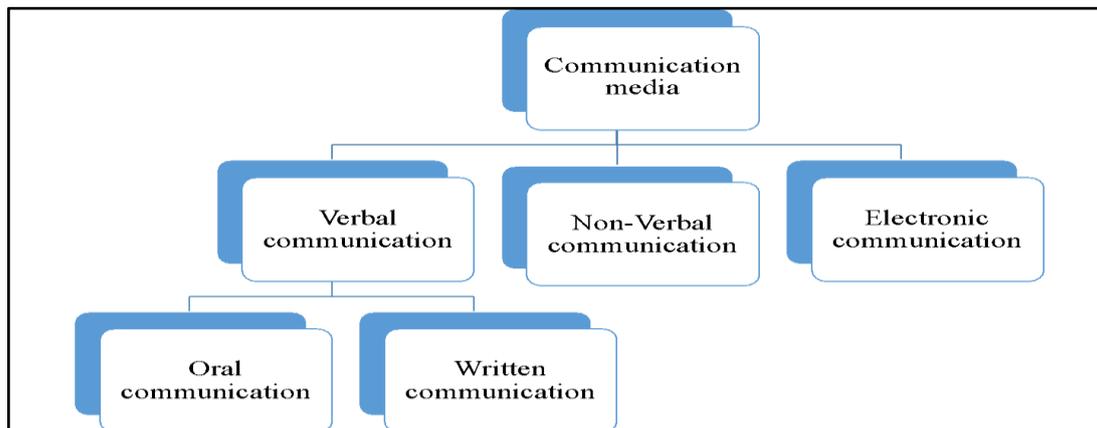
To make the communication effective, the communicator must understand the need, background and the intelligence level of the receiver. The person who sends messages must know what is exactly required and when it is required. Communication network must be wide and should cover all levels of the enterprise for its effectiveness.

10. Principle of Integrity

The message sent must be in consistence with the objectives, policies, rules and regulations of the organisation. The provisions of the policies, rules and regulations related to communication must be adhered by both sender and receiver.

**ACTIVITY 2**

The digital age has brought many new ways to communicate such as email, Twitter, and Facebook. How has communication changed? What is helpful?

Types of Communication Media

A communication media refers to a channel through which information is exchanged between internal and external stakeholders of the business. These media are classified into written, oral and electronic, and they can be formal, informal or unofficial.

Oral Communication

It refers to conveying of message through spoken words such as face-to-face conversation, video conferences, group presentations, telephonic/electronic conversations, speeches and lectures.

Written Communication

It refers to conveying information using written words. It includes texts, memos, letters, documents, reports, newsletters, spreadsheets, and electronic texts such as e-mails and SMS which are the digital version of written communication.

Non-verbal or Gestural Communication

It refers to conveying information without using words. The information is conveyed with the help of facial expressions, posture or body movements or other visual or auditory signs and symbols such as colours and music.

Electronic or Multimedia Communication

It refers to dissemination and reception of business information through television and radio broadcasts, internet and web-based channels such as social media, interactive blogs, and public and intranet networks.



Summary

- Principles of effective communication ensure the effective functioning of an organisation.
- All the messages sent should be clear, concise and understandable by the receiver.
- The message should be conveyed at the right time and to the right person.
- The media used should be such that the message is conveyed properly and is understood rightly.
- The message sent must be in consistence with the objectives, policies, rules and regulations of the organisation.



Self-check for Learning

If you are designing a product for nation-wide sale, which channel would be most appropriate and why?

1. Considering you as a manager of a business firm, draft a notice to your employees informing them that there will be a 10% pay cut from all the employees' salary. You may site the decline in sale for the month due to COVID-19 pandemic as the main reason.

2. ECONOMICS

2.1. MEASUREMENT OF PRICE ELASTICITY OF DEMAND

Learning Objectives



- Derive formula to calculate price elasticity of demand using percentage method.
- Calculate the elasticity of demand for a good.
- Determine the elasticity of demand on the demand curve using point method/geometric method.

Introduction

The elasticity of demand for different goods is different. It is important to measure the elasticity of demand as it helps in determining the price of various factors of production. The efficiency of factors of production stands to reason that more high-quality goods can be produced at a lower price. Eventually, a change in the price of a commodity affects its demand. Most businesses find the impact of a price change and use it to adjust the price of goods to maximize profits. Higher price elasticity of demand suggests that consumers are more responsive to a product's price change. Therefore, it is important to know the price elasticity of demand in advance of price change. *The elasticity of demand is the responsiveness of the quantity demanded of a commodity to a change in its price.* The following points highlight a few important methods of measuring price elasticity of demand.

- Percentage method
- Total expenditure method and
- Point method/geometric method

A. Percentage or Proportionate Method

In this method, price elasticity of demand is measured as the ratio of the percentage change in quantity demanded to the percentage change in the price of the commodity.

Thus, mathematically expressed, it is:

$$e_p = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}} \\ = \frac{\text{Change in Quantity Demanded/Initial quantity}}{\text{Change in Price/Initial Price}}$$

$$\text{i.e.} = \frac{\Delta Q/Q}{\Delta P/P} \text{ where, } \Delta \text{ implies change.}$$

$$e_p = \frac{\Delta Q}{\Delta P} \times \frac{P_1}{Q_1}$$

Where:

- e_p stands for price elasticity of demand.
- Q stands for quantity (initial).
- P stands for price (initial).
- ΔQ is the new quantity minus the initial quantity.
- ΔP is the new price minus the initial price.

Example: A consumer buys 40kg of rice at Nu. 25 per kg. When its price falls to Nu. 20 per kg, its demand rises to 50kg. Find the price elasticity of demand.

Solution:

Given, $\Delta Q = 50 - 40 = 10$ kg; $\Delta P = 25 - 20 = \text{Nu.}5$; $P = \text{Nu.} 25$; $Q = 40$ kg

$$\text{Thus, } e_p = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

$$e_p = \frac{10}{5} \times \frac{25}{40}$$

$$e_p = 1.25 \dots \dots \dots \text{It is the price elasticity of demand.}$$

Therefore, $e_p > 1$ (It is the price elasticity of demand)

Note: Mathematically speaking, price elasticity of demand is negative, since the change in quantity demanded is inversely related to change in price. However, we ignore the negative sign and take into account only the numerical value of the elasticity.



ACTIVITY 1

Consider the demand for a good. At a price of Nu.4, the demand for the good is 25 units. Suppose the price of the good increases to Nu. 5, and as a result, the demand for the good falls to 20 units, what is the price elasticity of demand. Calculate.

B. Expenditure Method

This method measures the elasticity of demand by considering the change in total expenditure because of the change in the price of a commodity. In other words, the total expenditure method indicates the direction in which total expenditure on product changes as a result of the change in the price of the commodity. Total expenditure is the product of price and quantity, that is, $TE = P \times Q$ (TE is a total expenditure, P is the price and Q is the quantity).

By using this method, the elasticity of demand can be classified as follows:

1. Elastic demand: When the total expenditure (total revenue) varies inversely with price, price elasticity of demand is greater than one (elastic demand). In other words, with the fall in price, total expenditure increases, or with a rise in price, total expenditure decreases.

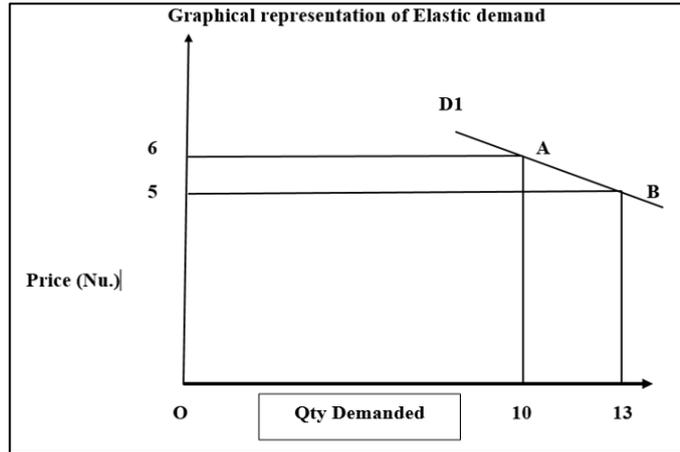
Let's look at the example given below:

Price in Nu.	Quantity (Units)	Total Expenditure
6	10	60
5	13	65

$e_p > 1$

SELF-INSTRUCTIONAL MATERIAL

Explanation: When the price of the commodity was Nu. 6, quantity demanded was 10 units and the total expenditure was Nu. 60. When the price dropped to Nu. 5, the quantity demanded increased from 10 units to 13 units which resulted in an increase of total expenditure from Nu. 60 to Nu. 65. Hence, the price elasticity of demand is greater than one ($e_p > 1$).



2. Inelastic demand:

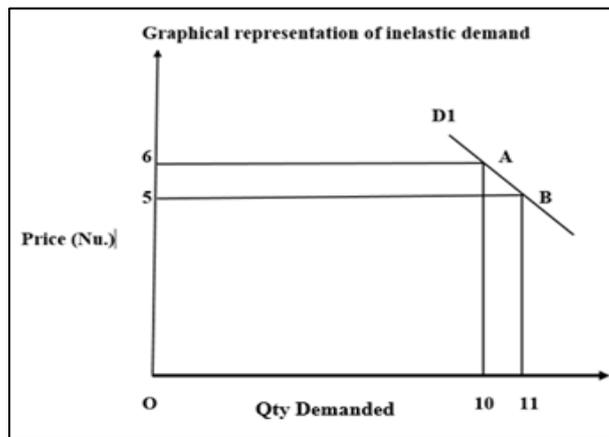
When the total expenditure (total revenue) varies directly with the price, the price elasticity of demand is less than one (inelastic demand). In other words, a fall in the price of the commodity results in a decrease in total expenditure and a rise in the price leads to an increase in total expenditure. In such a case, the elasticity of demand will be less than one.

Let's look at the example given below:

Price in Nu.	Quantity (Units)	Total Expenditure
6	10	60
5	11	55

$e_p < 1$

3. Unitary elastic demand: When the total expenditure (total revenue) remains the same, whatever may be the change in the price level, price elasticity of demand is said to be unity or equal to one.

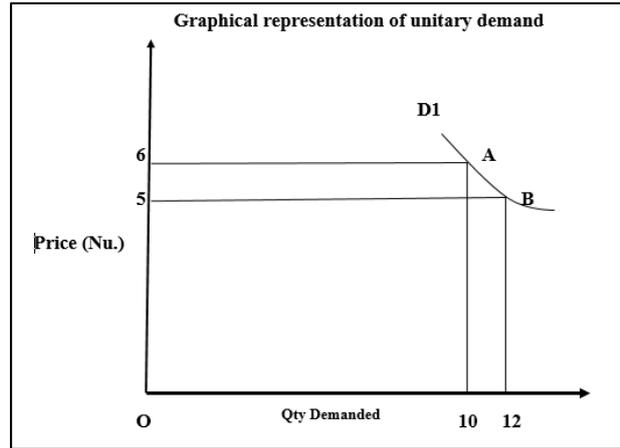


Let's look at the example given below:

Price in Nu.	Quantity (Units)	Total Expenditure
6	10	60
5	12	60

$e_p = 1$

Explanation: When the price of the commodity was Nu. 6, quantity demanded was 10 units and the total expenditure was Nu. 60. When the price dropped from Nu. 6 to Nu. 5, quantity demanded increased from 10 units to 12 units. However, the total expenditure remains constant at Nu. 60. Here price elasticity of demand is equal to one, i.e., ($e_p=1$).



C. Point Method or Geometric Method

According to this method, the price elasticity of demand at any point on the demand curve is measured by dividing the lower segment of the demand curve with the upper segment of the demand curve at that point. It can be calculated by dividing the lower segment by the upper segment.

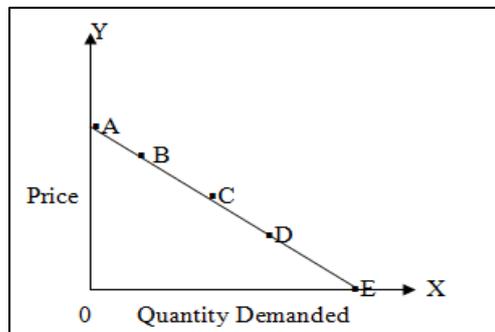
That is, $e_p = \frac{\text{Lower Line Segment}}{\text{Upper Line Segment}}$

Example:

Calculate the elasticity of demand at point A, B, C, D, and E from the diagram given below. Remember that, here the demand curve is a straight line.

i. *On a Linear Demand Curve*

Consider the demand curve as shown by the following diagram.



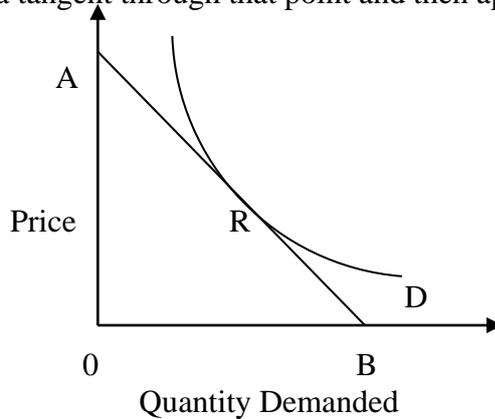
e_p at A = $\frac{\text{Lower Line Segment}}{\text{Upper Line Segment}} = \frac{AE}{0} = \infty$ Perfectly Elastic

- i. e_p at B = $\frac{BE}{AB}$, since $BE > AB$; $e_p > 1$ Elastic
- ii. e_p at C = $\frac{CE}{AC}$, since $CE = AC$; $e_p = 1$ Unitary Elastic
- iii. e_p at D = $\frac{DE}{AD}$, since $DE < AD$; $e_p < 1$ Inelastic
- iv. e_p at E = $\frac{0}{AE} = 0$ Perfectly Inelastic

Note: If point C is the mid-point of the points on the demand curve, the elasticity of demand at points above C will be greater than 1 (elastic) and at points below C will be less than 1 (inelastic). At C, it will be unity.

ii. *On a Non-linear Demand Curve*

To estimate the price elasticity of demand at a point on the non-linear demand curve, we need to draw a tangent through that point and then apply the same formula.



$$e_p \text{ at R} = \frac{\text{Lower Line Segment}}{\text{Upper Line Segment}} = \frac{RB}{AR}$$

Since $RB < AR$; $e_p < 1$Inelastic

**Summary**

- Price elasticity measures the responsiveness of the quantity demanded of a good to a change in its price. It is computed as the percentage change in quantity demanded divided by the percentage change in price.
- Elastic demand curves indicate that the quantity demanded a response to price changes in a greater than proportional manner.
- An inelastic demand curve is one where a given percentage change in price will cause a smaller percentage change in quantity demanded.
- Unitary elasticity means that a given percentage changes in price lead to an equal percentage change in quantity demanded.
- Point elasticity is the price elasticity of demand at a specific point on the demand curve instead of over a range of it.

**Self-check for Learning**

1. Price of a commodity rises from Nu. 5 to Nu. 6. As a result, its demand falls from 100 units to 80 units. Find out the price elasticity of demand by percentage method.
2. A household increases the demand for a commodity from 40 units to 50 units when its price falls by 10 percent. What is the price elasticity of demand? Is it elastic or inelastic?

2.2. SUPPLY, ITS DETERMINANTS AND LAW OF SUPPLY

Learning Objectives



- Interpret the meaning of supply.
- Explain the determinants of supply or factors affecting supply.
- State the law of supply.

Introduction

The theory of supply is much related to the theory of demand. Demand explains the behaviour of the consumer whereas supply explains the behaviour of producers, sellers or firms. Buyers want to purchase goods and services while sellers want to sell goods and services. "Supply" represents the amount of goods a market can provide, while "demand" stands for the amount of goods customers are willing to buy. The law of supply expresses the direct relationship between the supply and price of a product while other factors remain the same. The law of supply states that the supply of a product increases with an increase in its price while other factors remain constant.

Meaning of Supply and Law of Supply

Supply refers to the quantity of a product that a seller agrees to sell in the market at a particular price within a given time.

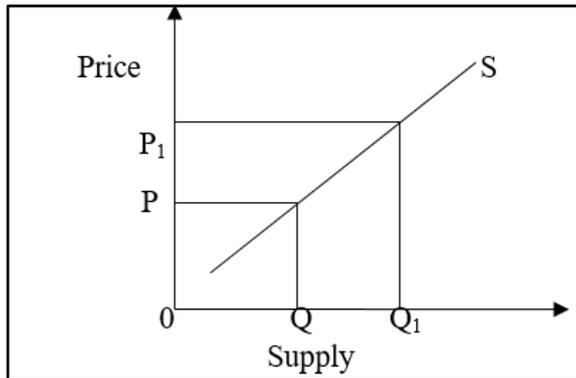
The law of supply states that other things remaining the same, at a higher price, producers are willing to supply more and at a lower price, producers are willing to supply less. So there is a direct relationship between price and quantity supplied of a commodity.

Supply Schedule: A tabular representation of the law of supply. It explains the direct relationship between the price and quantity supplied of a commodity.

Price of Potatoes (Nu.)	Quantity Supplied (Kg)
15	30
18	35
20	40
25	45

Supply Curve

A supply curve is a graphic representation of the relationship between product price and quantity of product that a seller is willing and able to supply. It explains that when the price of a commodity is high, its supply will be more and when the price is low, supply will be also less.



The figure above shows that when the price of the good is OP , the quantity supplied is OQ . On the other hand, when price increases to OP_1 from OP , the quantity supplied also increases to OQ_1 from OQ . This tells us that price and supply are directly related to each other.



ACTIVITY 1

Answer the following question.

1. How does your supply curve look like? Is it a negatively sloping curve or a positively sloping curve?
2. Why is pricing a critical aspect of the law of supply?

Determinants of Supply

Similar to the theory of demand and its determinants, there are several factors affecting supply determining the seller's ability and willingness to provide the commodity for sale in the market.

1. *Price of a commodity*: Unlike the relationship between price and demand, there is a positive relationship between price and quantity supplied. Sellers will sell more quantity of a commodity at a higher price and supply less at a lower price with all parameter being equal. The reason is simple. A firm provides goods or services to earn profits and if the prices rise, the profit rises too.
2. *Goals of a firm*: the supply of a firm is determined by the goals of the firm. Some firms aim at profit maximization so they supply more with higher profits, some firms aim at sale maximization, such firms supply more to reach maximum consumers and some firms aim at risk minimization, so they supply a smaller quantity to avoid risk.
3. *Prices of inputs*: If the producer has to pay a high price to acquire factors of production, their cost of production will be high which results in a lesser amount of profit. Therefore, the seller will supply less and vice versa.
4. *Technological change*: Technological improvements help reduce production cost and increase profit, thus stimulate higher supply. Therefore, using advanced techniques of production increases the supply of a commodity and vice versa.
5. *Prices of substitutes in production*: the prices of substitute goods also affect the supply of a product. For example, if the price of wheat increases, the farmers would grow more wheat than rice. This would decrease the supply of rice in the market.

6. *Expectations regarding future prices:* If a producer/ seller expects the future price of his or her commodity to be higher, the supply changes accordingly. They will try to hold on to their inventories (goods) and offer it to the consumers/buyer in the future and thus they can capture the higher price. On the other hand, if the producers/ seller expects a fall in the price of his or her commodity in future than they will supply more at present.
7. *Number of firms in the market:* When there are large numbers of producers/sellers in the market, there will be more supply of goods and services in the market. On the other hand, when there are limited producers/sellers in the market the supply of products would be less.
8. *The policy of taxation and subsidies:* Commodity taxes like excise duty, import duties, GST, etc. have a huge impact on the cost of production. These taxes can raise overall costs. Hence, the supply of goods that are impacted by these taxes increases only when the price increases. On the other hand, subsidies reduce the cost of production and usually lead to an increase in supply.
9. *Agreement among producers:* Sometimes producers may form a pool to create artificial scarcity of goods in the economy to enjoy the high price. Therefore, the market would experience a decreased supply.
10. *Natural factors:* Natural factors are particularly important for the supply of agricultural products. If the factors are favourable (adequate rain, climatic condition), the supply will increase and vice versa.
11. *Availability of transport and communication:* An improvement in transport and communication facilities will expand the size of the market which motivate producers to produce and supply more products. Transport is always a constraint to the supply of products, as the products are not available on time due to poor transport facilities. Therefore even if the price of a product increases, the supply would not increase.



Summary

- Supply curves and supply schedules are tools used to summarize the relationship between supply and price.
- A supply schedule is a table that shows the quantity supplied at each price.
- A supply curve is a graph that shows the quantity supplied at each price.
- The law of supply is a fundamental principle of economic theory which states that keeping other factors constant; there is a direct relationship between price and quantity.
- Movements along the supply curve occur only if there is a change in quantity supplied due to change in its price.
- A shift in the supply curve occurs only if a non-price determinant of supply changes.
- Changes in the cost of inputs, natural disasters, new technologies, and the impact of government decisions, etc all affect the cost of production. In turn, these factors affect how much firms are willing to supply at any given price.



Self-check for Learning

Answer the following questions in your notebook.

1. What can cause an increase in supply?
 - a. Increase in taxes
 - b. Technology improves
 - c. Production costs increases
 - d. Price is expected to rise in the future
2. Which of the following causes the supply of leather shoes to decrease?
 - a. an increase in the price of leather shoes
 - b. an increase in the price of leather
 - c. a decrease in the price of shoelaces
 - d. an increase in the number of shoemakers
3. A dress manufacturer is expecting higher prices for dresses in the near future. What would happen to the supply of dresses currently?
4. How would the emergence of coronavirus disease influence supply in the market?
5. What would be the effect of a decrease in the supply of a commodity on the price of the commodity? How will it affect the consumer's purchasing power?

2.3. MOVEMENT AND SHIFT OF THE SUPPLY CURVE

Learning Objectives



- Demonstrate movement along the supply curve and shift of the supply curve.
- Differentiate expansion of supply and contraction of supply.
- Explain exceptional supply curves.

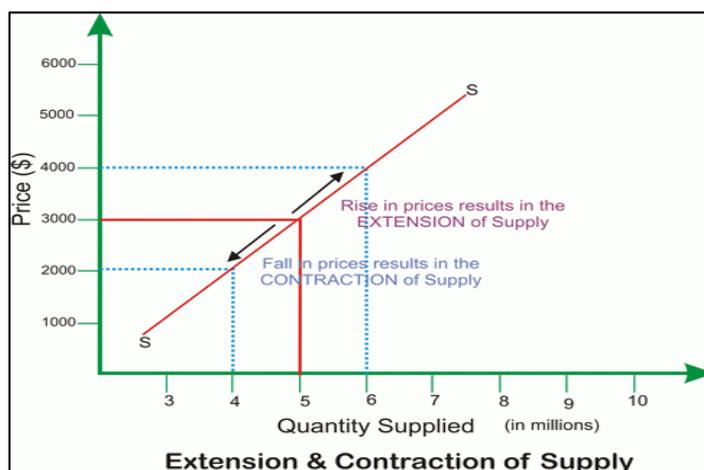
Introduction

The amount of commodity supplied changes with the rise and the fall of the price while other determinants of supply remain constant. This change, when shown in the graph, is known as movement along a supply curve. When the quantity supplied of the commodities changes due to change in non-price factors (other than price), the supply curve shifts entirely either left or right. For instance, the introduction of better technology in industries helps in reducing the cost of production and induces production of more units of a commodity at the same price. As a result, the quantity of commodity supplied increases but the price of the commodity remains as it is.

Movement along the Supply Curve

Movement along the supply curve can be defined as a graphical representation of a change in supply for a commodity brought by the change in its price while other things remain constant. If price changes supply too changes. The movement in the supply curve can be of two types – extension and contraction.

Extension in a supply curve is caused when there is an increase in the price or quantity supplied of the commodity while the contraction is caused due to a decrease in the price or quantity supplied of the commodity assuming other factors affecting supply remaining constant.



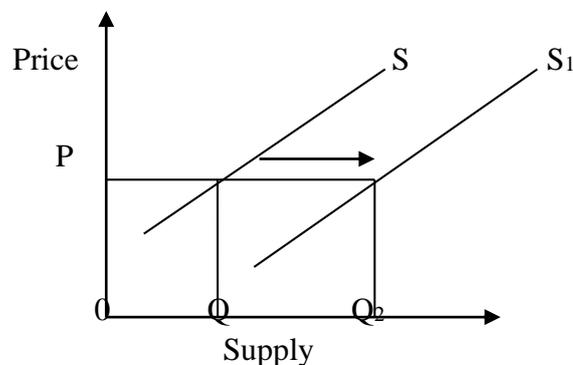
Explanation of the above figure

The X-axis represents quantity supplied and the y-axis represents a price. SS is the supply curve. Initially, when the price was \$3000, quantity supplied was 5 million. When the price increased from \$3000 to \$4000, the quantity supplied increased from 5 million to 6 million. This increase in quantity supplied due to change in price is called expansion/ extension/increase of supply and it is represented by an upward movement along the supply curve (shown by arrow). On the other hand, when the price decreased from \$3000 to \$2000, quantity supplied decreased from 5 million to 4 million. This decrease in quantity supplied of a commodity due to the fall in price is called contraction/decrease of supply and it is represented by a downward movement along the supply curve.

Shift of the Supply Curve

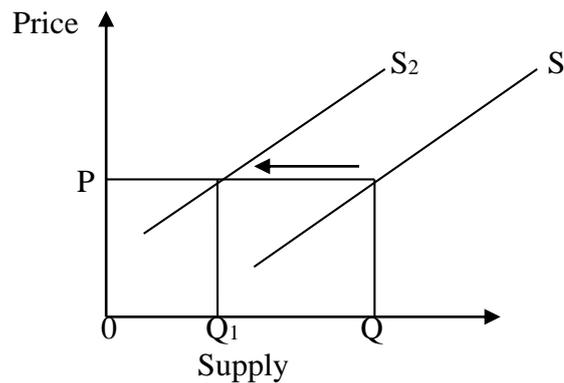
A shift in the supply curve occurs when the amount supplied of a commodity increase or decreases due to change in other factors while the price remains the same. The shift of the supply curve is also called a change in quantity. The shift in supply curve can also be of two types – rightward shift and leftward shift. The rightward shift occurs in the supply curve when the quantity of supplied commodity increases at the same price due to favourable changes in non-price factors of production of the commodity. Similarly, a leftward shift occurs when the quantity of supplied commodity decreases at the same price.

A. Increase in Supply: It is a situation where the increase in quantity supplied of a commodity is brought about by factors other than its price such as improvement in technology and favourable monsoon. As a result, supply curve shifts towards the right.



In the above graph, the increase in quantity supplied from OQ to OQ₁ at the same price OP was due to other determinants like improvement in technology (supply curve shifting rightward from S to S₁) is called ‘increase in supply’.

B. Decrease in Supply: Decrease in supply refers to the fall in quantity supplied of a commodity due to some other factors, price of the commodity remaining constant. In this case, supply curve shift towards left.

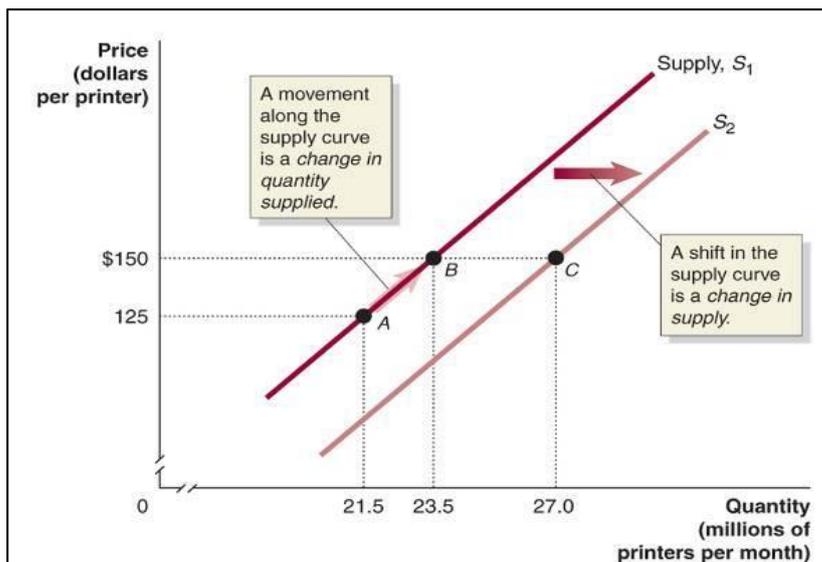


In the above diagram, the decrease in quantity supplied from OQ to OQ_1 at the same price OP (due to other determinants, supply curve shifting leftward from S to S_2) is called 'decrease in supply'. It might be due to increase in input costs.



ACTIVITY 1

Instruction: Study the diagram given below and answer the following questions.



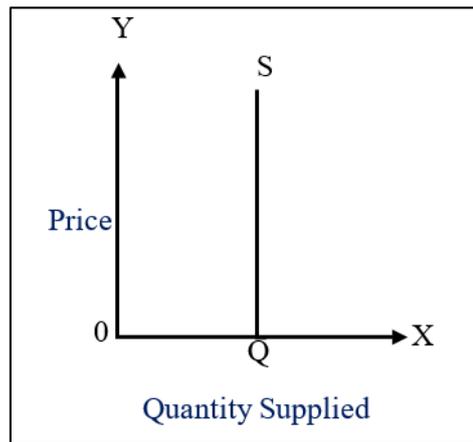
1. Compare the two situations discussed in the above diagram.
2. Use a diagram to explain the other two situations opposite to what is discussed in the above diagram.
3. Explain the diagram in your own words but remember to discuss the two important situations

Exceptional Supply Curve

Normally, the supply curve sloped upward to the right but in certain exceptional cases, the supply curve may take different shapes depending on the types and nature of the commodities supplied. Now, we will look into those different shapes of a supply curve beside an upward supply curve.

1. Vertical Supply Curve

In case of certain commodities like old paintings, old manuscripts, rare postage stamps, old coins etc., supply is fixed. Supply will not change irrespective of increases or decreases in price. In this case, supply curve is vertical as given below.

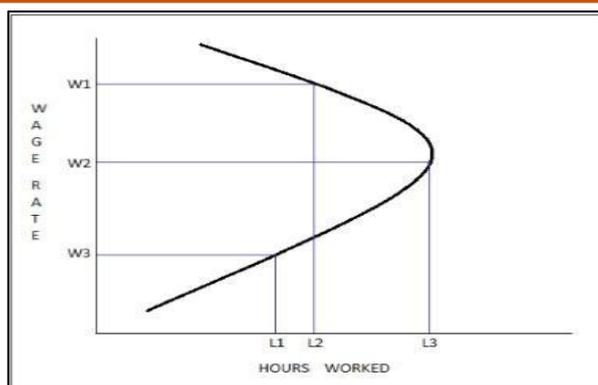


In the above graph, X-axis represents quantity supplied and Y-axis represents price. S is the supply curve (vertical line) which indicates that supply is perfectly inelastic irrespective of any change in price. In such a case, demand will remain fixed with the change in price. Such a situation will occur in the case of commodities whose supply cannot be increased or decreased according to demand.

2. Backward sloping supply curve

The backward bending supply curve is the exception to the law of supply. According to Alfred Marshal, other things being equal, price & supply i.e directly related. Therefore, the supply curve slopes upward from left to right. Whereas in case the supply of labour it bends backward to the left. It explains that when the price (wage rate) increases, initially labour increases his working hours and earns more wages. But a further increase in the wage rate, labour supply does not increase. Thus, labour supply is backward bending. Remember that money is the mean and not an end in itself. People need money to buy goods & services which satisfy their wants. When a labour earning enough money to meet his requirements then he wants leisure, therefore, when the wage rate goes up, he earns more and works less which is why the labour supply curve is the backward bending or exceptional supply curve.

Let us assume that a labourer works for 40 hours at the wage rate of Nu 350 and earns Nu. 1400 per week. Let us further assume that the wage rate goes up to Nu. 560. The labourer now works for 60 hours and earns Nu. 2100 per week. The wage rate further increases to nu.700 but now the same labourer works 50 hours and earns & 2500 per week (works less & earns more). It explains the backward bending of supply curve as shown in the figure below.



In the above graph, x-axis represents quantity supplied and y-axis represents price (wage). Here, the supply curve is a backward sloping curve indicating that as price increases (wage rate in case of the above diagram), people are willing to supply less as they want to have more time for relaxation and enjoyment. In such cases, people will supply lesser and lesser as the wage rate (price) increases more and more.



Summary

- The movement along the supply curve is the change in quantity supplied due to change in price while other factors remain the same.
- Shift in the supply curve occurs when units of the commodity supplied increases or decreases because of change in other factors with price remaining the same.
- *Expansion/Extension of supply*- The amount of commodity that the producers or suppliers are willing to offer at the marketplace can change even in cases when factors other than the price of the commodity change.
- *Increase in supply*-When more quantity of a commodity is supplied at the same price due to change in other factors.
- *Contraction of supply*- When the quantity supplied of a commodity falls due to a fall in the price of a commodity while other factors affecting supply remaining constant.
- *Decrease in supply*- When less quantity of a commodity is supplied at the same price due to change in other factors.
- *Vertical Supply Curve*: In case of certain commodities like old paintings, old manuscripts, rare postage stamps, old coins etc., supply is fixed.
- *Backward sloping supply curve*: A backward sloping curve indicates that supply as price increases (wage rate in case of the above diagram), people are willing to supply less.



Self-check for Learning

Answer the following questions in your notebook.

1. What causes shifts and movements in supply curve?
2. What are the factors that affect the current supply of mobile phones?

2.4. DETERMINATION OF MARKET PRICE

Learning Objectives



- Define equilibrium, equilibrium price and equilibrium quantity.
- Explain how the price is determined with the help of a diagram.
- Show, with the help of diagrams, the effect of the following changes on the equilibrium price: When the demand for a commodity alone changes, when the supply of a commodity alone changes.
- Explain the effect of simultaneous increase in both demand and supply on equilibrium price and quantity.
- Show diagrammatically a situation when there is no change in the equilibrium price.

Introduction

As discussed in the previous lessons, demand and supply curves respectively tell us about the different quantities of a good that are demanded by the consumers and the quantities which producers are willing to produce and sell at different prices. But they do not tell us what the actual price of a good will be. We now come to an important question: how do forces of demand and supply interact to determine market prices?

When consumers' buys and firms sell goods, they interact in the product market and a price is determined. In this session, we are going to look into how forces of demand and supply help in attaining 'equilibrium', and how the 'equilibrium price' is determined. We will also look into the effects of shift of demand and supply on the equilibrium price and quantity.

Before that, we will have to be familiar with some basic concepts of *Equilibrium*, *Equilibrium Price* and *Equilibrium Quantity*.

Price and Equilibrium Quantity

- *Equilibrium*: Situation in which quantity demanded equals quantity supplied.
- *Equilibrium Price*: The price at which the quantity demanded equals quantity supplied.
- *Equilibrium Quantity*: The amount that is bought and sold at an equilibrium price.

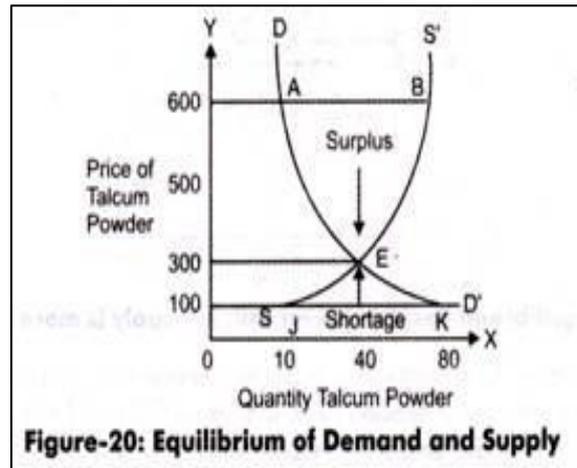
We will now look into, how equilibrium price is determined by the two market forces. This can be explained with an illustration.

Demand and Supply Schedule for Talcum Powder				
Prices(Nu)	Demand (in thousands)	Supply (in thousands)	Market Position	Effect on Price
100	80,000	10,000	Shortage	Rise
200	55,000	28,000	Shortage	Rise
300	40,000	40,000	Equilibrium	Stable
400	28,000	50,000	Surplus	Fall
500	20,000	55,000	Surplus	Fall
600	15,000	60,000	Surplus	Fall

It is clear from the above table that the equilibrium price for talcum powder is 300 at which demand is equal to price. Let us now look into the determination of equilibrium price by understanding why no price other than 300 can be the equilibrium price. At price 200, quantity demanded exceeds quantity by 27000. There is excess demand. So the price will increase.

Now, consider prices higher than 300. At these prices, there is excess supply. This would result in a decrease in price. Thus, the equilibrium will be at 300 where quantity demanded is equal to quantity supplied.

Diagrammatic representation:



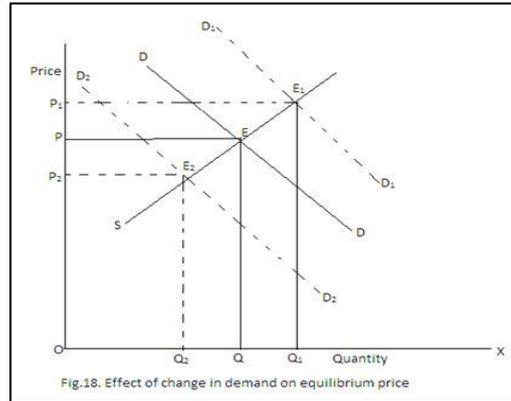
- Explanation of Figure 20: X-axis represents quantity demanded and supplied of Talcum Powder and y-axis represents price of Talcum Powder. SS represents the supply of and DD represents the demand for Talcum Powder. Initially, at price 300, quantity demanded and quantity supplied of Talcum Powder is 40. Here, the equilibrium price is 300, equilibrium quantity is 40 and equilibrium point is E. A slight increase or decrease in price can change the quantity supplied and quantity demanded.

• **Effects of changes (shifts) of demand and supply curve**

When there is an increase in demand, the demand curve shifts to the right upward and when there is a decrease in demand, the demand curve shifts to the left downward. On the other hand, an increase in supply shifts the supply curve to the right downward and decrease in supply shifts the supply curve to the left upward. These shifts in the supply and demand curves do change the equilibrium price, equilibrium quantity and equilibrium point. In the coming paragraphs, we will go through the effects of shifts in demand and supply curves.

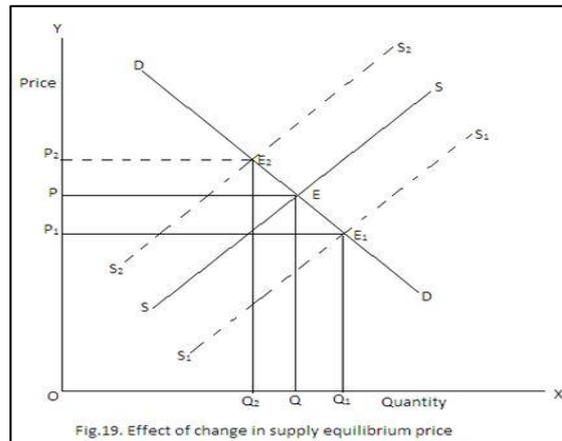
1. Effects of changes (shifts) in demand on the equilibrium price and quantity.

Explanation of Figure 18: When demand increases, the demand curve shifts to the right from DD to D1D1, which results in the increase in the equilibrium price from OP to OP1 and equilibrium quantity from OQ to OQ1. The demand curve shifts towards the left from DD to D2D2 when there is a decrease in demand. This will result in a decrease in equilibrium price from OP to OP2 and equilibrium quantity from OQ to OQ2. Here, the supply remained constant throughout.



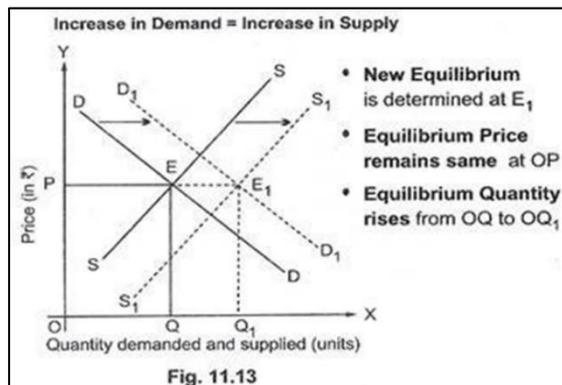
2. Effects of changes (shifts) of supply on the equilibrium price and quantity

An increase in the supply of a commodity will shift the supply curve to the right downward causing a decrease in equilibrium price from OP to OP1 but increasing equilibrium quantity from OQ to OQ1. On the other hand, a decrease in supply will result in a leftward shift in supply curve. As a result, equilibrium price will rise from OP to OP2 but equilibrium quantity decrease from OQ to OQ2. Here, demand for the commodity remained constant throughout.



3. Effects of simultaneous changes (shifts) in demand and supply.

When there is a simultaneous increase in demand and supply, equilibrium price may remain the same, fall and rise depending upon the relative magnitude of increase in demand and supply.

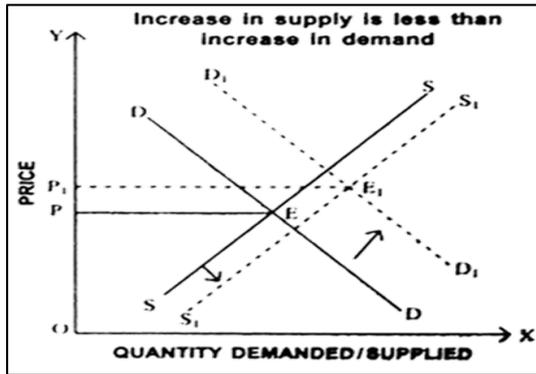


The three possibilities:

i. When equilibrium price remains the same

Explanation of Figure 11.13: Equilibrium price will remain unchanged when the demand for and supply of a commodity increases by equal magnitudes. Increase in supply and demand does not bring any change in the equilibrium price but equilibrium quantity increases from OQ to OQ_1 .

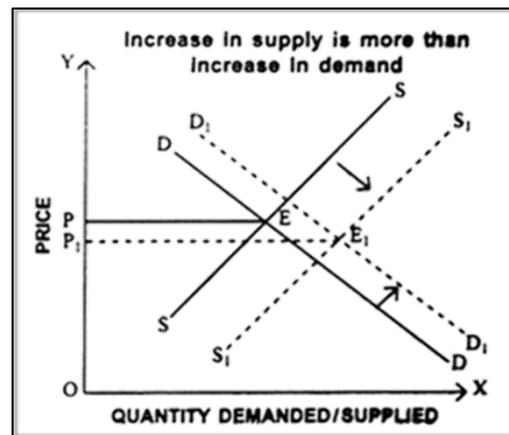
ii. When equilibrium price rises



Explanation of the above figure: Equilibrium price will rise from OP to OP_1 when quantity demand increases more than quantity supply. Simultaneously, the equilibrium quantity also increases.

iii. When equilibrium price falls

Explanation of the above figure: Equilibrium price falls when supply increases more than the increase in demand, price tends to fall from OP to OP_1 but the equilibrium quantity will increase.



ACTIVITY 1

1. What kind of supply shock do you expect in the market when the rice crop is severely damaged by the storm throughout the country? How will the market adjust itself to the supply shock? What suggestion would you offer to tackle the problems arising out of the supply shock?



Summary

- Equilibrium point: The optimum position of a market price that generates an equal amount of demand and supply for a product or service.
- Changes in the determinants of supply and/or demand result in a new equilibrium price and quantity.

- The price in a market at which the quantity demanded and the quantity supplied of a good is equal; this is also called a market-clearing price.
- In a market setting, disequilibrium occurs when quantity supplied is not equal to quantity demanded.
- If the market price is above the equilibrium price, the quantity supplied is greater than quantity demanded, creating a surplus. The market price will fall.
- If the market price is below the equilibrium price, the quantity supplied is less than quantity demanded, creating a shortage. The market price will rise because of this shortage.



Self-check for Learning

Now that you understood the effects of shifts in supply-demand on equilibrium price and equilibrium quantity, answer the following questions in your notebook.

1. What would happen to the equilibrium price and equilibrium quantity when the decrease in demand is less than the decrease in supply?
2. Why will the equilibrium price of a commodity not change even if there is a decrease in both demand and supply?

2.5. MARKET STRUCTURE

Learning Objective:



- Explain the meaning of market.
- Classify the types of market based on geographical location and degree of competition.
- Compare and contrast the features of perfect competition, monopoly, monopolistic and oligopoly markets.

Introduction

In the ordinary sense, the word market refers to a physical place where commodities are bought and sold. The concept of the market in this common usage gives an idea of a single place to which people go to buy something. However, development in the means of transport and communication and the modern banking system has extended the concept of the market well beyond the idea of a single physical place. Thus, the market is no more a physical place rather a mechanism or arrangement.

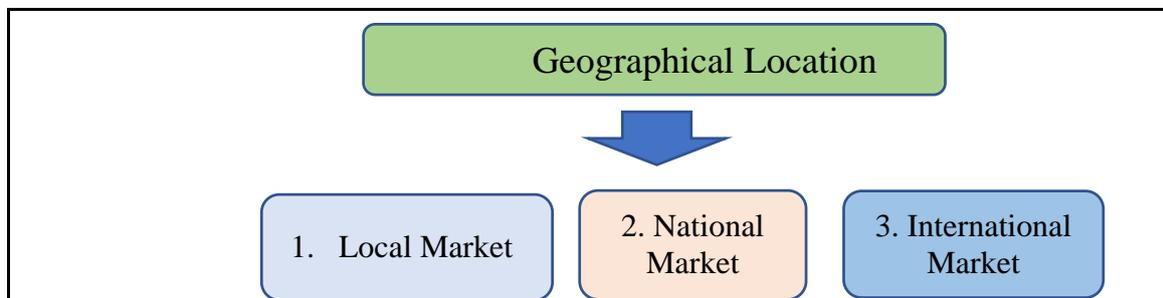
Market

Market refers to a situation in which buyers and sellers interact to carry out the exchange of goods and services. There are two significant features of a market and that includes

1. The market need not be a particular place- It is an arrangement or mechanism by which buyers and sellers of a commodity can contact each other for having an economic exchange and are able to strike a deal about price and quantity
2. Buyers and sellers should be able to strike a deal about price and the quantity to be bought and sold-buyers and sellers need not come face to face as long as they make a deal over price and quantity through any system of communication.

Classification of Market

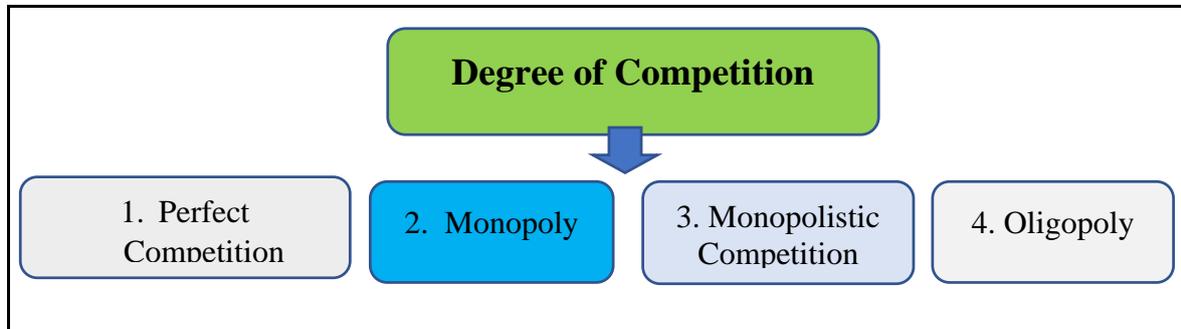
Markets are classified based on two categories, and they are geographical location and degree of competition. Based on geographical location, there are three types of market and based on a degree of competition, there are four types of market. In the following paragraphs, we will look into these types of market and their essential features.



Local Market: Local market is a situation or a place where the exchange of goods and services takes place within a locality. For example: Buying and selling of goods and services in Punakha Dzongkhag.

National Market: National market is a situation where the exchange of goods and services takes place within the geographical boundary of a country. For example: Buying and selling of goods and services within the country (between the dzongkhags).

International Market: The international market is a situation in which the exchange of goods and services takes place between two or more countries. For example: Buying and selling of goods between two or more countries (between Bhutan and India)



Perfect Competition

Perfect competition is a market structure in which there are a large number of producers (firms) producing a homogenous product so that no individual firm can influence the price. The firm under perfect competition is a price taker. If all apples produced by different sellers are identical, they can be examples of perfectly competitive market. However, such markets rarely exist in reality.

Features of Perfect competition

- **Large number of buyers and sellers:** There are a large number of buyers and sellers, each too small to influence the price of the commodity. A firm is called as price taker rather than a price maker.
- **Homogenous product:** All firm produce homogenous or same commodities. The commodities are homogeneous in terms of shape, size, colour, taste etc. The products of various firms under the perfect competition are perfect substitutes of one another. Thus, if one firm tries to increase price of their product, it would lose all its customers to other firm selling the product.
- **Freedom of entry and exit:** New firms are free to enter the industry and existing firms are free to leave the industry. There are no barriers, be it, legal, man-made and natural to enter and leave the market. The condition of free entry and exit ensures that all the firms will end up earning only normal profits in the long-run.
- **Perfect knowledge:** Each firm has perfect knowledge about the price prevailing in the market and it would not sell the commodity below the market price. Similarly, each buyer has perfect knowledge about the market price and is not prepared to pay higher than the market price.
- **Perfect mobility of the resources:** Perfect mobility of the resources ensures that resources can enter or quit a firm or industry at will. This means that resources are able to switch over from one use to another without any restriction.
- **Absence of transport cost:** This assumption is necessary to maintain uniform price throughout the market. Otherwise, prices for identical goods would differ.

Monopoly

It is a market where only a single seller of the product in a market structure. A monopolist is the sole producer of the product, which has no close substitutes. For example: Bhutan Power Corporation of Bhutan

Features of Monopoly

- **Single seller:** Since there is only one seller, any change in the amount of output produced by the monopolist would influence the market price. It is the case of one firm controlling the supply of the product. However, the number of buyer is too large and therefore no buyer can influence the price of the product under monopoly.
- **No close substitute:** An essential condition for the existence of monopoly is that no close substitute should be available for the product. Monopoly is the market without any competition.
- **Closed entry:** There are some restrictions on the entry of the new firms into the monopoly industry. The closed entry may result from natural, legal or man-made restrictions.
- **Price maker:** A monopoly firm is a price maker or price setter. Since it is the only producer of the product, the price of the commodity is fully controlled by the monopolist.
- **Possibility of price discrimination:** Price discrimination refers to a situation when a producer sells the same product to different buyers at different prices. A Monopolist may charge different prices from different consumers.



ACTIVITY 1

Now that you understood two types of market based on degree of competition, try assessing yourself by attempting the following questions in your notebook

2. Discuss two main differences between Perfect Competition and Monopoly form of market
3. According to you, which form of market seems to enjoy more advantage over each other? Justify.

Monopolistic Competition

It is a form of market in which there are fairly large numbers of sellers of a particular product, but each seller sells somewhat differentiated but close product. For example: Colgate, Pepsodent toothpaste, Sensodyne toothpaste

Features on Monopolistic Competition

1. **Large number of buyers and sellers:** The number of sellers is fairly large but it is not unusually large. Therefore, the firm under monopolistic competition can follow independent price policy. They set their own prices. There are a large number of buyers that no individual buyer can influence the price of the product.

2. **Differentiated product:** Product differentiation is the key element of Monopolistic market. Each firm produces a product that is somewhat different from the products of its competitors but is not entirely different. The products are substitutes to each other but are not perfect substitutes. Product differentiation characterizes most of the real markets today.
3. **Free entry and exit:** Like perfect competition, there is no restriction on the entry of new firms. New firms are free to produce close substitutes. Similarly, there is no restriction on the firms deciding to leave the industry.
4. **Selling cost:** Selling cost incurred by the firm promote sales of the product through various sales promotion techniques like advertisement, offering discounts etc.
5. **Non-price competition:** Firms under monopolistic competition compete with each other not merely by price-cutting, but by producing differentiated products and advertisement.
6. **Independent price policy:** A firm under monopolistic competition can make its own price and output decisions. It can set their own prices of the commodity, so is the price makers of its product.

Oligopoly

Oligopoly is that form of market structure in which there are very few firms selling a product so that there is intense competition among them. Generally, the number of sellers is between two to ten in a situation of an oligopoly market. For example: Bank of Bhutan, Bhutan National Bank, and Tashi Bank.

Features of Oligopoly

- **Intense competition:** When there are a few firms in an industry, there will be intense competition. Each firm with only a few rivals knows that it has the power to influence the market price. Similarly, it also knows that the other firms in the industry are powerful too.
- **Interdependence:** Any action by the firm will call for a reaction by the rival firms. Therefore, while taking any decision a firm has to take into account reaction of the other firms. This sometimes leads to price war and price-cutting among the competitors.
- **Nature of the product:** The firms under oligopoly may produce homogeneous product or differentiated product. Pure-oligopoly is when the product is homogeneous.
- **Importance of selling cost:** In view of intense competition and interdependence of the firms, the firms compete with each other through various sales promotion like discounts, advertisement and door to door services for which the firms have to incur selling cost.
- **Indeterminate demand curve:** An important feature of oligopoly is that the demand curve faced by an oligopolistic is indeterminate. An oligopoly cannot ignore the reaction of the rival firms. Therefore, the demand curve faced by an oligopolistic keeps shifting.



Summary

- A market is that mechanism by which buyers and sellers are brought together. It is not necessarily a fixed place.
- Origin of market: International market spreads across the world; National market spreads within the country; Regional market is confined to certain region and Local market is limited to certain area or region.
- Situation would arise where there is many firms operating in the market under perfect competition.
- A monopoly market is characterized by the profit maximize, price maker, and high barriers to entry, single seller, and price discrimination.
- Monopolies and competitive markets mark the extremes in regards to market structure.
- Monopolistic firm have price inelastic demand; they are price makers because the good is highly differentiated.
- An oligopoly is a situation where a few firms sell most or all of the goods in a market. Oligopolists earn their highest profits if they can band together as a cartel and act like a monopolist by reducing output and raising price.



Self-check for Learning

Monopolistic Competition and Oligopoly are another form of market based on degree of competition. They have different features and attributes. Try answering the following questions based on these two markets to check your understanding.

1. How is Monopolistic competition market different from Oligopoly in terms of nature of product that they sell?
2. Give examples of few products which can be categorized under monopolistic and oligopoly market besides what is already given above.

3. ACCOUNTANCY

3.1. ACCOUNTING THEORY

Learning Objectives



- Understand the conceptual framework of accounting.
- Identify and explain elements of Financial Statements.
- Explain recognition criteria of elements in a Financial Statement.

Introduction

The basic aim of accounting is to give information to the interested parties to enable them to make important business decisions. The required information, particularly in the case of external parties, is given in the basic financial statements: Statement of Income (profit and loss account) and the Statement of Financial Position (Balance Sheet).

Besides the said sources of information, the internal parties and other staff of the company can get additional information from the records of the organisation. Thus, the primary objectives of accounting can be stated as:

- a) Maintenance of records of business transactions.
- b) Calculation of profit or loss.
- c) Processing of financial position.
- d) Provide information to the parties.

In the first lesson, you have learned about accounting assumptions and conventions when preparing financial statements (like a separate entity, going concern, money measurement, accounting period, accruals, matching and historical cost).

In this lesson, you will learn the qualitative characteristics of useful information in Financial Statements, elements of Financial Statement, and its recognition and measurement criteria.

1. Qualitative Characteristics of Useful Information in Financial Statements

The Companies Act and the corporate governance rules prevent companies director from approving financial statements for public declaration unless they are satisfied that the financial statements present a true and fair picture of the economic activities of the business to the different stakeholders. Further, statutory auditors under Companies Act require auditors to provide opinions on whether financial statements are prepared and presented in true and fair manner. The conceptual framework of financial reporting suggests that the financial statements provide a true and fair picture of business activities.

If financial information is to be useful, it must be relevant and faithfully represent what it ought to represent. The usefulness of financial information is enhanced if it is comparable, verifiable, timely and understandable. These qualitative characteristics of financial information can be discussed under two categories.

A. Fundamental Qualitative characteristics

The fundamental qualitative characteristics are relevance and faithful representation.

a) Relevance

Relevance refers to how helpful the information is for financial decision-making processes.

For accounting information to be relevant, it must possess:

1. *Confirmatory value* provides information about past events.
2. *Predictive value* provides predictive power regarding possible future events.

Therefore, accounting information is relevant if it can provide helpful information about past events and help in predicting future events or in taking action to deal with possible future events.

b) Materiality

In accounting, materiality is a threshold set to determine whether in the judgement of the preparer of financial statements, the misstatements of which could influence the decision of the stakeholder. This means that there is a minimum amount of which the stakeholders may treat the misstatement as significant and cannot be tolerated. In other words, information is said to be material, if by nature or amount, is significant to those information users.

Materiality is an entity-specific aspect based on the nature or magnitude of misstatement or both. For example, a company purchases a CCTV of Nu. 200,000. The decision whether to capitalize this item as an asset or write it off as an expense depends on the size of the entity. If the buying entity is a large size limited company, this cost could be expensed, whereas, if it is a small entity or an individual household, it is reasonable to be capitalized.

Materiality also plays a significant role when deciding whether to report an item as a separate item in the financial statements. For example, when an entity decides whether to disclose an irrecoverable debt of Nu.50, 000 as a separate item or this to be included in the selling and distribution expenses depends on the materiality level.

c) Faithful representation

Financial reports represent economic activities undertaken by a business entity and communicate these realities to the stakeholders. To be useful, financial information in financial statements must not only be relevant but it must also faithfully represent the economic activities that it ought to represent. To achieve this faithful representation, the financial information in financial statements must have three characteristics. These are:

i. Completeness

Completeness requires financial statements to disclose all information including all necessary descriptions and explanations for a user to understand the nature and value of item presented in the financial statements. For example, in accounting of an asset, the entity must include at a minimum, a description of the nature of assets in the group, value of asset in the group, description of what the numbers represent such as original cost and adjustment costs. The omission of information can cause the information presented in the financial statements to be biased and mislead the information users.

ii. Neutrality

Information contained in the financial statements must be free from bias. It should reflect a balanced view of the affairs of the company without attempting to present them in a favored light.

iii. Free from error

Free from error does not mean perfectly accurate in all respects. It means there are no errors or omissions in the description of the item including its nature and the related amounts. For example, an estimate of depreciation cannot be determined with cent percent accuracy.

However, a representation of that estimate can be faithful if the amount and the estimating process is described clearly in the financial statements.

Practically, these qualities may not be achieved fully. However, management of the entity must enhance those qualities as much as possible.

B. Enhancing Qualitative Characteristics

These are qualitative characteristics that enhance the usefulness of information. These include:

a) Comparability

Comparability means the information presented in the financial statements is carefully identified and measured so that it can be compared over time or with other similar entities.

This is achieved through:

- Having consistency in accounting of transactions over a period of time,
- Disclosing accounting policies so that any changes or discrepancies in treatment of transactions is informed to the users, and
- The Bhutanese Accounting Standards (BAS) and other similar accounting standards can contribute to comparability by reducing the options available to different entities when accounting for similar transactions and requiring the disclosure of accounting policies in the financial statements.

b) Verifiability

Verifiability means that accounting data can be objectively verified by any knowledgeable person to arrive at a convincing conclusion. The accounting process requires all transactions and events to be recorded by using double-entry system and that all accounting records should be supported by documentary evidences. This system allows external verifications of accounting data and validates its usefulness.

c) Timeliness

The timeliness qualitative characteristic expects that information should be provided to the users within a reasonable time. The information not provided on time loses its importance and relevance. For example, if financial statements for the year ended 31st December 2019 are furnished in October 2020, they do not remain useful because considerable time has elapsed and corrective action may not be possible in proper time. However, some information may continue to be relevant and timely even long after the end of a reporting period.

d) Understandability

Understandability means whether the information presented in the financial statements is understandable to the information users. The framework suggests that financial statements are prepared in a way that assists in understanding. Understandability can be increased through a proper classification of items and presenting information in the financial statements clearly and concisely. Some transactions such as lease and employee benefits are inherently complex and cannot be made easy to understand. Any attempt to make these transactions less complex may potentially distort the information. The framework, therefore, expects that users should have a reasonable knowledge of business and economic activities and seek the aid of those who can review and analyse the information diligently.

e) Consistency

This means accounting policies and methods should be applied consistently over the period of time unless it is reasonable to change and such changes provide a better measurement of transactions and information to the users.

2. The Elements of Financial Statements (Conceptual Framework)

The framework identifies five elements of financial statements:

Financial statements show the financial effects of transactions and other events by grouping them into broad classes according to their economic characteristics. These are termed as **elements of financial statements**.

These elements are as follows:

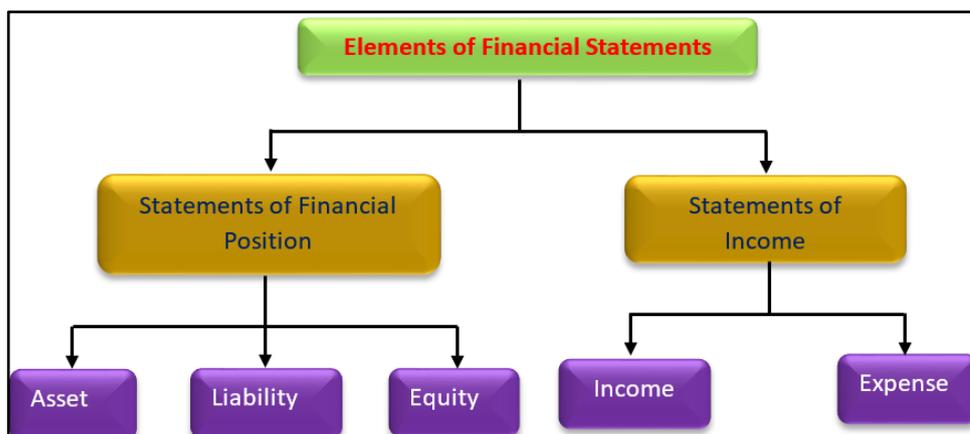


Figure: *Element of financial statements*

Assets: These are items of economic resources that the benefit are expected to yield in future period.

Examples are property plant and equipment, accounts receivable, copyright, etc.

Liabilities: These are legally binding obligations payable to another entity or individual. Examples are accounts payable, loans, outstanding expenses, etc

Equity: This is the amount invested in a business by its owners and any other retained earnings.

Revenue: Fees earned from providing services and the amounts of merchandise sold. Examples are product sales and service sales.

Expenses: An expense is the money spent, or costs incurred, by a business in their effort to generate revenues. Examples are interest expense, compensation expense, and utility expense.

Of these elements, assets, liabilities, and equity are included in the Statement of Financial Position (Balance Sheet).

Revenues and Expenses are included in the Income Statement.

2.1 Definition of the element relating to Statement of Financial Position

a) Asset

An asset is defined as:

- A resource controlled by the entity.
- As a result of past events.
- Where future economic benefits are expected to flow to the entity.

Let us look closely at this definition!

When we say an asset is a resource controlled by the entity, it means the entity can obtain economic benefits from the asset, or restrict others from getting economic benefits from the asset.

Many assets have a physical form, which we can see and hold them but there are also intangible assets such as trademarks, copyrights and patents which have no physical form. The result of past events means that assets are only created when the event to control them takes place.

An intention or plan to purchase an asset should not result in the recording of the asset on the financial statements.

Suppose you are seriously planning to buy a Mercedes Benz, just because you intend to buy the car doesn't mean it's your asset.

When we say there will be expected future economic benefits from an asset, we mean the asset will contribute either directly or indirectly to the flow of cash and cash equivalents to the entity.

An asset should be expected to provide future economic benefits to the entity.

Examples of assets are Accounts receivables, Inventory (Stock) which are also known as **Current Assets**, land and Building, Machinery Furniture and Equipment which are also known as **Non-Current Assets (Fixed Assets)**.

b) Liabilities

A liability is defined as:

- A present obligation of an entity.
- Arising from past events.
- The settlement of which is expected to result in an outflow of resources that embody economic benefits.

When we say a liability is a present obligation, we mean an obligation that already exists. This usually means a legally enforceable right exists, such as a signed contract or a piece of legislation.

A past transaction or event means the event causing the liability has occurred, such as a contract to buy services, or perhaps a customer has bought your product, resulting in a warranty obligation.

If the event hasn't occurred, so if the entity only intends to enter into an agreement at a later date, the liability should not be recognized. The settlement of liability should result in an outflow of resources that embody economic benefits. This usually involves the payment of cash or cash equivalents.

Examples are the account payable, taxes payable and wages payable.

What is obligation?

- *Obligation refers to a duty or responsibility to act or perform in a certain way.*

What is present obligation?

- *An obligation is a present obligation if, based on the evidence available, its existence at the balance sheet date is considered probable, i.e. more likely than not.*

What is event?

- *A thing that happens or takes place in a business and can be reasonably measured.*

c) Equity

Equity is the remaining interest in an entity after all its liabilities have been deducted from the value of its assets.

$$\text{Equity} = \text{Assets} - \text{Liabilities}$$

Equity is sub-classified into capital, retained earnings, reserves representing appropriations of retained earnings.

2.2 Definition of the Element relating to Statement of Income

a) Revenue

Fees earned from providing services to the outsider and the amounts of merchandise sold. Often the term income is used instead of revenues. Income increases economic benefits during the accounting period in the form of inflows or enhancements of assets or decreases of liabilities that result in increases in equity, other than those relating to contributions from equity participants.

The definition of Revenue encompasses both revenue and gains.

Examples of revenue accounts include:

- *sales – e.g. sale of goods*
- *fees – e.g. sale of service*
- *interest – e.g. banks and fund management companies*
- *royalties – e.g. mining and legal rights*
- *rent – e.g. investment properties*

If the revenues earned are a main activity of the business, they are considered to be **operating revenues**. If the revenues come from a secondary activity, they are considered to be **non-operating revenues**. For example, interest earned by a manufacturer on its investments is a non-operating revenue. Interest earned by a bank is considered to be part of operating revenues.

b) Expense

An expense is the money spent, or costs incurred, by a business in their effort to generate revenues. It is the amount spent to produce and sell goods and services to earn revenue. For example, the **cost of goods sold** is an expense caused by **sales**. Insurance Expense, Wages Expense, Advertising Expense, Interest Expense.

Expenses decrease economic benefits during the accounting period in the form of outflows or depletions of assets or incurrences of liabilities that result in decreases in equity, other than those relating to distributions to equity participants.

Expenses associated with the main activity of the business are referred to as **operating expenses**. Expenses associated with a peripheral activity are **non-operating or other expenses**. For example, a retailer's interest expense is a non-operating expense. A bank's interest expense is an operating expense.

3. Recognition of the Elements of Financial Statements

Recognition is the process of incorporating in the statement of financial position or income statement an item that meets the definition of an element and satisfies the criteria for recognition. If an item meets the definition of an element but does not qualify for recognition criteria it should be disclosed as a note.

a) Recognition of assets

An asset is recognised in the statement of financial position when:

- it is probable that the future economic benefits will flow to the entity, and
- the asset has a cost or value that can be measured reliably.

b) Recognition of liabilities

A liability is recognised in the statement of financial position when:

- it is probable that an outflow of resources embodying economic benefits will result from the settlement of a present obligation, and
- the amount at which the settlement will take place can be measured reliably.

c) Recognition of income

Income is recognised in the income statement when:

- an increase in future economic benefits related to an increase in an asset (e.g. sales) or a decrease of liability (e.g. waiver of a debt payable) has arisen,
- the amount can be measured reliably,
- the revenue is earned,
- the item can be measured reliably, and
- there is a sufficient degree of certainty of receiving the revenue.

d) Recognition of expenses

Expenses are recognised in the income statement when:

- a decrease in future economic benefits related to a decrease in an asset or an increase of a liability has arisen, and
- the amount can be measured reliably.

In practice, expenses are recognised when:

- the expense is incurred, and
- the item can be measured reliably.

**ACTIVITY 1**

Now, having understood the definition of the element relating to the Statement of Financial Position and its recognition criteria, study the case study given below and answer the questions.

Case Study 1

Druk Air Corporation hired an airbus A319 from Air India to meet its increasing demand for short haul passengers making holidays in Bhutan, India and Nepal. The flight first time began to fly under dragon flag with 100 passengers from Paro to Delhi on 26.10.2017. The airbus A319 branded as dream liner was known for its safety, comfort and swiftness. It carries up to 160 passengers and has a maximum range of 6,900 km.

Druk Air management intends to account this airbus as an asset in its statement of financial position. The aircraft was hired for three years and Druk Air had no intention to buy this aircraft after its hiring charges were fully paid. Hiring charges of Nu. 900,000 (\$14,516) were paid to Air India on a monthly basis.

Required:

- (i) Bring out the general rules accountants apply when deciding when to recognize assets.
- (ii) Assess whether the hired airbus A319 can be accounted as asset in the books of Druk Air Corporation.
- (iii) Calculate the amount of hire charges for 2017 year ending. Explain how hiring charges can be treated in the books of Druk Air Corporation Ltd.

**ACTIVITY 2**

Choose the most appropriate answer from the choices given.

1. Financial statement that measures business financial conditions at a specific point of time is:
 - A Income statement.
 - B Statement of changes in equity.
 - C Statement of financial position.
 - D Statement of receipt and payment.

2. The most important assumption we use when preparing financial statements of a business entity is
 - A Separate entity.
 - B Matching.
 - C Going concern.
 - D Money measurement.
3. A child daycare centre collected Nu. 180,000 in December 2019 as an advance fee from students. In which year this amount should be recognised as revenue?
 - A 2019
 - B 2020
 - C 2021
 - D 2022
4. At the end of December 2019, the ABC childcare centre owed Nu. 245,135 to its teachers as salaries accrued. In which year, should this be matched with income earned?
 - A 2018
 - B 2019
 - C 2020
 - D 2021
5. The difference between fundamental and enhancing qualitative features of financial statement is:
 - A Fundamental qualitative characteristics are more critical than enhancing qualitative features to provide relevant information to users.
 - B The enhancing qualitative features are less useful to small business entities as their information may not be widely used.
 - C Enhancing qualitative features are covered by fundamental qualitative features.
 - D Fundamental and enhancing qualitative features are equally important when preparing financial statements.



Summary

1. The financial statements consist of:

(a) Statement of financial position

Statement of financial position provides a snapshot of the financial position of a business at a specific point of time. The items presented in the statement of financial position are assets, liabilities and equity.

(b) Statement of income

The income statement presents the performance or results of operating activities of the business for a period of time. The performance of a business is often measured by the amount of profit earned during the accounting period. The profit is calculated as the difference between income and expenses when the matching concept is applied. Net income (profit) = Income – Expenses. The items presented in the statement of financial position are Revenue and Expenses.

2. Fundamental Qualitative characteristics

The fundamental qualitative characteristics are relevance and faithful representation.

3. Enhancing Qualitative Characteristics

These are qualitative characteristics that enhance the usefulness of information.

4. Elements of financial statements are as follows:

- a) **Assets.** These are items of economic benefit that are expected to yield benefits in future periods. They are further classified as **Current Assets** and **Non-Current Assets (Fixed Assets)**.
 - b) **Liabilities.** These are legally binding obligations payable to another entity or individual.
 - c) **Equity.** This is the amount invested in a business by its owners, plus any remaining retained earnings.
 - d) **Revenue.** Fees earned from providing services and the amounts of merchandise sold.
 - e) **Expenses.** This is the reduction in the value of an asset as it is used to generate revenue. Examples are interest expense, compensation expense, and utility expense.
- 5.** Assets, Liabilities, and Equity are included in the Statement of Financial Position (Balance Sheet).
- 6.** Revenues and Expenses are included in the Income Statement.
- 7.** Recognition is the process of incorporating in the statement of financial position or income statement an item that meets the definition of an element and satisfies the criteria for recognition. If an item meets the definition of an element but does not qualify for recognition criteria it should be disclosed as a note.

**Self-check for Learning**

Fill in the blanks with appropriate words:

1. Assets are resources of the enterprise resulting from past events and transactions from which future..... will flow.
2. Liabilities are presentof the enterprise from the pastand transactions.
3. Equity is the residual interest in the assets of the enterprise after deducting
4. Revenue increases the economic benefit during the accounting period as a result of, in the value of assets andin the value of liabilities.
5. Expenses decrease the economic benefit during the accounting period as a result of,..... in the value of assets andin the value of liabilities.
6. The Business Entity Concept implies that a business unit is from the persons who supply the capital to it.

7. According to theConcept, revenue is considered as being raised on the date on which it is realized.
8. The Concept requires that the same accounting method should be used from one accounting period to next.
9. Transaction between owner and business are recorded due to Concept.
10. Going Concern Concepts assumes that business will be carried on forPeriod.
11. Withdrawal of money by owner is not an expense but a reduction of
12. The Concept requires that accounting transactions should be free from the bias of accountant and others.

3.2. JOURNAL LEDGER AND TRIAL BALANCE

Learning Objectives



- Understand the conceptual framework of accounting.
- Understand qualitative characteristics of useful information in Financial Statements.
- Identify and explain elements of Financial Statements.
- Explain recognition criteria of elements in a Financial Statement.

Introduction

In the previous lesson, you have learned about types of business activities, classification of accounts, the various rules of debit and credit, in relation to various accounts, and the concept of the accounting equation. In this lesson, you will learn the three stages in the process of accounting. In the first stage, you will learn how to record business transactions in a book of accounts which is named as '**journal**'. In the second stage, you will learn the posting into **ledger**. Ledger is a book that contains accounts. Ledger is also called the "**principal book of accounts**" as all the accounting information can be collected from this book. In the third stage, you will learn how to prepare Trial Balance. Trial Balance is a statement containing a balance of all ledger accounts as at a given date. It is prepared with the objective of checking the arithmetical accuracy of ledger posting.

Meaning of Journal

The term 'Journal' comes from the French word 'Jour' meaning 'day'. In a journal, all the day to day business transactions are recorded in a sequence or date-wise. Transactions, when recorded in a journal, are known as entries. It is the book in which business transactions are recorded for the first time and then are classified into other books of accounts. This journal is also known as 'Book of original record' or 'Book of prime entry'.

Business transactions of financial nature are classified into various categories based on modern classification such as **assets, liabilities, capital, revenue and expenses**. According to traditional classification, it can be classified as **personal accounts, real accounts and nominal accounts**. These accounts are debited or credited according to the rules of debit and credit applicable to the specific accounts based on Modern Approach or Traditional Approach. This process of recording entries in the Journal is known as '**journalising**'.

In small business firms, generally, one Journal Book is maintained and then the entries are posted from there to the concerned accounts in the ledger. Ledger is a book which contains various accounts. But in case of big business firms, transactions are directly recorded into various special journals depending upon the types of transactions like **cash book** to record all receipts and payments of cash including bank transactions, **purchases book** to record all credit purchases of goods, **sales Book** to record all credit sales of goods, **purchases returns book** to record goods returned to suppliers, **sales returns book** to record goods returned by customers, **bill receivable book** to record the receipts of bills of exchange, **bills payable**

book to record the issue of bills of exchange, and **general journal** to record those transactions which cannot be recorded in any of the special journal books mentioned above.

Terms or Expressions Associated with Journal

“A journal is a chronological record of accounting transactions showing the names of the accounts that are to be debited or credited, the amounts of debits and credits, and any useful supplementary information about the transactions. It is analogue to a diary”.

-Robert Anthony

- (i) **Book of Original Entry:** A journal is called a **book of original entry** because a transaction is first recorded or written in this book and thereafter transferred, i.e. posted into the ledger account.
- (ii) **Journal Entry:** An entry recorded in the journal is called a **journal entry**.
- (iii) **Journalizing:** The process of recording a transaction in a journal is known as **journalizing**.
- (iv) **Posting:** The transfer of journal entry to a ledger account is called **posting**.

Nature of Journal

Journal is a book in which transactions are first recorded in chronological order, i.e. in the order they occur (date, month and year). Thus, it is a **book of prime entry**. The functions of journal are:

- To record the transactions in the order they occur.
- To analyze transactions into debit, credit and record.
- To record both debit and credit aspects of transactions correctly.
- To facilitate posting of transactions into ledger accounts.

Features or Characteristics of Journal

Features or characteristics of a journal are:

- A journal contains day to day transaction in a chronological order.
- It is a book of original entry in which transactions are first written and thereafter posted into the Ledger.
- It records both the debit and credit aspects of transactions by using the Double Entry System of Book Keeping.
- A Journal is a record which shows complete details of a transaction in one entry.

Advantages of a Journal

The advantages of a journal are:

- i) **Journal Reduces the Possibility of Error:** The possibility of errors is reduced as the amounts to be debited and credited are written side by side and the two can be compared to see if they are equal. If the accounts are written up directly, it is possible that a wrong amount may be written or the amount written in the debit side may be more or less than that in the credit side.

- ii) **Journal Provides an Explanation of the Transaction:** Along with the entry in the Journal, a short explanation (narration) is written so that it is possible to understand the entry properly.
- iii) **Journal Provides a Chronological Record of all Transactions:** Transactions are entered in the journal in a chronological order; hence the order in which they occur enters the record permanently.

Disadvantages of Journal

- It is time consuming since transactions are recorded on a daily basis.
- It makes the recording difficult and bulky since the business has to keep a record of all the transactions.
- It does not provide the balance of accounts at a glance.

Format of Journal

Journal entries in the books of.....as at: - (dd/mm/yy)

Date	Particular	Ledger folio	Debit (Amount)	Credit (Amount)
(1)	(2)	(3)	(4)	(5)

The following are the details of the various columns of the journal:

- (1) **Date:** In this column of the journal, the date of the business transactions with its month and year is recorded.
- (2) **Particulars:** The details regarding a transaction i.e. the accounts which have to be debited or credited are recorded in this column. The entry is recorded in this column in the following way:
- In the first line, the account which has to be debited is written and then the short form of Debit i.e. Dr. is written against that account's name in the right corner.
 - In the second line after leaving some space from the left of the entry in the first line the account which has to be credited is written starting with a preposition 'To'. Then in the third line, narration for the entry which explains the particular transaction is written within *Brackets*. After every journal entry, horizontal line is drawn in the particular column to separate one entry from the other.

Example: Salaries paid in cash.

Journal entries in the books ofas at: (dd/mm/yy)

Date	Particular	Ledger Folio	Debit (Amount)	Credit (Amount)
	Salaries A/c Dr. To Cash A/c (Being salaries paid in cash)			

- (3) **Ledger Folio:** The transactions entered in a Journal are posted, to the various related

accounts in the Ledger. In the ledger Folio, we enter the page number where the account pertaining to the entry is opened and posted from the Journal.

- (4) **Debit Amount:** In this column, the amount to be debited is written against the same line in which the account was debited.
- (5) **Credit Amount:** In this column, the amount to be credited is written against the same line in which the account credited was written.

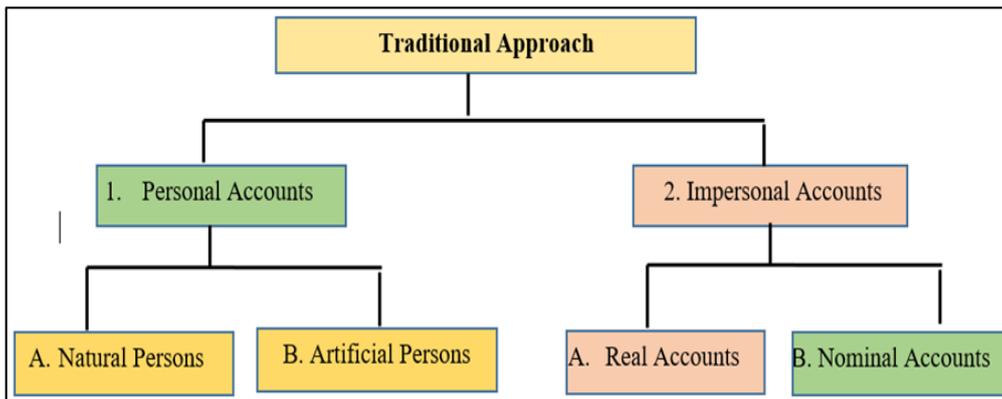
Example: Salaries paid in cash

Journal entries in the books of.....as at: - (dd/mm/yy)

Date	Particular	Ledger Folio	Debit (Amount)	Credit (Amount)
DD/MM/YY	Salaries A/c Dr. To Cash A/c (Being salaries paid in cash)		80,000	80,000

- (6) At the end of the page, both the Dr. and Cr. Columns are totalled up. The total of both these columns should be equal as the same amount is entered in the debit as well as the credit column.

Classification of Accounts:



I. Personal Accounts.

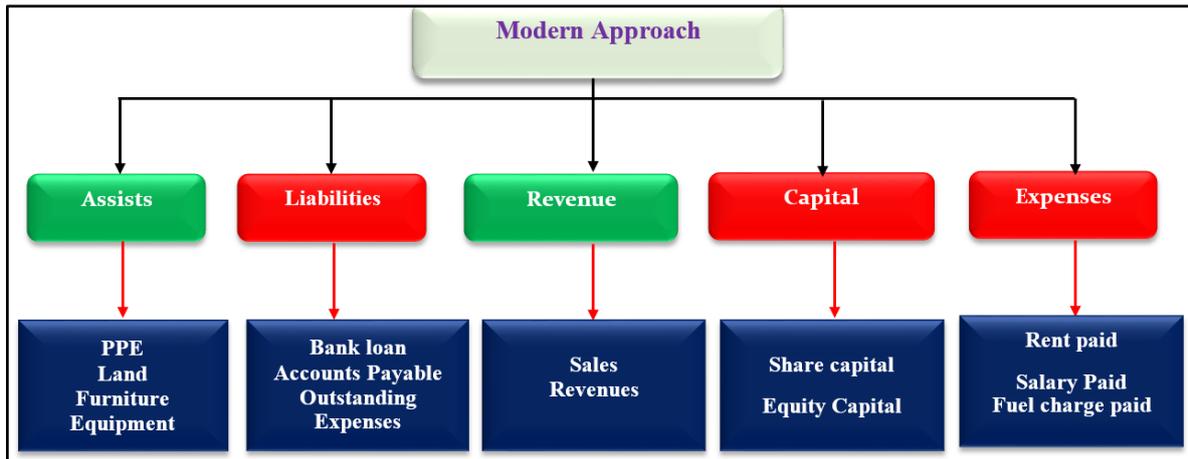
These accounts are related to individuals, firms, companies, etc.

II. Real Accounts.

All assets of a firm, which are tangible or intangible, fall under the category “*Real Accounts*”

III. Nominal Accounts.

Accounts which are related to expenses, losses, incomes or gains are called Nominal accounts.



I. Assets Accounts

Assets are the properties, possessions or economic resources of a business. They help in business operations and help in earning revenues.

II. Liabilities Accounts

Liabilities are the amounts that an entity owes to the outsiders. These are the obligations or the debts payable by the business.

III. Capital Accounts

The money brought into the business by the owner is called Capital or Owner's Equity. Capital is an obligation of the business that has to be paid back to the owner.

IV. Revenue Accounts

Revenue is the amount earned by the business by selling goods or rendering services.

V. Expenses Accounts

All costs incurred or money spent by a business in order to earn revenues is called expenses.

General Approach to Recording Transactions Using Double Entry Bookkeeping Principle

The following steps will help you to pass the journal entry:

Step 1: Identify the accounts involved in a transaction.

First of all, the accounts affected should be identified. For example, Pema starts business with Nu. 800,000 as capital. The accounts involved in the transaction are 'Cash' and 'Capital'. The concept of identifying the accounts involved is same as discussed in the previous lesson under Accounting Equation.

Step 2: Identify the nature of affected accounts based on 'Traditional Approach'.

Whether they are Personal Account, Real Account or Nominal Account or with the Modern Approach i.e. whether they are Assets, Liabilities, Capital, Revenue and Expenses.

In the above case, Capital and Cash are two accounts involved, **Capital is Personal Account and Cash is Real Account** based on Traditional Approach of classification. If we go by the Modern Approach of classification, Pema's equity is Capital and Cash is Asset.

Step 3: Identify which account is to be debited and which account is to be credited by applying the rules of debit and credit.

After finding the accounts involved as discussed in step 1 and classifying the accounts involved as discussed in step 2, then rules of debit and credit should be applied to the affected accounts. You are aware of these rules. However, for revision purposes, these are given below:

Rules of Debit and Credit

Based on Traditional Classification of Accounts. Based on Modern Classification of Accounts

Type of Account	Debit	Credit	Type of Account	Debit	Credit
Personal A/c	The receiver	The Giver	Assets A/c	Increase	Decrease
Real A/c	What comes in	What goes out	Liabilities A/c	Decrease	Increase
			Capital A/c	Decrease	Increase
Normal A/c	Expenses and Losses	Incomes and Gains	Revenue A/c	Decrease	Increase
			Expenses A/c	Increase	Decrease

In the example given under Step 1, when partner starts business, Cash comes in the business. Therefore, Cash Account will be debited. As Pema (proprietor) is the giver of Cash, Pema's Capital Account will be credited (*Based on Traditional Approach*). We can also apply the *Modern Approach* as follow:

When Pema brings in Cash, Asset of the firm increases. Therefore, increase in Cash will be debited. As firm will have to pay back the amount to Pema, Capital also increases. Therefore, increase in capital will be credited.

Now, the journal entry will be passed in the Journal accompanied by a brief explanation i.e. narration. The corresponding amount will be written in the debit and credit columns. After completing one entry, a horizontal line will be drawn and an entry for the next transactions will be entered in the Journal.

The transaction, given above in the example, will be journalized in the following way:

JOURNAL

Date	Particular	Ledger Folio	Debit (Amount)	Credit (Amount)
1.1.20	Cash A/c Dr. To Pema's Capital A/c <u>(Being capital brought in cash)</u>		800,000	800,000

Let us look at some more illustrations provided below and see how ‘debit’ and ‘credit’ rules can be applied in recording business transactions with the help of **Traditional Approach and Modern Approach.**

Traditional Approach to ‘debit’ and ‘credit’ Account.

Transaction 1: Dorji started business with Nu. 500,000 cash on 1st January 2020.

Solution:

- *What records should the entity (business) keep?*
 - (i) Record of **Cash** inflow.
 - (ii) Record of **Dorji’s Capital** (amount payable to proprietor).
- *Nature of accounts involved*
 - (i) **Cash**- Real account
 - (ii) **Dorji’s Capital**- Personal account
- *Apply ‘Real’ and ‘Personal’ account rules to record the transaction*

Cash a/c	Dr	500,000		(Read as debit Cash account)
			Cr	500,000
				(Read as credit Dorji’s Capital account)

(Being cash introduced by owner to start business)

Real account rule of Debit what comes in is applied, as cash comes in the business.

Personal account rule of Credit the giver is applied, as Dorji is the giver of cash to the business.

Transaction 2: Business purchased goods worth Nu. 200,000.

Solution:

- *What records should entity (business) keep?*
 - (i) Record of **Purchase of Goods**.
 - (ii) Record of **Cash Outflow**.
- *Nature of accounts involved.*
 - (i) **Purchase** -Nominal account
 - (ii) **Cash** - Real account

Apply ‘Nominal’ and ‘Real’ account rules to record the transaction.

Purchases a/c	Dr	200,000		(Read as debit Purchase Account)
			Cr	200,000
				(Read as credit Cash Account)

(Being goods purchased for cash)

Nominal account rule of Debit all expenses and losses is applied, as purchase is an expense to the business.

Real account rule of Credit what goes out is applied, as cash goes out of the business.

Transaction 3: Business sold goods worth Nu. 120,000.

Solution:

- *What records should entity (business) keep?*

- Record of **Sales of Goods**.
- Record of **Cash Inflow**.

- *Nature of accounts involved.*

- Sales** - Nominal account
- Cash** - Real account

Apply 'Real' and 'Nominal' account rules to record the transaction.

Cash a/c	Dr	120,000	(Read as debit Cash account)
To Sales a/c	Cr	120,000	(Read as credit Sales account)

(Being goods sold for cash)

Real account rule of Debit what comes in is applied, as cash comes in the business by sale of goods.

Nominal account rule of Credit all incomes and gains is applied, as sales is an income to the business.

Transaction 4: Business paid rent Nu.20,000 for the month of January 2020.

Solution:

- *What records should entity keep?*

- Record of **Rent paid**.
- Record of **Cash Outflow**.

- *Nature of accounts involved.*

- Rent** - Nominal account
- Cash** - Real account

Apply 'Nominal' and 'Real' account rules to record the transaction.

Rent a/c	Dr	20,000	(Read as debit Rent Account)
To Cash a/c	Cr	20,000	(Read as credit Cash Account)

(Being rent paid for the month of January)

Nominal account rule of Debit all expenses and losses is applied, as rent is an expense to the business.

Real account rule of Credit what goes out is applied, as cash goes out when rent is paid.

Transaction 5: Business opened a new account with BOBL and deposited Nu.100,000 .

Solution:

- *What records should entity keep?*

- Record of **Inflow of Cash in the Bank**.
- Record of **Cash Outflow of cash from the firm**.

- *Nature of accounts involved.*

- Bank** - Personal account
- Cash** - Real account

SELF-INSTRUCTIONAL MATERIAL

Apply 'Personal' and 'Real' account rules to record the transaction.

BoBL a/c Dr 100,000 (Read as debit Bank account)

To Cash a/c Cr 100,000 (Read as credit Cash account)

(Being cash deposited in the bank)

Personal account rule of Debit the receiver is applied, as bank is the receiver of cash.

Real account rule of Credit what goes out is applied, as cash goes out when the amount is deposited in the bank.

Modern Approach to 'debit' and 'credit' Account.

Transaction 1: Dorji started business with Nu. 500,000 cash on 1 January 2020.

Solution:

- What records should entity (business) keep?
 - (i) Record of **Increase in Cash**.
 - (ii) Record of **Increase in Dorji's Capital** (amount payable to proprietor).
- Nature of accounts involved.
 - (i) **Cash** - Asset
 - (ii) **Dorji's Capital** - Capital

Apply 'Asset' and 'Capital' account rules to record the transaction.

Cash a/c Dr 500,000 (Read as debit Cash Account)

To Dorji's Capital a/c Cr 500,000 (Read as credit Dorji's Capital Account)

(Being cash introduced by owner to start business)

*Asset account rule of **Increase in assets are Debit** is applied, as cash of the business is increased.*

*Capital account rule of **Increase in capital are Creditis** applied, as capital is increased.*

Transaction 2: Business purchased goods worth Nu. 200,000.

Solution:

- What records should entity (business) keep?
 - (i) Record of **Increase in Purchase**.
 - (ii) Record of **Decrease in Cash**.
- Nature of accounts involved.
 - (i) **Purchase** - Asset
 - (ii) **Cash** - Asset

Apply 'Asset' account rules to record the transaction.

Purchases a/c Dr 200,000 (Read as debit Purchase account)

To Cash a/c Cr 200,000 (Read as credit Cash account)

(Being goods purchased for cash)

Asset account rule of *Increase in assets are Debit* is applied, as Goods is increased due to purchases.

Asset account rule of *Decrease in assets are Credit* is applied, as cash is decreased due to purchase of goods.

Transaction 3: Business sold goods worth Nu. 120,000.

Solution:

- What records should entity (business) keep?
 - (i) Record of *increase in cash*.
 - (ii) Record of *increase in sales*.
- Nature of accounts involved.
 - (i) *Cash*- Asset
 - (ii) *Sales* - Income

Apply 'Asset' and 'Income' account rules to record the transaction.

Cash a/c	Dr	120,000		(Read as debit Cash Account)
	To Sales a/c		Cr	120,000 (Read as credit Sales Account)

(Being goods sold for cash)

Asset account rule of *Increase in assets are Debit* is applied, as cash is increased due to sales.

Income account rule of *Increase in incomes are Credit* is applied, as sales is increased.

Transaction 4: Business paid rent Nu.20,000 for the month of January 2020.

Solution:

- What records should entity keep?
 - (i) Record of *Rent increase*.
 - (ii) Record of *Cash decrease*.
- Nature of accounts involved.
 - (i) *Rent* - Expenses
 - (ii) *Cash* - Asset

Apply 'Expense' and 'Asset' account rules to record the transaction.

Rent a/c	Dr	20,000		(Read as debit Rent account)
	To Cash a/c		Cr	20,000 (Read as credit Cash account)

(Being rent paid for the month of January)

Expense account rule of *Increase in expenses are Debit* is applied, as expenses on rent is increased.

Asset account rule of *Decrease in assets are Credit* is applied, as cash is decreased due to payment of rent.

Transaction 5: Business opened new account with BOBL and deposited Nu.100,000 .

Solution:

- *What records should entity keep?*
 - (i) Record of **Increase in bank balance**.
 - (ii) Record of **decrease in Cash**.
- *Nature of accounts involved.*
 - (i) **Bank** - Asset
 - (ii) **Cash** - Asset

Apply 'Asset' account rules to record the transaction.

BOBL a/c Dr 100,000 (Read as debit Bank Account)

To Cash a/c Cr 100,000 (Read as credit Cash Account)

(Being cash deposited in the bank)

*Asset account rule of **Increase in assets are Debit** is applied, as bank balance of the firm is increased.*

*Asset account rule of **Decrease in assets are Credit** is applied, as cash is decreased due to amount deposited in the bank.*

Now with the help of Illustration 1 and 2 given below, let us try to understand how to do analysis of transactions in detail and identify the **accounts affected, kind of accounts**, and see **how to apply rules to debit and credit accounts** to pass the journal entries.

Illustration 1.

Enter the following business transactions in the Journal.

Date	Transactions	Amount (Nu.)
1.1. 2019	Ugyen commenced business with cash	700,000
2.1.2019	Goods purchased for cash	150,000
3.1.2019	Goods purchased on credit from Sita	50,000
4.1.2019	Cash paid to Sita	40,000
4.1.2019	Furniture purchased from karma	100,000
5.1.2019	Deposited into TBank	200,000
7.1.2019	Rent paid in cash	25,000
10.1.2019	Goods sold for cash	180,000
15.1.2019	Goods sold on credit to Lungten	40,000
20.1.2019	Cash received from Lungten	30,000
25.1.2019	Salary paid in cash	30,000
28.1.2019	Salary paid by issue of cheque	5,000
31.1.2019	Cash withdrawn by Ugyen for private purposes	15,000

As explained above before passing the journal entries, it is very essential to determine the **accounts affected, kinds of accounts, and how to apply the rules to debit and credit accounts**. The two Table below shows the analysis of transactions with the help of *Modern Approach and Traditional Approach of Classification of Accounts*.

Tabular Analysis of transactions (with Modern Approach of Classification of Accounts)

Date	Particular	Accounts Involved	Nature of Accounts	Increase or Decrease in accounts	Debited Account	Credited Account
1.1.2019	Cash received from owner Ugyen	Cash	Asset	Increase	Cash A/c	Capital A/c
		Capital	Capital	Increase		
2.1.2019	Goods purchased for cash	Purchases	Expense	Increase	Purchases A/c	Cash A/c
		Cash	Asset	Decrease		
3.1.2019	Goods purchased on credit from Sita	Purchases	Expense	Increase	Purchases A/c	Sita's A/c
		Sita (Creditor)	Liability	Increase		
4.1.2019	Cash paid to Sita	Sita (Creditor)	Liability	Decrease	Sita's A/c	Cash A/c
		Cash	Asset	Decrease		
4.1.2019	Furniture purchased from karma	Furniture	Asset	Increase	Furniture A/c	Karma's A/c
		Karma (Creditor)	Liability	Increase		
5.1.2019	Deposited into Tbank	Bank	Asset	Increase	Bank A/c	Cash A/c
		Cash	Asset	Decrease		
7.1.2019	Rent paid in cash	Rent	Expense	Increase	Rent A/c	Cash A/c
		Cash	Asset	Decrease		
10.1.2019	Goods sold for cash	Cash	Asset	Increase	Cash A/c	Sales A/c
		Sales	Revenue	Increases		
15.1.2019	Goods sold on credit to Lungten	Lungten (Debtor)	Asset	Increase	Lungten A/c	Sales A/c
		Sales	Revenue	Increase		
20.1.2019	Cash received from Lungten	Cash	Asset	Increase	Cash A/c	Lungten A/c
		Lungten (Debtor)	Liability	Decrease		
25.1.2019	Salary paid in cash	Salary	Expense	Increase	Salary A/c	Cash A/c
		Cash	Asset	Decrease		
28.1.2019	Salary paid through cheque	Salary	Expense	Increase	Salary A/c	Bank A/c
		Bank	Asset	Decrease		
31.1.2019	Cash withdrawn for private purpose	Drawings	Capital	Increase	Drawings A/c	Cash A/c
		Cash	Assets	Decrease		

Tabular Analysis of transactions (with Traditional Approach of Classification)

Date	Particular	Accounts Involved	Nature of Accounts	How account are affected	Debited Account	Credited Account
1.1.2019	Cash received from owner Ugyen	Cash Capital	Real Personal	Cash is coming in. Ugyen is the giver of cash.	Cash A/c	Capital A/c
2.1.2019	Goods purchased for cash	Purchases Cash	Nominal Real	Goods come in and Purchase is an expense. Cash is going out.	Purchases A/c	Cash A/c
3.1.2019	Goods purchased on credit from Sita	Purchases Sita	Nominal Personal	Goods come in and Purchase is an expense. Sita is giver.	Purchases A/c	Sita A/c
4.1.2019	Cash paid to Sita	Sita (Creditor) Cash	Personal Real	Sita is receiver of cash. Cash is going out.	Sita's A/c	Cash A/c
4.1.2019	Furniture purchased from karma	Furniture Karma (Creditor)	Real Personal	Furniture is coming in. Karma is giver.	Furniture A/c	Karma A/c
5.1.2019	Deposited into Tbank	Bank Cash	Personal Real	Bank is the receiver. Cash is going out.	Bank A/c	Cash A/c
7.1.2019	Rent paid in cash	Rent Cash	Nominal Real	Rent is an expense. Cash is going out.	Rent A/c	Cash A/c
10.1.2019	Goods sold for cash	Cash Sales	Real Nominal	Cash is coming in. Sales is an income.	Cash A/c	Sales A/c
15.1.2019	Goods sold on credit to Lungten	Lungten (Debtor) Sales	Personal Nominal	Lungten is the receiver. Sales is an income.	Lungten's A/c	Sales A/c
20.1.2019	Cash received from Lungten	Cash Lungten	Real Personal	Cash is coming in. Lungten is giver of cash.	Cash A/c	Lungten's A/c

SELF-INSTRUCTIONAL MATERIAL

25.1.2019	Salary paid in cash	Salary Cash	Nominal Real	Salary is an expense. Cash is going out.	Salary A/c	Cash A/c
28.1.2019	Salary paid by issue of cheque	Salary Bank	Nominal Personal	Salary is an expense. Bank is the giver.	Salary A/c	Bank A/c
31.1.2019	Cash withdrawn for private purpose	Drawings Cash	Personal Real	Increase Decrease	Drawings A/c	Cash A/c

On the basis of the above table, following journal entries can be passed in the General Journal.

JOURNAL

In the Books of Mr. Pema as at 31/01/2019

Date	Particulars	Ledger Folio	Debit Amount Nu.	Credit Amount Nu.
1.1.2019	Cash A/c Dr. To Pema's Capital A/c (Being capital brought in cash by Ugyen)		700,000	700,000
2.1.2019	Purchases A/c Dr. To Cash A/c (Being goods purchased for cash)		150,000	150,000
3.1.2019	Purchases A/c Dr. To Sita's A/c (Being goods purchased from Sita on credit)		50,000	50,000
4.1.19	Sita's A/c Dr. To Cash A/c (Being cash paid to Sita)		40,000	40,000
4.1.2019	Furniture A/c Dr. To Karma (Being Furniture purchased from Karma on credit)		100,000	100,000
5.1.2019	Bank A/c Dr. To Cash A/c (Being cash deposited in Tbank)		200,000	200,000
7.1.2019	Rent A/c Dr. To Cash (Being rent paid)		25,000	25,000
10.1.2019	Cash A/c Dr. To Sales A/c (Being goods sold for cash)		180,000	180,000
15.1.2019	Lungten's A/c Dr. To Sales A/c (Being goods sold to Lungten on credit)		40,000	40,000

SELF-INSTRUCTIONAL MATERIAL

20.1.2019	Cash A/c To Lungten A/c (Being Cash received from Lungten)	Dr.	30,000	30,000
25.1.2019	Salary A/c Dr. To Cash A/c (Being salary paid in cash)		30,000	30,000
28.1.2019	Salary A/c Dr. To Bank A/c (Being salary paid to staff by issue of cheque)		5,000	5,000
31.1.2019	Drawing's A/c To Cash A/c (Being cash withdrawn by the owner for private purpose)	Dr.	15,000	15,000
		Total	1,565,000	1,565,000

Illustration 2

Let us do an analysis of the following transactions, with both the approaches and pass the journal entries in the books of the entity.

Transaction 1: Sonam Usel started business with cash Nu.800,000 on 1 January 2020.

Transaction 2: Loan from BoBL Nu.100,000.

Transaction 3: Purchased furniture for Nu.80,000 in cash from RK furniture house.

Transaction 4: Purchase furniture from R.C Furniture for Nu. 50,000.

Transaction 5: Purchased goods for cash Nu.250,000.

Transaction 6: Purchased goods from Sonam Nu.30,000.

Transaction 7: Sold goods for cash to Deepak Nu.100,000

Transaction 8: Sold goods to Khandu on credit for Nu.50,000

Transaction 9: Cash received from Khandu Nu. 40,000.

Transaction 10: Cash paid to Sonam Nu.20,000.

Transaction 11: Opened account and deposited into BNB cash into Nu.50,000.

Transaction 12: Withdrew cash from business for personal use Nu.5,000.

Transaction 13: Withdrew cash from bank for office use Nu.10,000.

Transaction 14: Paid salary to staff Nu. 20,000.

Transaction 15: Paid rent by cheque Nu.7,000.

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Solution:**Analysis of transactions with the help of traditional approach.**

Sl.no	Particulars	Accounts Involved	Nature of Accounts	How Affected	Debited Account	Credited Account
1.	Sonam Usel started business with cash Nu. 800,000.	Cash Capital	Real Personal	Cash is coming in. Sonam Usel is the giver of cash.	Cash Nu.800,000	Capital Nu 800,000
2.	Borrowed from BOBL Nu.100,000	Cash BOBL Loan	Real Personal	Cash is coming in. Bank is the giver of cash.	Cash Nu.100,000	BOBL loan Nu.100,000
3.	Purchased furniture for Nu.80,000 for cash.	Furniture Cash	Real Real	Furniture is coming in. Cash is going out	Furniture Nu.80,000	Cash Nu.80,000
4.	Purchased furniture from RC Furniture for Nu.50,000.	Furniture RC Furniture	Real Personal	Furniture is coming in. RC furniture is giver.	Furniture Nu. 50,000	RC Furniture Nu.50,000
5.	Purchased goods for cash Nu. 250,000	Purchases Cash	Nominal Real	Goods comes in. Purchase is an expense. Cash is going out.	Purchase Nu.250,000	Cash Nu.250,000
6.	Purchased goods from Sonam Nu.30,000	Purchases Sonam	Nominal Personal	Goods come in. Purchase is an expense. Sonam is giver.	Purchase Nu. 30,000	Sonam Nu. 30,000
7.	Sold goods for cash to Deepak Nu.100,000	Cash Sales	Real Nominal	Cash is coming in. Sale is an income.	Cash Nu. 100,000	Sales Nu.100,000
8.	Sold goods to Khandu on credit for Nu. 50,000	Khandu Sales	Personal Nominal	Khandu is the receiver. Sale is an income.	Khandu Nu. 50,000	Sales Nu.50,000
9.	Cash received from Khandu Nu. 40,000	Cash khandu	Real Personal	Cash is coming in. Khandu is the giver of cash.	Cash Nu. 40,000	Khandu Nu. 40,000
10.	Cash Paid to Sonam Nu. 20,000	Sonam Cash	Personal Real	Sonam is the receiver. Cash is going out.	Sonam Nu. 20,000	Cash Nu. 20,000
11.	Deposited cash into BNB bank Nu.50,000	Bank Cash	Personal Real	Bank is the receiver of cash. Cash is going out.	Bank Nu. 50,000	Cash Nu.50,000
12.	Withdrew cash for personal use Nu.5,000	Drawings Cash	Personal Real	Sonam Usel is the receiver. Cash is going out.	Drawings Nu. 5,000	Cash Nu.5,000

SELF-INSTRUCTIONAL MATERIAL

13.	Withdrew cash from bank for office use Nu. 10,000	Cash Bank	Real Personal	Cash is coming in. Bank is giver of cash.	Cash Nu. 10,000	Bank Nu. 10,000
14.	Paid salary to staff Nu.20,000	Salary Cash	Nominal Real	Salary is an expense. Cash is going out.	Salary Nu. 20,000	Cash Nu. 20,000
15.	Paid rent by cheque Nu.7,000	Rent Bank	Nominal Personal	Rent is an expense. Bank is giver of cash.	Rent Nu. 7,000	Bank Nu.7,000

Analysis of transactions with the help of modern approach.

Sl.no	Particulars	Accounts Involved	Nature of Accounts	Increase or Decrease in accounts	Debited Account and Amount	Credited Account and Amount
1.	Sonam Usel started business with cash.	Cash Capital	Asset Capital	Increase Increase	Cash Nu. 800,000	Capital Nu 800,000
2.	Loan from BOBL Nu.150,000	Cash BOBL Loan	Asset liability	Increase Increase	Cash Nu.100,000	BOBL Nu.100,000
3.	Purchased furniture for Nu.80,000 for cash.	Furniture Cash	Asset Asset	Increase Decrease	Furniture Nu.80,000	Cash Nu.80,000
4.	Purchased furniture from R.C for Nu.50,000 .	Furniture R.C furniture	Asset Liability	Increase Increase	Furniture Nu. 50,000	RC Furniture Nu.50,000
5.	Purchased goods for cash Nu. 250,000	Purchases Cash	Expense Asset	Increase Decrease	Purchase Nu.250,000	Cash Nu.250,000
6.	Purchased goods from Sonam Nu.30,000	Purchases Sonam	Expense Liability	Increase Increase	Purchase Nu. 30,000	Sonam Nu. 30,000
7.	Sold goods for cash to Deepak Nu.100,000	Cash Sales	Asset Income	Increase Increase	Cash Nu. 100,000	Sales Nu. 100,000
8.	Sold goods to Khandu on credit for Nu. 50,000	Khandu Sales	Asset Income	Increase Increase	Khandu Nu. 50,000	Sales Nu.50,000
9.	Cash received from Khandu Nu. 40,000	Cash khandu	Asset Asset	Increase Decrease	Cash Nu. 40,000	Khandu Nu. 40,000
10.	Cash Paid to Sonam Nu. 20,000	Sonam Cash	Liability Asset	Decrease Decrease	Sonam Nu. 20,000	Cash Nu. 20,000
11.	Deposited cash into BNB bank Nu.50,000	Bank Cash	Asset Asset	Increase Decrease	Bank Nu. 50,000	Cash Nu.50,000
12.	Withdrew cash for personal use Nu.5,000	Drawings Cash	Capital Asset	Decrease Decrease	Drawings Nu. 5,000	Cash Nu.5,000
13.	Withdrew cash from bank for office use Nu. 10,000	Cash Bank	Asset Asset	Decrease Increase	Cash Nu. 10,000	Bank Nu. 10,000
14.	Paid salary to staff Nu.20,000	Salary Cash	Expense Asset	Increase Decrease	Salary Nu. 20,000	Cash Nu. 20,000
15.	Paid rent by cheque Nu.7,000	Rent Bank	Expense Asset	Increase Decrease	Rent Nu. 7,000	Bank Nu.7,000

On the basis of the above table, following journal entries can be passed in the General Journal.

JOURNAL

In the books of Ms. Sonam Usel as at

Sl.No	Particulars	Ledger folio	Debit Amount Nu.	Credit Amount Nu.
1.	Cash A/c Dr. To Sonam Usel's Capital A/c (Being capital introduced by Sonam Usel)		800,000	800,000
2.	Cash A/c Dr. To BOBL loan A/c (Being loan from Bank)		150,000	150,000
3.	Furniture A/c Dr. To Cash A/c (Being Furniture purchased for cash)		80,000	80,000
4.	Furniture A/c Dr. To RC Furniture A/c (Being Furniture purchased on credit from RC Furniture)		50,000	50,000
5.	Purchases A/c Dr. To Cash A/c (Being goods purchased for cash)		250,000	250,000
6.	Purchase A/c Dr. To Sonam's A/c (Being goods purchased on credit from Sonam)		30,000	30,000
7.	Cash A/c Dr. To Sales A/c (Being goods sold to Deepak for cash)		100,000	100,000
8.	Khandu's A/c Dr. To Sales A/c (Being goods sold to Khandu on credit)		50,000	50,000
9.	Cash A/c Dr. To Khandu's A/c (Being cash collected from Khandu)		40,000	40,000
10.	Sonam A/c Dr. To Cash A/c (Being cash paid to Sonam on account of goods purchased on credit)		20,000	20,000
11.	Bank A/c Dr. To Cash A/c (Being account opened and cash deposited)		50,000	50,000
12.	Drawing's A/c Dr. To Cash A/c (Being cash withdrawn by proprietor for personal use)		5,000	5,000

SELF-INSTRUCTIONAL MATERIAL

13.	Cash A/c To Bank A/c (Being cash withdrawn from bank)	Dr.		10,000	10,000
14.	Salary A/c To Cash A/c (Being salary paid to staff)	Dr.		20,000	20,000
15.	Rent A/c To Bank A/c (Being cheque issued for payment of rent)	Dr.		7,000	7,000
		Total		1,662,000	1,662,000

**ACTIVITY 1****Instruction:**

You have learned the steps in journalizing the business transactions, now read the business scenario given below and apply your skills as an accountant of the firm to record the business transactions.

Pema started business with cash Nu. 500,000 on 1st January 2020. He purchased inventories (goods) for Nu.150,000 and sold the same for Nu. 200,000. He paid Nu. 15,000 as wages. He received rent of Nu. 25,000 for the month of January. He purchased a laptop worth Nu.50,000 on credit from Sangay Gyelmo and Furniture from Nalay Pem for cash Nu. 50,000. At the end of the month, Pema opened an account and deposited Nu. 300,000 and paid Nu 30,000 to Sangay Gyelmo. In order to further expand his business, he borrowed Nu. 200,000 from Druk PNB as a loan.

**ACTIVITY 2**

- Following accounts are being maintained in the books of Yangzin Furniture Traders. Classify them under Personal, Real and Nominal Accounts:
(i) Land; (ii) Building; (iii) Interest received; (iv) Salary; (v) Drawings (vi) Purchases; (vii) Capital; (viii) Wages; (ix) Account Payable; (x) Dema's Drawings.
- Classify the following into assets, Liabilities, Capital, Revenue and Expense:
(i) Plant and Machinery; (ii) Bank Loan; (iii) Purchases; (iv) Furniture and Fixture; (v) Outstanding Expenses; (vi) Sales; (vii) Wages; (viii) Motor Vehicle; (ix) Capital.

Ledger

When the transactions for a given period have been recorded in the Journal, the next step is to classify these records according to the accounts affected. This classification is done in another book called Ledger.

The second stage in the accounting process is posting (transferring) into Ledger. We shall learn the posting of transactions recorded in the Journal into Ledger.

Meaning of Ledger

Ledger is a book that contains different accounts relating to **Assets, Liabilities, Capital, Revenue and Expenses**. Ledger is also called the “Principal Book of Accounts” or “Book of Final Entry” because the transactions that are first recorded in the Journal are finally posted in the Ledger. The double entry bookkeeping concept is applied while preparing a ledger. This states that every aspect of transaction must be entered in ledger accounts and the sum of ‘debit’ should be equal to ‘credit’. It is the most important book of accounts, since the Trial Balance is drawn with the help of ledger balances and from the Trial Balance, Financial Statements are prepared. The balance of **Assets, Liabilities, and Equity** are shown in the **Statement of Financial Position (Balance Sheet)** whereas total of **Revenues and Expenses** are shown in the **Income Statement**.

Features of Ledger

Some important characteristics of ledger are listed below.

- (i) It is prepared from Journal.
- (ii) Ledger Accounts show the current balance in all the accounts.
- (iii) Trial Balance and Financial Statements (**Income Statement and Financial Position Statement**) are prepared from Ledger Accounts.
- (iv) Ledger Accounts summarise the effects of transactions upon **Assets, Liabilities, Capital, Revenues and Expenses**.

Importance of Ledger

a) Useful for management

The information given in different ledger accounts will help the management in preparing budget. It also helps the management to check the performance of business it is managing.

b) Knowledge of financial position

Ledger provides information about assets and liabilities of the business. From this we can judge the financial position and health of the business.

c) Instant information

The business always needs to know what the business owes to others and what the others owe to the business. The ledger account provides this information at a glance through the account receivables and payables.

d) Business results

Ledger provides detailed information about revenues and expenses at one place. While finding out business results the revenue and expenses are matched with each other.

e) **Preparation of trail balance**

Ledger helps the preparation of trial balance so that it becomes possible enough to check any arithmetical accuracy.

f) **Reduced possibilities of error**

Maintenance of ledger account reduces the possibilities of errors and misappropriation of business funds.

Format of Ledger

Name of Particular Account

Dr.

Cr.

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount

Posting

The process of transferring the information contained in a Journal to ledger is called **posting**. In other words, the process of transferring of the debit amounts and credit amounts from the Journal to the ledger Account is called **posting**. Posting is necessary in order to know how transactions have changed the account balances.

Following procedure is followed for posting of journal entries into the ledger:

1. Posting of an Account debited in a Journal entry.

- First.** Identify in the Ledger the account to be debited.
- Second.** Enter the date of the transaction in the 'Date' column on the debit side of the account.
- Third.** Write the name of the account which has been credited in the respective entry in the 'Particulars' column on the debit side of the ledger account as 'To (name of account credited)'. (ref. line 3 in the diagram below)
- Fourth.** Record the page number of the Journal where the entry exists in the 'Journal Folio (J.F.)' column.
- Fifth.** Enter the amount debited in journal in the 'Amount' column on the debit side. (ref. line 4 in the diagram below)

2. Posting of an Account credited in a Journal entry.

- First.** Identify in the Ledger the account to be credited.
- Second.** Enter the date of the transaction in the 'Date' column on the credit side of the account.

Third. Write the name of the account which has been debited in the respective entry in the ‘Particulars’ column on the credit side of the account as ‘By (name of account debited)’. (ref. line 1 in the diagram below)

Fourth. Record the page number of the Journal where the entry exists in the ‘Journal Folio (J.F.)’ column.

Fifth. Enter the amount debited in journal in the ‘Amount’ column on the debit side. (ref. line 2 in the diagram below)

Example:

On 1st January 2019, an entity purchased Building at Nu.900, 000 for cash from Tenzin.

Give Journal entry and prepare ledger accounts.

Journal

Date	Particulars	L/F	Debit Amount	Credit Amount
2017 April 1	Building A/c.....Dr To Cash A/c (Being Machinery Purchased for cash)		900,000	900,000

Ledger

Dr

Building Account

Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
2017 April 1	To Cash A/c		900,000				

Dr

Cash Account

Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
				2017 April 1	By Building A/c		900,000

Illustration 1 will help you to understand how posting only is done in their respective accounts after journal entries are passed.

Illustration 1

Sangay commenced business on 1st January 2020 with a capital of Nu. 800,000. On 8th January, he purchased goods worth Nu. 350,000 and on 18th January, he paid salary Nu. 20,000 to his staff. On 20th January 2018, he further paid Nu. 10,000 as a monthly rental charge. He made total sales of Nu.500,000 as on 30th January 2020.

Pass the journal entries and prepare necessary ledger account for the month of January 2020.

Journal

In the Books of Mr. Sangay as at 30/01/2020

Date	Particulars	L/F	Debit (Nu)	Credit (Nu)
1/01/2020	Cash A/cDr To Sangay's Capital A/c (Being the capital contributed)		800,000	800,000
8/1/2020	Purchase A/c.....Dr To Cash A/c (Being goods purchased)		350,000	350,000
18/01/2020	Salary A/c.....Dr To Cash A/c (Being salary paid)		20,000	20,000
20/01/2020	Rent A/c.....Dr To Cash A/c (Being rent paid)		10,000	10,000
30/01/2020	Cash A/c.....Dr To Sales A/c (Being the cash received from sales of goods)		500,000	500,000
	Total		1,680,000	1,680,000

LEDGER

Dr **Cash Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
1/01/20	To Sangay's		800,000	8/1/20	By Purchase A/c		350,000
30/1/20	A/c		500,000	18/1/20	By Salary A/c		20,000
	To Sales A/c			20/1/20	By Rent A/c		10,000

Dr Sangay's Account Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
				1/01/20	By Cash A/c		800,000

Dr Purchase Account Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
8/1/20	To cash A/c		350,000				

Dr Salary Account Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
18/1/20	To cash A/c		20,000				

Dr Rent Account Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
20/1/20	To cash A/c		10,000				

Dr Sales Account Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
				30/1/20	By Cash A/c		500,000

Balancing of an Account

Balancing is the difference between the total of debit and total of credit of an Account.

If debit side total is more than the credit side, the account shows a **debit balance**. Similarly, if the credit side total of an account is more than the debit side total, it is a **credit balance**.

SELF-INSTRUCTIONAL MATERIAL

Dr Purchase Account (Nominal A/c; Expense A/c) Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
8/1/20	To cash A/c		350,000	31/1/20	By balance c/d		350,000
			350,000				350,000
1/2/20	To balance b/d		350,000				

Dr Salary Account (Nominal A/c; Expense A/c) Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
18/1/20	To cash A/c		20,000	31/1/20	By balance c/d		20,000
			20,000				20,000
2/1/20	To balance b/d		20,000				

Dr Rent Account (Nominal A/c; Expense A/c) Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
20/1/20	To cash A/c		10,000	31/1/20	By balance c/d		10,000
			10,000				10,000
1/2/20	To balance b/d		10,000				

Dr Sales Account (Nominal A/c; Income A/c) Cr

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
31/1/20	To balance c/d		500,000	30/1/20	By Cash A/c		500,000
			500,000				500,000
				1/2/20	By balance b/d		500,000

In the illustration, Nominal Account (i.e. Purchases A/c, Salary A/c, Rent A/c, Sales A/c) are balanced only for the purpose of showing them in the Trial Balance. At the end of an accounting period, All Nominal Accounts balance will be closed by transferring to Income Statement and Personal and Real Accounts (i.e. Capital, Cash) balance will be closed by transferring to Statement of Financial Position (Balance Sheet).

Meaning of Trial Balance

Once the entries have been posted into the ledger and the ledger accounts have been balanced, these accounts may show **closing debit or credit balances**. With the help of **closing debit and credit balances** as at any given date, a statement is prepared. Such statement is called **Trial Balance**. Trial Balance is the first step towards the preparation of financial statements. It is usually prepared at the end of an accounting period to assist in the drafting of financial statements. Ledger balances are segregated into debit balances and credit balances. **Asset and expense accounts appear on the debit side of the trial balance whereas liabilities,**

capital and income accounts appear on the credit side. If all accounting entries are recorded correctly and all the ledger balances are accurately extracted, the total of all debit balances appearing in the trial balance must equal to the sum of all credit balances.

Purposes of preparing a Trial Balance

a) To check arithmetical accuracy

The main objective of preparing a trial balance is to check arithmetical accuracy of transactions while they are recorded in the journal and posted to the ledger. Arithmetical accuracy means writing correct figures, in the correct account and on its correct side while posting transactions from the journal. If total of debit column and credit column of trial balance is equal, then it is a general indication that no errors have been made in the journal and ledgers.

b) To help in disclosing some accounting error

The objective of preparing a trial balance is to locate the accounting errors at an early stage. As soon as business transactions take place, it is recorded in the journal and then posted into the ledger. If errors are committed in posting from journal to ledger, the totals of the two columns of trial balance will not tally.

c) To help in preparing Financial Statements

The objective of the trial balance is to help preparing financial statements of a business enterprise at the end of accounting year. The balances of income and expenses are placed in income statement and, balances of assets, liabilities and equity are used in preparing position statement. It acts as a link between ledger accounts and financial statements.

d) To help management in taking decision

The trial balance helps in comparing the balances of assets, liabilities, capital, incomes, and expenses between two different accounting periods. Such comparison helps in making a proper judgment of different activities of the business and arriving at important decisions.

e) To provide a summary of ledger accounts

The Trial Balance provides summary of information of all the ledger accounts in one place. It presents the balances of assets, liabilities, capital, incomes and expenses relating to a particular date.

Preparation of Trial Balance

Specimen of a Trial Balance

Trial Balance as at.....

Sl. No.	Ledger Accounts	L.F*.	Debit balance (Nu.)	Credit balance (Nu.)

*Ledger Folio (*LF) refers to the page number of the Ledger.*

Steps for preparing Trial Balance

Step 1: Balance all accounts of assets, liabilities, income and expenses in the general ledger. This may be called as extraction of account balances.

Step 2: Transfer all ledger balances to the trial balance template as shown in the specimen above. Remember, you should be able to identify the nature of ledger balances as debit or credit and accordingly place them under debit or credit columns correctly.

Step 3: Total the debit and credit columns of trial balance and see any difference. Generally, as said earlier, the total of debit and total of credit columns should agree unless there is an error in recording and positing of entries in the ledgers. Let us now look at some illustrations.

Illustration 1

On 1st January 2017, XYZ Mines Ltd. invested Nu. 1,000,000 mainly focusing on the extraction and production of Plaster of Paris (PoP) to meet the increasing demands of the Health Ministry of Bhutan. The other transactions on the commencement of the business included the following:

January 2017		
1 st Jan, Purchased raw materials	Nu.	300,000
2 nd Jan, Paid for transportation charges	Nu.	50,000
7 rd Jan, Paid wages for local labours	Nu.	10,000
7 th Jan, Manager Salary	Nu.	20,000
11 th Jan, Engineer's drawings fees	Nu.	10,000
11 th Jan, Site supervisor's salary	Nu.	15,000
13 th Jan, Purchased concrete mixture	Nu.	100,000
20 th Jan, Hired a utility pick up Bolero and paid hiring charges	Nu.	25,000
20 th Jan, Paid rent for office	Nu.	7,500
22 nd Jan, Purchased cement and bricks from ABC Cement Agent	Nu.	150,000
23 rd Jan, Paid insurance	Nu.	30,000
27 th Jan, Paid to ABC Cement Agent Nu. 145,000 in full settlement		
29 th Jan, Sold used materials for construction	Nu.	13,000

Assuming that you are employed by XZY Mines as an accountant, prepare a trial balance for the company.

Solution:

Dr **Cash Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
1/17	To capital A/c		1,000,000	1/1/17	By Purchase A/c		300,000
29/1/17	To sales		13,000	2/1/17	By transportation		50,000
				7/1/17	By wages		10,000
					By salaries		20,000
				11/1/17	By drawing Charges		10,000
					By salaries		15,000
				13/1/17	By concrete Mixture		100,000
				20/1/17	By Hiring charges		25,000
					By Rent		7,500
				23/1/17	By insurance		30,000
				27/1/17	By ABC Cement		145,000
				31/1/17	By balance c/d		300,500
			1,013,000				1,013,000
1/2/17	To balance b/d		300,500				

Dr **Capital Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
31/1/17	To balance c/d		1,000,000	1/1/17	By cash		1,000,000
			1,000,000				1,000,000
				1/2/17	By balance b/d		1,000,000

Dr **Purchases Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
1/1/17	To Cash		300,000	31/1/17	By balance c/d		450,000
22/1/17	To Choden cement		150,000				450,000
			450,000				
1/2/17	To balance b/d		450,000				

Dr **Transportation Charges Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
2/1/17	To cash		50,000	31/1/17	By balance c/d		50,000
			50,000				50,000
1/2/17	To balance b/d		50,000				

SELF-INSTRUCTIONAL MATERIAL

Dr				Cr			
Wages Account							
Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
7/1/17	To cash		10,000	31/2/17	By balance c/d		10,000
			10,000				10,000
1/2/17	To balance b/d		10,000				

Dr				Cr			
Salaries Account							
Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
7/1/17	To cash		20,000	31/1/17	By balance c/d		35,000
	To cash		15,000				35,000
			35,000				
1/2/17	To balance b/d		35,000				

Dr				Cr			
Drawings Charges Account							
Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
11/1/17	To cash		10,000	31/1/17	By balance c/d		10,000
			10,000				10,000
1/2/17	To balance b/d		10,000				

Dr				Cr			
Concrete Mixture Account							
Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
13/1/17	To cash		100,000	31/1/17	By balance c/d		100,000
			100,000				100,000
1/2/17	To balance b/d		100,000				

Dr				Cr			
Hiring Charges Account							
Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
20/1/17	To cash		25,000	31/1/17	By balance c/d		25,000
			25,000				25,000
1/2/17	To balance b/d		25,000				

Dr				Cr			
Rent Account							
Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
22/1/17	To cash		7,500	31/1/17	By balance c/d		7,500
			7,500				7,500
1/2/17	To balance b/d		7,500				

Dr **ABC Cement Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
27/1/17	To cash		145,000	22/1/17	By purchases		150,000
27/1/17	To Discount Received		5,000				
			150,000				150,000

Dr **Insurance Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
23/1/17	To cash		30,000	31/1/17	By balance c/d		30,000
			30,000				30,000
1/2/17	To balance b/d		30,000				

Dr **Discount Received Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
31/1/17	To balance c/d		5,000	27/1/17	By ABC Cement A/c		5,000
			5,000				5,000
				1/2/17	By balance b/d		5,000

Dr **Sales Account** **Cr**

Date	Particulars	J/F	Amount	Date	Particulars	J/F	Amount
31/1/17	To balance c/d		13,000	29/1/17	By cash		13,000
			13,000				13,000
				1/2/17	By balance		13,000

Trial Balance of ZYZ Mines Ltd. as at 31st January 2017

SL	Accounts	L.F	Debit Balance (Nu.)	Credit Balance (Nu.)
1	Capital			1,000,000
2	Cash and Cash Equivalent		300,500	
3	Purchase		450,000	
4	Transportation		50,000	
5	Wages		10,000	
6	Salaries		35,000	
7	Drawing		10,000	
8	Concrete Mixer		100,000	
9	Hiring Charges		25,000	
10	Rent		7,500	
11	Insurance		30,000	
12	Discount Received			5,000
13	Sales			13,000
	Total		1,018,000	1,018,000

Illustration 2

Ledger balances extracted from the books of a Kinley Bidha Enterprise is provided below. Prepare Trial Balance as on 31st December, 2019.

Heads of Accounts	Nu.	Heads of Accounts	Nu.
Cash & Cash Equivalent	21,000	Sales	105,000
Bills Receivable	18,000	Purchases	75,000
Bills Payable	16,000	Carriage Inward	27,00
Trade Receivables	24,600	Salaries	12,000
Trade Payables	32,400	Advertisement	2,400
Capital	50,000	Insurance	1,600
Drawings	18,000	Furniture	7,500
Office Rent	2,000	Inventory	18,600

Solution:

Trial Balance of Kinley Bidha Enterprise as at 31st December 2019

SL	Ledger Accounts	L.F	Debit Balance Nu.	Credit Balance Nu.
1.	Cash and Cash Equivalent		21,000	
2.	Bills Receivable		18,000	
3.	Bills Payable			16,000
4.	Trade Receivables		24,600	
5.	Trade Payables			32,400
6.	Capital			50,000
7.	Drawings		18,000	
8.	Sales			105,000
9.	Purchases		75,000	
10.	Carriage Inward		2,700	
11.	Salaries		12,000	
12.	Advertisement		2,400	
13.	Insurance		1,600	
14.	Furniture		7,500	
15.	Inventory		18,600	
16.	Office Rent		2,000	
	Total		203,400	203,400

**ACTIVITY 3**

1. SMART Ltd started business with initial capital Investment of Nu. 700,000 on 1st October 2020.

Other transactions for the month were:

Date	Transactions
2/10/2020	Purchased inventories for Nu. 500,000.
5/10/2020	Purchased plant for Nu. 150,000 from Jigme.
8/10/2020	Sold inventories for Nu. 300,000. (1/4 th of the inventories were sold on credit to Tandin)
11/10/2020	Paid to Jigme Nu.100,000.
16/10/2020	Rent paid for the month Nu.20,000.
18/10/2020	Withdrew Nu. 10,000 for office use and Nu. 15,000 for domestic use
20/10/2020	Paid electricity charge for Nu.1,500 and telephone bill for Nu.3,500
21/10/2020	Received Nu. 20,000 for commission.
23/10/2020	Received cash from Tandin Nu.50,000.
24/10/2020	Sold goods for Nu.50,000.

You are required to pass journal entry with proper format, prepare necessary ledger account and a trial balance as on 31/10/2020.

**ACTIVITY 4****Case study:**

On 1/1/2020, Kinley Bidha commenced business with Nu.500,000. On 8/1/20 she purchased land and building for Nu.200,000. She purchased inventories from Pelmo for Nu.120,000 for cash on 10/1/2020. She further purchased inventories from Esha on credit worth Nu.80,000 on 20/1/2020. She realised that she needed furniture in his business and acquired it for Nu.50,000 on 21/1/2020. On 27/1/2020 she sold inventories for Nu.150,000 to Bimlha; receiving Nu.100,000 in cash and balance amount to be receivable after one month. On 31/1/2020 she paid Nu.15,000 and Nu.10,000 for salary and rent respectively.

You are required to pass the journal entries for the above business transactions, post into respective ledger accounts and extract a trial balance as on 31/1/2020.



Summary

- 1) The book in which all business transactions are recorded date wise in a systematic manner, is known as Journal.
- 2) Transactions when recorded in a Journal is termed as ‘Entries’.
- 3) Rules of Journalizing.

Rules of Debit and Credit

Based on Traditional Classification of Accounts. Based on Modern Classification of Accounts

Type of Account	Debit	Credit	Type of Account	Debit	Credit
Personal A/c	The receiver	The Giver	Assets A/c	Increase	Decrease
Real A/c	What comes in	What goes out	Liabilities A/c	Decrease	Increase
			Capital A/c	Decrease	Increase
Normal A/c	Expenses and Losses	Incomes and Gains	Revenue A/c	Decrease	Increase
			Expenses A/c	Increase	Decrease

- 4) Steps in Journalising
 - Step 1. *Identify the accounts involved in the transaction.*
 - Step 2. *Determine the nature of accounts, e.g., Real, Nominal, Personal (Traditional Approach) or Assets, Liabilities, Capital, Revenue, Expenses (Modern Approach).*
 - Step 3. *Apply the rule of ‘Debit’ and ‘Credit’.*
 - Step 4. *Draw ruling of a journal and record the transactions.*
- 5) Advantages of Journal.
 - (i) It provides a chronological record of transactions.
 - (ii) It reduces the possibility of errors.
 - (iii) It provides an explanation to an entry by way of narration.
- 6) Ledger is a book that contains different accounts relating to **Assets, Liabilities, Capital, Revenue and Expenses.**
- 7) Posting to the ledger is the process of transferring information contained in the journal to the ledger.
- 8) Rules for posting:
 - (i) *Each debit entry in Journal is posted to the debit side of the respective account in ledger. The amount to be entered in that particular account in ledger is the same as appearing in the debit column against that entry in Journal.*
 - (ii) *Each credit entry in Journal is posted to the credit side of the respective account in ledger. The amount to be entered in that particular account in ledger is the same as appearing in the credit column against that entry in Journal.*
- 9) Ledger being the principal book of accounts, a ledger contains all the information regarding various accounts.
- 10) Trial Balance is a statement containing the balances of all ledger accounts at any given date.

11) Objectives of Trial Balance:

- (i) To ensure the arithmetical accuracy of ledger posting.
- (ii) To facilitate preparation of financial statements.

12) Function of Trial Balance:

- (i) It provides a check on accuracy of the posting.
- (ii) It provides a condensed picture of each account in a ledger.

13) Accounting errors may still remain even if the total of the Trial Balance are equal.



Self-check for Learning

1. Classify the following accounts into real, personal and nominal account.

- | | |
|------------------|--------------------------|
| a. Interest | g. Cash |
| b. Drawings | h. DSB publishers |
| c. Capital | i. BDBL |
| d. Bank loan | j. Outstanding Wages |
| e. Sales | k. Commission receivable |
| f. Motor vehicle | l. Discount received |

2. Pass journal entries for the given narration.

Journal entries in the books of.....as at

Date	Particular	L/F	Debit (Nu.)	Credit (Nu.)
1.?.....?..... (Being the business commenced with cash)			
2.?.....?..... (Being the purchased assets on credit)			
3.?.....?..... (Being the purchases of inventories for cash)			
4.?.....?.....?..... (Being the rent and salary paid in cash)			

3. ABC Ltd. has the following balances in the beginning of the accounting year 2019.

Cash in hand	Nu. 20,000
Cash at bank	Nu. 30,000
Land	Nu. 250,000

Furniture	Nu. 100,000
Account payable	Nu. 50,000
Salary	Nu. 15,000
Purchases	Nu. 120,000
Capital	Nu. 275,000
Sales	Nu. 200,000
Account receivable	Nu. 40,000
Bank Loan	Nu. 50,000

Draft a Trial Balance from the above information.

4. What do the following entries mean?

Journal entries in the books of.....as at

Date	Particular	L/F	Debit (Nu.)	Credit (Nu.)
1	Drawings a/c To Cash a/c (.....?.....)	Dr	1,000	1,000
2	Rent a/c To Outstanding rent a/c (.....?.....)	Dr	500	500
3.	Accrued rent a/c To rent a/c (.....?.....)	Dr	300	300
4	Depreciation a/c To machinery a/c (.....?.....)	Dr	250	250
5	Advertisement a/c To purchases a/c (.....?.....)	Dr	150	150

5. On which side will the increase in the following accounts be recorded? Also mention the nature of account on the basis of Modern Approach.

- | | |
|----------------------|-----------------------------|
| i. Machinery account | v. Receivables account |
| ii. Payables account | vi. Sale account |
| iii. Cash account | vii. Rent account |
| iv. Capital account | viii. Rent received account |

3.3. REVENUE RECOGNITION

Learning Objectives



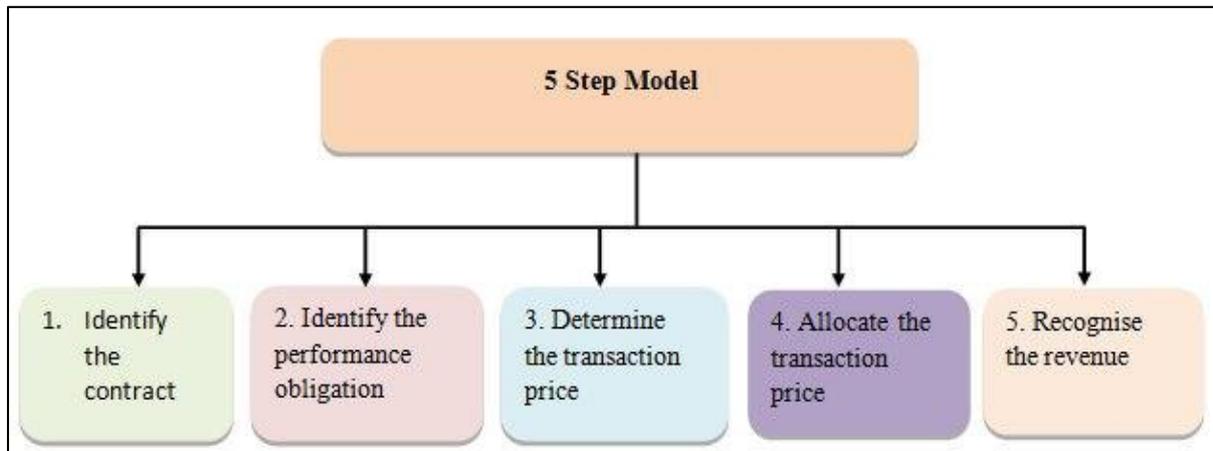
- Explain the meaning of revenue.
- Explain the meaning of contract.
- Identify the performance obligation.
- Record revenue in the books of accounts.

Introduction

Revenue is one main elements of financial statement and it is a very important component in financial reporting. The five elements of financial statement were discussed in our previous lesson. This five-step model applies to revenue earned from a contract with a customer with limited exceptions, regardless of the type of revenue transaction or the industry. We are also not going to touch on contract modification this time.

Organisation of the text

The diagram highlights the layout of the revenue standard and the corresponding sections in the notes on revenue recognition. Each section provides an overview, the requirements of the standard, examples illustrating basic scenarios in the business.



Revenue refers to the income earned from the **principal revenue producing activities**, also known as operating activities of the enterprise. Examples are net sale of goods and services, trading commission, etc. For a financing company, interest earned, dividend, service charges for arranging loans, etc. However, we will try to learn with examples to recognize anything as revenue. We will use 5 step model to learn this topic.

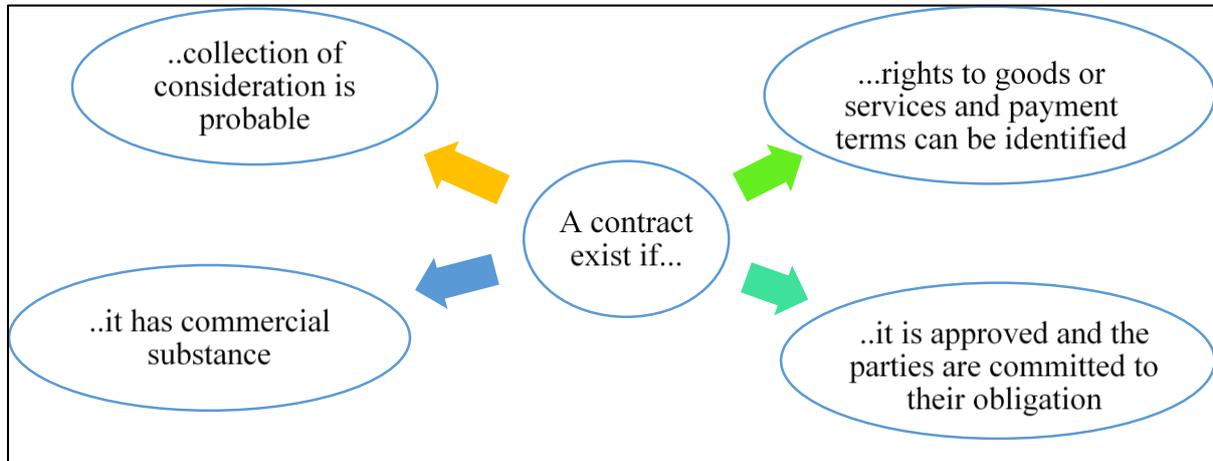
Note: This 5-step model is deliberately condensed to classes XI and XII level for Bhutan.

Step 1- Identify the contract with a customer

- Criteria to determine whether a contract exists

The standard defines a ‘contract’ as an agreement between two or more parties that creates enforceable rights and obligations and specifies that enforceability is a matter of law. Contracts can be written, oral or implied by an entity’s customary business practices.

A contract with a customer is in the scope of the standard when it is legally enforceable and meets all of the following criteria.



“Mr. Dawa (from Thimphu) and Mr. Tashi (from Kalikhola) has been doing business for many years. On 3rd May 2020 Mr. Dawa called Mr. Tashi over the phone to send him 500kgs of green chillies from Kalikhola. Mr. Tashi agreed to send the same on 5th May 2020 via Bumpa Transport. Both of them fixed price at Nu. 160/kg and Mr. Dawa will pay through online banking once the chillies are delivered to him. As agreed, chillies are received by Mr. Dawa on 5th May 2020 and made the payment on the same day to Mr. Tashi’s bank account via Mbob.”

If you study above business case carefully you can find all the elements of valid contract.

- Collection of consideration is probable: consideration is Nu 160/kg and is collectable on 5th May 2020 on delivery of chillies.
- Rights to goods or services and payment terms can be identified: Chillies ownership will pass to Mr. Dawa when chillies get delivered to him on 5th May 2020. The right to get payment by Tashi arises once the chillies get delivered to Mr. Dawa. So, second criterion is clearly met here.
- It is approved and the parties are committed to their obligation: Mr. Dawa agreed to pay Nu. 160/kg and Mr. Tashi agreed to send 500kgs of chillies to Mr. Dawa. So, both the parties agreed and promised to fulfil the obligation. Thus, we can say they are committed willingly to the contract.
- It has commercial substance: the agreement or contract is to sell and buy chillies, it is commercial in nature. It is not a donation or free supply. So, this criterion is also met.

In short, we can conclude the above contract is a valid contract.



ACTIVITY 1

Study the case study given below and comment on it, if it can be considered as valid contract. “Galing Enterprise is in medical supplies business. It also sells bear’s bile to its high-end customers. Yoezer Thinley, one of its daily customer advanced Nu. 500,000 to send him few grams of the bear’s bile. However, Galing Enterprise did not get their supplies from their suppliers and failed to deliver to Mr. Yoezer Thinley.”

(hint: It is illegal, so it is not a valid contract, but solve it in sequence like demonstrated in the previous case)



ACTIVITY 2

“On 26th March 2020, Karma Tshongkhang and Mr. Pema had a conversation over the phone to supply 25 nos. of HP laptop (head phone as free gift) to Mr. Pema on or before 2nd April 2020. Both the parties agreed to the contract.”

Is this a valid contract?

Step 2 - Identify the performance obligation

Step two requires the identification of the separate performance obligations in the contract. This is often referred to as ‘unbundling’, and is done at the beginning of a contract. The key factor in identifying a separate performance obligation is the distinctiveness of the good or service, or a bundle of goods or services. A good or service is distinct if the customer can benefit from the good or service on its own or together with other readily available resources and is separately identifiable from other elements of the contract. In short, we should identify what should be done by each party to the contract.

Let’s use the same case;

“Mr. Dawa (Thimphu) and Mr. Tashi (Kalikhola) has been doing business for many years. On 3rd May 2020 Mr. Dawa called Mr. Tashi over the phone to send him 500kgs of green chillies from Kalikhola. Mr. Tashi agreed to send the same on 5th May 2020 via Bumpa Transport. Both of them fixed price at Nu. 160/kg and Mr. Dawa will pay through online banking once the chillies are delivered to him. As agreed, chillies are received by Mr. Dawa on 5th May 2020 and made the payment on the same day to Mr. Tashi’s bank account via Mbob.”

Mr. Dawa and Mr. Tashi are two parties to the contract. Their performance obligation is identified.

Name of the parties	Performance obligation
Mr. Dawa	Receive 500 kgs of chillies and pay Nu 160/kg to Mr. Tashi on 5 th May 2020
Mr. Tashi	Collect 500kgs of chillies and send to Mr. Dawa on 5 th May 2020 without fail.



ACTIVITY 3

Second step says that we should segregate performance of every party in the contract. In the case study, the identified performance obligation of Mr. Dawa is to receive 500 kgs of chillies and pay to Mr. Tashi @ Nu. 160/kg, while performance obligation of Mr. Tashi is to send 500kgs of chillies on 5th May 2020 to Mr. Dawa.

Study the case study given below and identify the performance obligation of the parties involved.

“On 26th March 2020, Karma Tshongkhang and Mr. Pema had a conversation over the phone to supply 25 nos. of HP laptop (head phone as free gift) to Mr. Pema on or before 2nd April 2020. Both the parties agreed to the contract. Hp laptop cost Nu. 43,000 each and headphone cost Nu. 380 each. However, Karma Tshongkhang agreed to give at Nu. 43000 and free headphone each for every laptop.”

Step 3. Determine the transaction price (TP)

In this step, the transaction price of the contract needs to be determined. Transaction price is the amount of consideration that an entity expects to be entitled for fulfilling the performance obligation. This amount excludes amounts collected on behalf of the third party, for example, government taxes.

In the example above, the transaction price to be received by Mr. Tashi is Nu. 160/kg for 500 kgs of chillies delivered to Mr. Dawa. The total transaction price will be Nu. 80,000 (160X500). This transaction price should be agreed upon by both the parties from the inception of the contract.



ACTIVITY 4

Study the case below and identify the transaction price.

“On 26th March 2020, Karma Tshongkhang and Mr. Pema had a conversation over the phone to supply 25 nos. of HP laptop (head phone as free gift) to Mr. Pema on or before 2nd April 2020. Both the parties agreed to the contract. Hp laptop cost Nu. 43,000 each and headphone cost Nu. 380 each. However, Karma Tshongkhang agreed to give at Nu. 43000 and free headphone each for every laptop.”

Step 4. Allocate the transaction price (TP) in the contract

In business contracts there can be lots of performance obligation in a single contract. Therefore, the transaction price needs to be segregated and allocated separately. The allocation of the transaction price is done on the basis of performance obligation. Allot transaction price to the separate performance obligations. The allocation is based on the relative standalone selling prices of the goods or services promised and is made at inception

of the contract. It is not adjusted to reflect subsequent changes in the standalone selling prices of those goods or services.

Here we are completely ignoring the following cases;

- warranties
- rights of return
- principal-versus-agent considerations
- breakage

These will be learned in the higher studies.

In our example, the transaction price is single and it is covered in Nu. 160/kg. However, Mr. Tashi has to pay transportation charges of the Bumpa Transport for sending his chillies to Thimphu.



ACTIVITY 5

Allot the transaction price.

“On 26th March 2020, Karma Tshongkhang and Mr. Pema had a conversation over the phone to supply 25 nos. of HP laptop (head phone as free gift) to Mr. Pema on or before 2nd April 2020. Both the parties agreed to the contract. Hp laptop cost Nu. 43,000 each and headphone cost Nu. 380 each. However, Karma Tshongkhang agreed to give at Nu. 43000 and free headphone each for every laptop.”

Step 5. Recognize revenue when (or as) the entity satisfies a performance obligation

The final step is to recognise revenue and book under revenue in the books of accounts of the entity. Before booking the revenue, we must ensure that the performance obligation is fulfilled by the entity irrespective of whether the performance obligation from customers side if fulfilled or not.

In the case of chilli business between Mr. Dawa and Mr. Tashi, Mr. Tashi may recognise Nu.80,000 as revenue as soon as the chillies received confirmation is given by Mr. Dawa. So, in Mr. Tashi’s books of account the revenue will be reported as follows;

Cash A/C	Dr. Nu. 80,000	
To Sales Revenue A/C		Nu. 80,000
(Being goods sold on cash)		



ACTIVITY 6

From the case below, recognise revenue and report in the books of Karma Tshongkhang.

“On 26th March 2020, Karma Tshongkhang and Mr. Pema had a conversation over the phone to supply 25 nos. of HP laptop (head phone as free gift) to Mr. Pema on or before 2nd April

2020. Both the parties agreed to the contract. Hp laptop cost Nu. 43,000 each and headphone cost Nu. 380 each. However, Karma Tshongkhang agreed to give at Nu. 43000 and free headphone each for every laptop.”

(Hint: Revenue 25 Laptop X Nu 43,000 = Nu. 1, 075, 00)



Summary

- Revenue refers to the income earned from the operating activities of the enterprise.
- To recognize revenue we use 5 step model:
 - i) Identify the contract.
 - ii) Identify the performance obligation.
 - iii) Determine the transaction price.
 - iv) Allocate the transaction price.
 - v) Recognise the revenue.



Self-check for Learning

Write answers to the following questions.

- a. What is Revenue?
- b. What is meant by commercial substance in a business contract?
- c. Not all the business contracts are legal. Justify?
- d. Whose performance obligation is more important to recognise revenue?
- e. Why there is need to allot transaction price?

3.4. ACCOUNTING PROPERTY, PLANTS AND EQUIPMENT

Learning Objectives



- Explain the meaning of PPE.
- State the recognition criteria of PPE.
- Measure PPE.
- Report PPE in the books of accounts.

Introduction

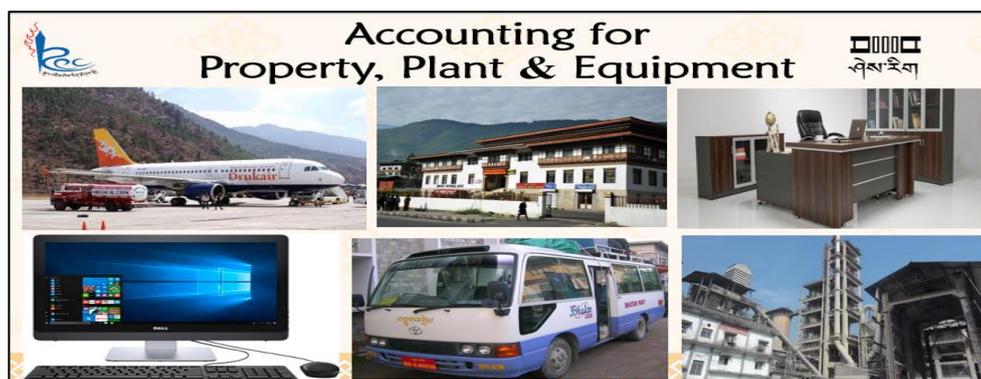
Business entity mobilises different kinds of assets for carrying out business. No organisation can function without physical assets. The assets are termed as Property, Plant and Equipment PPE or tangible assets. There are also other categories of assets such as intangible assets and inventories. However, the lesson is designed only on Property, Plant and Equipment.

In a broader sense, assets are those economic resources owned and controlled by the business entity as a result of past events and has future economic inflows or benefit after putting those into use.

Property, Plant and Equipment PPE

Property, Plant and equipment PPE refers to tangible assets that are held for use in the production or supply of good or services, for rental to others, or for administrative purposes, and are expected to be used in more than one accounting period. The long-term use is what distinguishes PPE from office supplies or inventories. Accounting for PPE has become so important as it constitute major portion of the business in general. For example Druk Green Power Corporation (DGPC) has about 79 % of its assets in the form PP&E.

For example, Chhukha Hydro Power Plant colony has many buildings which are reported as PPE in the books of DGPC. Bhutanese Accounting Standard 16 (BAS 16) presents definition, recognition, measurement, presentation and disclosure of PPE. However, Yangphel Real Estate business constructs buildings with intention of selling it after completion, will be reported as inventories which is covered under BAS 2. The standard defines, recognises, measures, presents and discloses information on inventories. Although the business many have similar assets, it is reported differently based on the nature of business. Therefore not all buildings are PPE and different accounting standards are applied to define, recognise, measure and disclose depending upon the nature of business.



Why account for PPE?

Accounting for PPE is important because:

- Incorrect accounting and reporting of PPE will not only mislead information users but also affect operations of business for investing and financing decisions
- Property, plant and equipment as an asset generate cash flows and income for the business. Therefore, any missing information about it will affect the accounting information users.

Let's learn about Plant of a cement factory. You can see some building like structure in the picture. It is a cement factory plant in Bhutan. This plant is reported as PPE in the books of Dungsam Cement Corporation limited.

Is it reported correctly? Is it owned and controlled by Dungsam Cement Corporation ltd? Yes, it is controlled and owned by Dungsam Cement Company as the plant is registered under the Dungsam Cement Corporation ltd.'s name. It controls the plant because, Board of Directors and CEO of the company decides what should be done with this plant. Therefore the two recognition criteria are fulfilled.

Is it a result of past event?

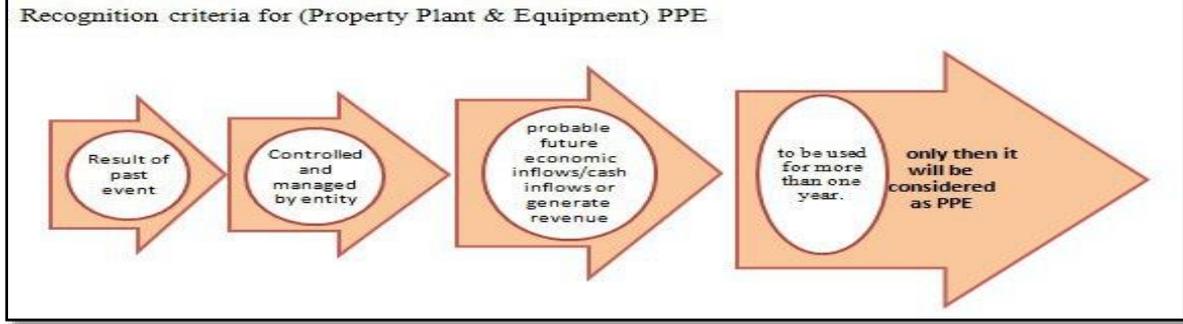
It is a result of past event because, Dungsam Cement Company has purchase the land first, then constructed all those structures. The company has incurred huge expenses to bring up such a massive plant. Thus, it is a result of past event.

Will this plant bring future economic benefits to the company?

This structure will bring in inflow of cash or economic benefit (revenue or cash) to the company. All the cements are produced in this factory and huge amounts of revenue are generated through this plant. In fact, this plant is the main income generator for Dungsam Cement Corporation ltd. It is their operating activity.

Therefore, the factory plant is reported as PPE because, it is an asset owned and controlled by the company. It is the result of construction by themselves (past event) and it is probable that there will be future economic inflows to the company.





Some examples of PPEs and its function in the business.

Categorization of PP&E

Property

Supply of goods and services

Administrative Purpose

Plant

Production of goods

Equipment

Administrative Purpose

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Now we know how assets are defined and classified as PP&E. The next step is to recognize it and book it under PP&E. So, let's explore some recognition criteria for PP&E.

Recognition: The cost of PPE shall only be recognized as an asset if it is probable that future economic benefits associated with the asset will flow to the entity and that the cost of the item can be measured reliably.

Note: Property, plant and equipment does not include:

- a. Biological assets related to agricultural activity (see Section 34 Specialised Activities), or
- b. Mineral rights and mineral reserves, such as oil, natural gas and similar non-regenerative resources.

Recognition Criteria of PP&E

The item of PP&E can be recognized (recorded) in the books if-

- 1) It is probable that *future economic benefits* associated with the item will flow to the entity; and
- 2) the *cost* of the item can be measured reliably

Direct or Indirect

Initial Cost

Subsequent Cost

Let us study the following case study and try to figure out what are the direct and indirect cost? Find out how much is the initial cost and subsequent cost?

Illustration I

Kunzang from Dagapela was waiting to establish a rice mill in his village for many years. In May 2019, he decided to purchase rice mill from his lifelong savings. He contacted a supplier in Phuntsholing and came to know the price of the rice mill is Nu. 45,000 without transport charges. He then contacted Farm Machinery Centre at Paro. He negotiated with Paro FMC and fixed price at Nu. 35,600 with additional cost of Nu. 3,500 as transportation charge till Kunzang's house.



Paro FMC agreed to send machinery by themselves on the agreed terms and conditions. Kunzang paid all the amount using mobile banking system. The machinery was received on 1st April 2019. The cost of machine at this point of time is Nu.39,100 (35600+3500). Nu. 35,600 is cost of machine and Nu. 3500 is direct cost on transportation without which the machinery cannot reach to Kunznag's place. So, this type of cost is capitalized in the initial stage.



Now Kunzang is so excited and he cannot wait for installing this machine. He has incurred an additional cost of Nu. 8,900 as an installation charges to the labours for four working days. He was so glad and called his neighbours for free testing of milling rice. Three neighbours



bought 50 kgs each and milled their rice. It was performing so smooth and got excellent finishing. While three neighbours were very happy with the free service, Kunzang was very proud with the positive feedback received.

Kunzang added the cost of installation of the machine to the cost of machine i.e. Nu. 8,900 to 39,100 and disclosed total cost of machine as Nu. 48,000. Now the total cost of machine consist of initial cost and the subsequent cost.

Initial measurement: PPE is initially recorded at cost. In addition to the purchase price, the cost of the PPE includes any costs directly attributable in bringing the asset to the location and conditions necessary for its intended use. Costs such as import duties, delivery, installation and site preparation are included in the cost of the asset. Costs related to general overhead allocation and refundable taxes (GST) are excluded from the cost base.

All items of PPE should **initially** be measured at 'cost'. Initial cost comprises of the following:

- The cost of purchase, including any import duties and non-refundable sales taxes, after deducting net of any trade discounts.
- Any costs directly attributable to bringing the asset to the location and condition necessary for it to be capable of operating.
- Finance cost such as interest on construction loans.
- Estimated removal cost.

Let's reflect back on how Kunzang recorded his expenses on purchase of rice mill? The cost of machine is Nu.35,600 and transportation charge is Nu. 3,500. He also incurred expenses of Nu. 8,900 for installation. He cannot do away with any of these expenses to make his machine workable. These costs are unavoidable. It means if he does not pay installation charge of Nu. 8,900, machine will simply be left idle. He did not pay any tax as these products are not levied tax by the government. Since he did not borrow money for the purchase of machine, there is no need to account borrowing cost. It is fully financed by himself. There is no debt equity for him.

If we thoroughly analyse the case of Kunzang, the directly attributable cost constitutes of the following:

- Employee benefits payable to staff for installing, constructing, or initially testing the asset.
- Site preparation.
- Professional fees directly associated with construction, such as architect or consultant fees.
- Any other overhead costs directly associated with assembly cost.

SELF-INSTRUCTIONAL MATERIAL

Mr. Kunzang has used this method and added to the cost of machine. Which means cost is being capitalized.

Let us take another example;

For self-constructed assets (such as building of a warehouse), the costs are determined using the same principles as for acquired assets. Certain borrowing costs, such as interest, can be capitalized under certain circumstances until the asset is ready for its intended use.

Illustration II

Tharchen from Trongsa has been doing lots of research on Interlocking Bricks and its benefits in construction sector. There was positive recommendation from engineering side as it has good quality and other benefits. The machine can produce bricks from clay and stone dust (powder). Government has already recommended construction companies to use such bricks. He wanted to be the first person to establish such machine in Bhutan. The machine is costing Nu.

500,000 without taking into account of the other charges and government taxes.

He inquired everywhere and finally decided to buy at Nu. 500,000. Transportation from India via Gelephu to Trongsa is agreed at Nu. 30,000 with the logistic company. He paid 10 % customs duty to RRCO Gelephu, when the machine entered Bhutan. Since he had savings of only Nu. 360,000, he had to take loan of Nu. 500,000 from Bhutan Development Bank Ltd at 9.35% interest per annum on 1st January 2017. He was able to get the machine only by the mid of March 2017. He spends 3 months to prepare site for installation of machine. His expenses on site preparation came to Nu 165,000.

On 1st June 2019 he tested the machine and produced 200 bricks for checking the function of the machine and the bricks quality. The machine was perfect and the bricks manufactured was of high quality. Even the government had issued him with Quality Standard Certificate.

It was almost 1st July when he started doing commercial production. In the first six months of commercial production, he manufactured about 400,000 units of



bricks and sold at Nu. 23 per brick. Company has gained lots of reputation and demand in the market has increased 5 times more than the 1st half year of 2017. There were demand for 4 million bricks in 2018. Company has recruited more labours and started producing 24 hours a day for 6 days in a week. Sunday was left for minor repairs of the machine. The company did not fail to meet the demand in the market in 2018.

Self-assessment for the Value of Machine

Initial cost in year 2017

- Purchase price or invoice price – Nu. 500,000
- Government Tax – 10% of 500,000- Nu. 50,000
- Transportation charge/freight inward- Nu. 35,000
- Site preparation and machine installation cost – Nu. 165,000
- Interest on Nu. 500,000 till the date of commercial production – $9.35\% \times 500,000 \times \frac{6}{12} = 23,375$ (he paid interest for 6 months i.e. Jan, Feb, Mar, Apr, May, June 2017)
- The cost of Bricks manufacturing machine – Nu. 773,375
- So, the initial cost of machine is Nu. 773,375.

Journal entry in his books of accounts will be:

PPE account	Debit - Nu. 773,375		
	To Cash account	Credit -	Nu. 773,375
	(Being machine purchase on cash)		

Now at the end of 2018, the machine was severely damaged. Without the major repair the machine won't operate. The repair cost him Nu. 145,000. The cost of the machine needs to be either expense or capitalised based on ability to increase life of the machine or going to generate revenue in the future. Therefore, this expense needs to be capitalized and the repair has extended its useful life as revenue generating capacity of the machine. To reconsider the value of the machine at the beginning of 2019, it can be done either through Cost model or Revaluation model.

Subsequent measurement (PPE) — Replacement versus repairs - The day-to-day costs of maintaining an asset (such as an oil change, battery replacement or minor maintenance on a machines) are considered repairs and maintenance expenditures and should be expensed. Expenditures that are more significant, such as a new engine in a machine are capitalized. Often professional judgment must be exercised to determine the appropriate classification of these costs.

Subsequent measurement (PPE) — Cost and revaluation models PPE can be subsequently measured using either the cost or the revaluation model, and the chosen model must be applied to an entire class of assets. The cost model is most commonly used and measures the asset at its original cost, less accumulated depreciation and any accumulated impairment losses.

The revaluation model is not widespread; it is used when there are significant differences between the fair value and cost of the assets (common in the real estate industry, such as land). This model can only be used if the fair value can be reliably measured, and assets must be revalued regularly to ensure the carrying amount does not differ materially from its fair value.

Did you know?

Property, plant and equipment also excludes assets held for sale in the ordinary course of business, assets in the process of production for such sale, and assets in the form of materials or supplies to be consumed in the production process or in the rendering of services. Such assets are inventories (see Section 13 Inventories). Intangible assets are also not items of property, plant and equipment. They are accounted for in accordance with Section 18 Intangible Assets other than Goodwill.

Let's calculate the value of interlock bricks machine at the beginning of 2019 using cost model.

- Cost of machine @ 1st July 2017 = 773,375
- The depreciation rate is 10% p.a. depreciation till 31st Dec. 2018.
- 1st year 2017 (for 6 months) = $773,375 \times 10\% = 77337.5 \times 6/12 = 38,668.75$
- 2nd year 2018 (12 months) = $773375 \times 10\% = 77,337.5$
- The value of machine at 1st Jan 2019 = $773,375 - (38,668.75 + 77,337.5) = 657,368.75$
- (we used straight line method of depreciation) [assumption – no impairment loss till date]
- The machine had a major repairs costing Nu. 145,000
- This need to be added to the carrying value of asset = $657,368.75 + 145,000 = \text{Nu. } 802,368.75$
- After subsequent measurement of the interlock bricks machine, its value is now shown @ Nu. 802,368.75.

This is how the subsequent measurement is done.

Bundled Purchases

When a company acquires a group (or bundle) of assets in a single transaction, and the purchase price of each item is not detailed, the purchasing company must allocate the purchase price to the specific assets. The allocation is typically made based on the estimated relative fair value of the component parts. For example, if Nu. 100,000 was paid for two pieces of equipment with estimated fair values of Nu. 48,000 and Nu. 60,000, respectively, the costs allocated to the two pieces of equipment would be Nu. 44,444 [$(\text{Nu. } 48,000 / \text{Nu. } 108,000) \times \text{Nu. } 100,000$] for the first, and Nu. 55,556 [$(\text{Nu. } 60,000 / \text{Nu. } 108,000) \times \text{Nu. } 100,000$] for the second.

Illustration III

During 2018, Yoyo Corp. installed a production assembly line to manufacture furniture. In 2019, Yoyo purchased a new machine and rearranged the assembly line to install this machine. The rearrangement did not increase the estimated useful life of the assembly line, but it did result in significantly more efficient production. The following expenditures were incurred in connection with this project:

Machine Nu.750, 000, Import duties Nu. 50,000, Labour to install machine Nu. 140,000 Parts added in rearranging existing assembly line Nu. 400,000, Labour and overhead to rearrange the assembly line Nu. 180,000, General overhead allocation Nu. 35,000.

Required:

How much of the above expenditures related to the production assembly line asset should be capitalized in 2019?

Solution

The general overhead allocation costs should not be included in the cost base. All other expenditures are considered necessary costs to prepare the asset for its intended use (and therefore can be capitalized). The amount that can be capitalized is as follows: Nu. 750,000 + 50,000 + 140,000 + 400,000 + 180,000 = Nu. 1,520,000.

Nu. 1,520,000 should be capitalized.

Illustration IV

River Lodge Ltd. acquired vacant land for Nu. 750,000 on January 1, 2013. The land was revalued to Nu. 840,000 on December 31, 2015. Due to an economic downturn in the city, by December 31, 2016, the land was valued at Nu. 690,000.

Required:

Describe how River Lodge Ltd. would account for the changes in value for the land. Assume River Lodge Ltd. uses the revaluation model.

Solution

River Lodge Ltd. would allocate Nu. 90,000 as a credit to OCI for revaluation surplus because the fair value has increased, with a corresponding debit to the land account. The value of the land would be the fair value, Nu. 840,000.

At the end of December 31, 2016, the fair value has decreased by Nu. 150,000 since December 31, 2015. This is the amount by which the asset is impaired at the end of 2016. This decrease should be accounted for as follows: a debit of Nu. 90,000 to OCI to eliminate the surplus recorded in the previous year, and a debit to profit and loss for the remaining Nu. 60,000, with a Nu. 150,000 credit to the land account. The value of the land would be the fair value, Nu. 690,000



ACTIVITY 1

On 1st January 2001, an entity purchased an item of equipment for Nu. 600,000 including Nu. 50,000 refundable purchase taxes. The purchase price was funded by raising loan of Nu. 605,000 (including Nu. 5,000 loan raising fees). The loan is secured against the equipment. In January 2001, the entity incurred costs of Nu. 20,000 in transporting the equipment to the entity’s site and Nu. 100,000 in installing the equipment at the site. The entity was required to dismantle the equipment after 10 years of its useful life and restore the land for construction of factory building. The present value of the cost of dismantling the equipment and restoring the environment is estimated to be Nu. 100,000. In January 2001 the entity’s engineer incurred the following costs in modifying the equipment so that it can produce the products manufactured by the entity:

- Material – Nu. 55,000
- Labour – Nu. 65,000.
- Depreciation of plant and equipment used to perform the modifications – Nu. 15,000.

In January 2001 the entity’s production staff were trained in how to operate the new item of equipment. Training costs included:

- Cost of an expert external instructor – Nu. 7,000.
- Labour –Nu. 3,000.

In February 2001 the entity’s production team tested the equipment and the engineering team made further modifications necessary to get the equipment to function as intended by management. The following costs were incurred in the testing phase:

- Material, net of Nu. 3,000 recovered from the sale of the scrapped output – Nu. 21,000
- Labour – Nu. 11,000.
- Depreciation of plant and equipment used to perform the modifications – Nu. 5,000

The equipment was ready for use on 1 March 2001. However, because of low initial order levels the entity incurred a loss of Nu.23,000 on operating the equipment during March. Thereafter the equipment operated profitably. What is the cost of the equipment at initial recognition?

Solution

<i>Description</i>	<i>Calculation or reason</i>	<i>Nu.</i>
Purchase price	600,000 purchase price less 50,000 refundable purchase taxes	550,000
Loan raising fee	Included in the measurement of the liability	-
Transport cost	Directly attributable expenditure	20,000
Installation costs	Directly attributable expenditure	100,000

Environmental restoration costs	The obligation to dismantle and restore the environment arose from the installation of the equipment	100,000
Preparation costs	material 55,000 + labour 65,000 + depreciation 15,000	135,000
Training costs	Recognised as expenses in profit or loss. The equipment was capable of operating in the manner intended by management without incurring the training costs.	-
Cost of testing	21,000 material (i.e. net of the 3,000 recovered from the sale of the scrapped output) + 11,000 labour + 5,000 depreciation	37,000
Operating loss	Recognised as expenses in Statement of Income	-
Borrowing costs	Recognised as expenses in Statement of Income	-
Cost of equipment		942,000



ACTIVITY 2

On 1st January 2019 an entity acquired a plant for Nu. 500,000. The management estimates the useful life of the plant as five years measured from the date of acquisition. Furthermore, it estimates the residual value of the plant as Nu. 100,000. Management judges that the straight-line method reflects the pattern in which it expects to consume the plant's future economic benefits. At 31st December 2019 the plant was damaged and its recoverable amount was estimated as Nu. 300,000. What is the carrying amount of the plant on 31st December 2019?

Description	Calculation or reason	Nu.
Cost	Purchase price	500,000
Residual Value	Estimated by management	(100,000)
Depreciable Amount	Cost less residual value	400,000
Depreciation per year	400,000 depreciable amount/ 5 years useful life	80,000
Carrying amount before impairment	500,000 cost less 80,000 accumulated depreciation	420,000
Impairment	Carrying amount before impairment (420,000) less fair value costs to sell (300,000)	(120,000)
Carrying Amount	Impaired to fair value less costs to sell	300,000



Summary

PP&Es are resources that have;

- physical substance (a definite size and shape),
- are used in the operations of a business,
- are not intended for sale to customers,
- are expected to provide service to the company for a number of years, except for land.

Note: Here we are not talking about the assets on lease.



Self-check for Learning

Answer the questions in your notebook.

1. Which of the following items qualifies as property, plant and equipment?
 - A. Computer software bought for use in more than one accounting period.
 - B. A machine bought for use during a single accounting period.
 - C. A machine bought for use in more than one accounting period.
 - D. A machine bought for resale to a customer.
2. The "carrying amount" of an item of property, plant and equipment generally refers to:
 - A. The cost of the item.
 - B. The amount at which the item is recognised in the financial statements.
 - C. The depreciable amount of the item.
 - D. The replacement cost of the item.
3. A company pays Nu. 40,000 to replace a major component of a factory machine. The faulty component that is replaced is sold for Nu. 2,000. The carrying amount of the machine just before this replacement occurs is Nu. 450,000, of which Nu. 10,000 relates to the faulty component that is being replaced. The revised carrying amount of the machine after the replacement occurs and the profit or loss on disposal of the faulty component are:
 - A. Carrying amount Nu. 480,000, Loss Nu.10,000
 - B. Carrying amount Nu. 490,000, Profit Nu. 2,000
 - C. Carrying amount Nu. 490,000, Loss Nu. 8,000
 - D. Carrying amount Nu. 480,000, Loss Nu. 8,000
4. Which of the following would not be included in the cost of an item of property, plant and equipment?
 - A. Testing costs.
 - B. Site preparation costs.
 - C. Delivery and installation charges.
 - D. Refundable value added tax.
5. Borrowing costs that are directly attributable to the acquisition of a qualifying asset must be capitalised as part of the cost of that asset. True or False?
 - A. True
 - B. False

3.5. ACCOUNTING EQUATION AND FINANCIAL STATEMENT

Learning Objectives



- State the meaning of accounting equation.
- Appreciate the important of accounting equation.
- Relate the double entry concepts in computing accounting equation.
- Know to establish that assets are equal to liabilities and capital.
- Prepare accounting equation from given transactions.
- Mind map on how the financial statements are prepared from accounting equation information.

Introduction

In the previous lesson, you have learned about assumptions and conventions and the various basic accounting terms like Assets, Liabilities, Capital (owner's equity), Expenses and Revenue. In this lesson you will learn about accounting equation.

In order to have a clear picture of accounting equation, let us revisit one of the important concepts, Dual Aspect Concept. According to dual aspect concept, every transaction affects the business in two ways by the same amount. Suppose, Mr. Karma starts a business with a capital of Nu.800,000 there are two aspects of the transaction. On one hand, the business has assets of Nu. 800,000 in the form of cash (resource), while on the other hand, the business has to pay to the proprietor a sum of Nu. 800,000 as the resource was supplied by the proprietor.

This expression can be shown in form of following equation,

Assets (cash)	=	Capital (owner's equity)
Nu.800,000	=	Nu. 800,000

In the example given here, if the business borrow Nu. 50,000 from bank, the new situation will be as follows:

Assets (cash)	=	Capital (owner's equity)	+	Liability
Nu. 850,000	=	Nu. 800,000	+	Nu 50,000

Explanation: Resource of the business in the form of cash further increased by Nu. 50,000, the amount payable to Bank (liability) also increased as the resources is provided by bank. Whenever an asset is introduced in the business, a corresponding liability also emerges. A business does not have any amount of its own. Hence, we can say that

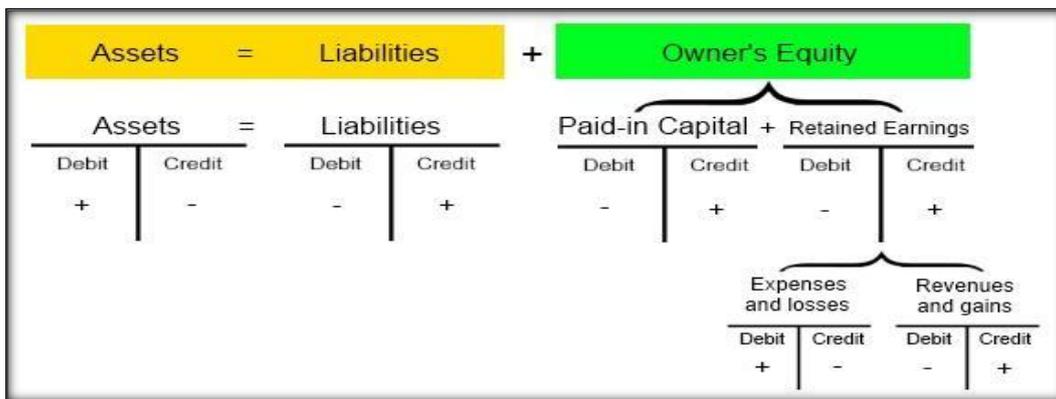
Business owns Nothing, And Owes Nothing, What it Owns, It Owes.

From the above relationship we can conclude that, An Accounting Equation is used to denote the relationship of assets with equities (owner’s equity) and outsider’s equity (liability). As a matter of fact, the entire system of double entry book keeping is based on this concept.

What is Meaning of Accounting Equation?

Accounting equation describes that the total value of assets of a business is always equal to its liabilities plus owner’s equity. This equation is the foundation of modern double entry system of accounting being used by small proprietors to large multinational corporations.

Diagram below represents accounting equation in detail.



Now let us study the effect of business transactions on Accounting Equation step-by-step and see how business transactions affects the Financial Position of the business with the help of 11 transactions given below.

Transaction 1. Commencement of business

Suppose Miss Tara starts a new business under the name “Smart Tara Stores” on 1st January 2020 by putting in Nu. 200,000. The effect of this transaction is two-fold:

First, a new asset, cash, is acquired: and

Second, a new liability to Tara (in the form of capital) is incurred.

It can be put in the Accounting Equation as below:

Assets =	Liabilities +	Owner’s equity
Cash Nu. 200,000	Nil	Capital Nu.200,000

Items that would appear in financial position (Balance sheet) of Smart Tara Stores as on January 1, 2020

Particular	Amount (Nu.)
Assets:	
Cash	200,000
Total	200,000
Liabilities:	
Pema’s Capital	200,000
Total	200,000

Since assets will always equal claims, the two sides of the Accounting Equation will always be equal. Every business transaction affects the Accounting Equation in such a way that the net effect on two sides of the equation is the same.

Transaction 2. Purchase of an asset for cash.

On 3rd January, the Smart Tara Store purchases furniture for cash Nu.20,000.

The effect of this transaction is two-fold:

First, cash is decreased by the amount paid out, i.e Nu. 20,000; and

Second, a new asset, furniture, is acquired.

The Accounting Equation:

Assets =	Liabilities +	Owner's equity
Cash Nu. 180,000 (200,000 -20,000) + Furniture Nu. 20,000	Nil	Capital Nu.200,000

i.e Nu. 200,000 = Nu. 200,000

Financial position (Balance sheet) of Smart Tara Stores as on January 3rd, 2020

Particular	Amount (Nu.)
Assets:	
Cash (200,000 – 20,000)	180,000
*PPE (Furniture)	20,000
Total	200,000
Liabilities:	
Tara's Capital	200,000
Total	200,000

* Property Plant and Equipment

Transaction 3. Purchase of an asset and incurring of a liability.

On 5th January 2020, the Smart Tara Store purchases Machinery for Nu.50,000 on credit from Roshna.

The effect of this transaction is two-fold:

First, a new asset, Machinery, is acquired; and

Second, a new liability to Roshna is incurred.

The Accounting Equation:

Assets =	Liabilities +	Owner's equity
Cash Nu. 180,000 + PPE (Furniture) Nu. 20,000 + PPE (Machinery) Nu. 50,000	- <i>Current Liability i.e</i> Roshna's Nu.50,000	Capital Nu.200,000 -

i.e Nu. 250,000 = Nu. 250,000

Financial position (Balance Sheet) of Smart Tara Stores as on January 5, 2020

Particular	Amount (Nu.)
Assets:	
Cash	180,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Total	250,000
Liabilities:	
Tara's Capital	200,000
Roshna's A/c (CL**)	50,000
Total	250,000

** Current Liability

Transaction 4. Payment of liability.

On 10th January 2020 paid Nu. 30,000 to Roshna in part of her account.

The effect of this transaction is two-fold:

First, asset, cash is decreased by Nu.30,000; and

Second, a liability to Roshna decreased by Nu.30,000.

The Accounting Equation:

Assets =	Liabilities +	Owner's equity
Cash (180,000 -30,000) Nu. 150,000 +	-	Capital Nu.200,000
PPE (Furniture) Nu. 20,000 +	-	-
PPE (Machinery) Nu. 50,000	Roshna's Nu. 20,000 (50,000 – 30,000)	-

i.e Nu. 220,000 = Nu. 220,000

Financial position (Balance sheet) of Smart Tara Stores as on January 10, 2020

Particular	Amount (Nu.)
Assets:	
Cash (180,000 -30,000)	150,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Total	220,000
Liabilities:	
Tara's Capital	200,000
Roshna (CL)	20,000
Total	220,000

Transaction 5. Withdrawal of cash for personal use.

On 15th January 2020 Tara (proprietor) withdrew Nu.10,000 for his personal use.

The effect of this transaction is two-fold:

First, asset, cash is increased by Nu.10,000; and

Second, Tara's capital or owner's equity decreased by Nu.10,000.

The Accounting Equation:

Assets =		Liabilities +	Owner's equity
Cash (150,000-10,000) Nu.	140,000 +	-	Capital Nu.190,000
PPE (Furniture) Nu.	20,000 +	-	(200,000 -10,000)
PPE (Machinery) Nu.	50,000	Roshna's Nu. 20,000	-

i.e Nu. 210,000 = Nu. 210,000

Financial position (Balance sheet) of Smart Tara Stores as on January 15, 2020

Particular	Amount (Nu.)
Assets:	
Cash	140,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Total	210,000
Liabilities:	
Tara's Capital (200,000 – 10,000)	190,000
Roshna (CL)	20,000
Total	210,000

Transaction 6. On 20th January 2020 borrowed loan from TBank Nu. 25,000.

The effect of this transaction is two-fold:

First, asset, cash is Increased by Nu.25,000; and

Second, Liability, Bank loan increased by Nu.25,000.

The Accounting Equation:

Assets =		Liabilities +	Owner's equity
Cash (140,000+ 25,000) Nu.	165,000 +	-	Capital
PPE (Furniture) Nu.	20,000 +	-	Nu.190,000
PPE (Machinery) Nu.	50,000	Roshna's Nu.	-
		20,000+	-
		TBank Loan Nu.	
		25,000	

i.e Nu. 235,000 = Nu. 235,000

Financial position (Balance sheet) of Smart Tara Stores as on January 20, 2020

Particular	Amount (Nu.)
Assets:	
Cash (140,000+ 25,000)	165,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Total	235,000
Liabilities:	
Tara's Capital	190,000
Roshna (CL)	20,000
TBank loan (NCL ***)	25,000
Total	235,000

*** Non-Current Liability

Transaction 7. On 21st January 2019 paid Nu.10,000 insurance in advance for the month of February 2019 .

The effect of this transaction is two-fold:

First, asset, cash, is decreased by Nu.10,000; and

Second, asset, prepaid insurance (firm yet to get the benefit) is increased by Nu.10, 000.

The Accounting Equation:

Assets	=	Liabilities +	Owner's equity
Cash (165,000 -10,000) Nu.	155,000 +	-	Capital Nu.190,000
PPE (Furniture) Nu.	20,000 +	-	-
PPE (Machinery) Nu.	50,000 +	Roshna's Nu. 20,000+	-
Prepaid Insurance Nu.	10,000	TBank Loan Nu. 25,000 +	-

i.e Nu. 235,000 = Nu. 235,000

Financial position (Balance sheet) of Smart Tara Stores as on January 21, 2020

Particular	Amount (Nu.)
Assets:	
Cash (165,000 -10,000)	155,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Prepaid Insurance	10,000
Total	235,000
Liabilities:	
Tara's Capital	190,000
Roshna (CL)	20,000
TBank loan (NCL)	25,000
Total	235,000

Transaction 8. On 22nd January 2020 purchased goods for cash Nu.50,000.

The effect of this transaction is two-fold:

First, asset, cash, is decreased by Nu.50,000; and

Second, new asset, stock increased by Nu.50,000.

The Accounting Equation:

Assets =		Liabilities +	Owner's equity
Cash (155,000 -50,000)	Nu. 105,000 +	-	Capital
PPE (Furniture)	Nu. 20,000 +	-	Nu.190,000
PPE (Machinery)	Nu. 50,000 +	Roshna's Nu. 20,000+	-
Prepaid Insurance	Nu. 10,000 +	TBank Loan Nu. 25,000 +	-
Goods	Nu. 50,000		-

i.e Nu. 235,000 = Nu. 235,000

Financial position (Balance sheet) of Smart Tara Stores as on January 22, 2020

Particular	Amount (Nu.)
Assets:	
Cash (155,000 -50,000)	105,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Prepaid Insurance	10,000
Goods	50,000
Total	235,000
Liabilities:	
Tara's Capital	190,000
Roshna (CL)	20,000
TBank loan (NCL)	25,000
Total	235,000

Transaction 9. On 23st January 2020 received Nu.15, 000 as advance payment for repair services to be provided over the next two month.

The effect of this transaction is two-fold:

First, asset, cash, is increased by Nu. 15,000; and

Second, Liability, Unearned Revenue (firm has not provided the service) is increased by Nu. 15, 000.

The Accounting Equation:

Assets =		Liabilities +	Owner's equity
Cash (105,000 +15,000)	Nu. 20,000 +	-	Capital
PPE (Furniture)	Nu. 20,000 +	-	Nu.190,000
PPE (Machinery)	Nu. 50,000 +	Roshna's Nu 20,000+	-
Prepaid Insurance	Nu. 10,000 +	TBank Loan Nu 25,000+	-
Goods	Nu. 50,000	Unearned Revenue 15,000+	-

i.e Nu. 250,000 = Nu. 250,000

Financial position (Balance sheet) of Smart Tara Stores as on January 23, 2020

Particular	Amount (Nu.)
Assets:	
Cash (105,000 +15,000)	120,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Prepaid Insurance	10,000
Goods	50,000
Total	250,000
Liabilities:	
Tara 's Capital	190,000
Roshna (CL)	20,000
TBank loan (NCL)	25,000
Unearned Revenue	15,000
Total	250,000

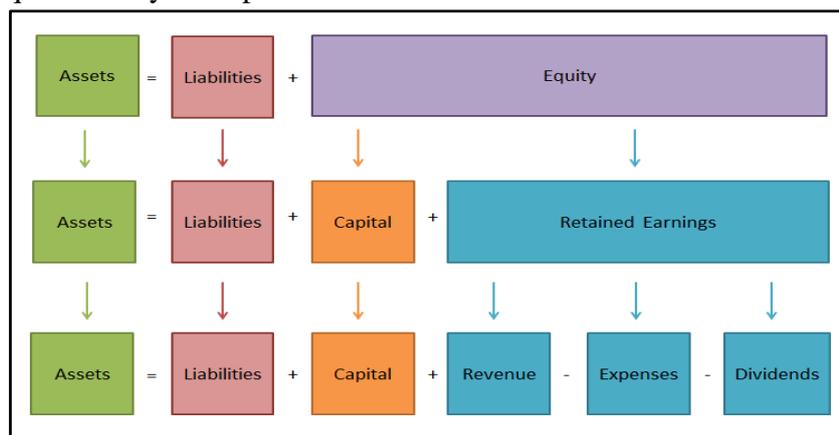
All the above transactions affect one of the fundamental elements of book keeping. The two side of the Balance Sheet, after the above transactions are recorded, remain equal
Expanded Accounting Equation

So for we discussed the Accounting Equation which dealt with increases and decreases in ASSETS, LIABILITIES and CAPITAL. The increase and decrease in CAPITAL take place also through –

Revenue, i.e., income and benefits which results in increase in capital, and

Expenses and losses which results in decrease in Capital.

To show the effect of income and benefits, and expenses and losses on capital, the Accounting Equation may be expanded as follows:



The Application of this Equation is explained below with the help of certain transactions generating income or resulting in a loss.

Transaction 10. On 25st January 2020 paid rent for the month Nu.20,000

The effect of this transaction is two-fold:

First, cash is decreased by Nu. 20,000; and

Second, rent is an expense. It results in a loss, which decreases owner’s Equity or Capital (adjustment done usually with retaining earnings)

The Accounting Equation:

Assets =		Liabilities +	Owner’s equity
Cash (120,000 -20,000)Nu. 100,000 +		Roshna’s Nu 20,000+	
PPE (Furniture) Nu. 20,000 +		TBank Loan 25,000+	Capital Nu.190,000-
PPE (Machinery) Nu. 50,000 +		Unearned Revenue	Rent Nu.20,000=
Prepaid Insurance Nu. 10,000 +		15,000+	Nu.170,000
Goods Nu. 50,000			

i.e Nu. 230,000 = Nu. 230,000

Financial position (Balance sheet) of Smart Stores as on January 25, 2020

Particular	Amount (Nu.)
Assets:	
Cash (120,000 -20,000)	100,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Prepaid Insurance	10,000
Goods	50,000
Total	230,000
Liabilities:	
Tara’s Capital (190,000 – 20,000)	170,000
Roshna (CL)	20,000
TBank loan (NCL)	25,000
Unearned Revenue	15,000
Total	230,000

Transaction 11. On 30th January 2020 the entire lot of goods were sold for Nu. 90,000.

Increase cash by Nu. 90,000; and

Decrease in goods by Nu.50,000 (Cost of goods sold)

The net result is that there is an increase in asset by Nu.40, 000, and also an income of Nu. 40,000 (90,000 sales – 50,000 cost price).

The Accounting Equation:

Assets =		Liabilities +	Owner’s equity
Cash (100000+90000) 190,000 +		Roshna’s Nu. 20,000+	Capital Nu.190,000-
PPE (Furniture) Nu 20,000 +		TBank Loan Nu. 25,000+	Rent Nu.20,000=
PPE (Machinery) Nu 50,000 +		Unearned Revenue 15,000 +	Nu.170,000 + Nu.
Prepaid Insurance Nu 10,000			40,000= Nu.210,000

i.e Nu. 270,000 = Nu. 270,000

Financial position (Balance sheet) of Smart Tara Stores as on January 30, 2020

Particular	Amount (Nu.)
Assets:	
Cash	190,000
PPE (Furniture)	20,000
PPE (Machinery)	50,000
Prepaid Insurance	10,000
Total	270,000
Liabilities:	
Tara's Capital (170,000 + 40,000)	210,000
Roshna (CL)	20,000
TBank loan (NCL)	25,000
Unearned Revenue	15,000
Total	270,000

The comprehensive illustration below will help you to get a picture of how a incorporated company prepares a income statement (prepared to find profit earned or loss incurred), statement of financial position (statement showing assets, capital and liabilities of the entity) and statement of change in equity are prepared at the end of the period after the records are kept in the books of accounts, which you will learn in detail in your next lesson.

Illustration 1

Home Repair Service Ltd discloses the following transactions summary for the month of January 2019.

Issued share capital for Nu.560,000 cash.

Assumed a bank loan for 224,000.

Purchased equipment for 168,000 cash.

Purchased Alto for 450,000; paid Nu. 100,000 cash and incurred a bank loan for Nu. 350,000.

Paid Nu. 134,400 for a comprehensive one-year insurance policy effective January 1.

Paid Nu.112,000 cash to reduce the bank loan.

Received Nu. 22,400 as an advance payment for repair services to be provided over the next two months as follows: Nu. 16,800 for February, Nu. 5,600 for March.

Performed repairs for Nu. 420,000 cash and Nu. 140,000 to be paid by customers at a later date.

SELF-INSTRUCTIONAL MATERIAL

Paid a total of Nu. 397,600 for operating expenses incurred during the month ;(Rent Nu. 89,600, Salaries Nu.224,000, Supplies Nu 84,000), also incurred an expense on account for Nu. 39,200.

Dividends of Nu. 11,200 were paid in cash to the shareholders.

The effect of above business transactions on:

- a) Statement of Financial position.
- b) Statement of Income and
- c) Statement of changes in equity are shown below.

Solution

Transaction	Assets				
	Cash	+ Accounts Receivables.	+ Prepaid Insurance	+ Equipment	+ Alto Car
1	Nu.560,000				
2	Nu.224,000				
3	-Nu.168,000			Nu.168,000	
4	-Nu.100,000				Nu.450,000
5	-Nu.134,400		Nu.134,400		
6	-Nu.112,000				
7	Nu.22,400				
8	Nu.420,000	Nu.140,000			
9	-Nu.397,600				
10	-Nu.11,200				
	Nu.303,200	+ Nu.140,000	+ Nu.134,400	+ Nu.168,000	+ Nu.450,000

Liabilities		
Bank Loan	+ Accounts Payable	+ Unearned Revenue
Nu.224,000		
Nu.350,000		
-Nu.112,000		
		Nu.22,400
	-Nu.39,200	
Nu.462,000	+ -Nu.39,200	+ Nu.22,400

Shareholders' Equity		
Share Capital	+	Retained Earnings
Nu.560,000		
		Nu.560,000
		-Nu.89,600
		-Nu.224,000
		-Nu.84,000
		-Nu.39,200
		-Nu.11,200
Nu.560,000	+	Nu.112,000

Transaction	Assets					=	Liabilities			+	Shareholders' Equity	
	Cash	Accounts Recv.	Prepaid Insurance	Equipment	Alto Car		Bank Loan	Accounts Payable	Unearned Revenue		Share Capital	Retained Earnings
1	Nu.560,000								Nu.560,000			
2	Nu.224,000					Nu.224,000						
3	-Nu.168,000			Nu.168,000								
4	-Nu.100,000				Nu.450,000							
5	-Nu.134,400		Nu.134,400									
6	-Nu.112,000					-Nu.112,000						
7	Nu.22,400							Nu.22,400				
8	Nu.420,000	Nu.140,000										
9	-Nu.397,600											
10	-Nu.11,200											
	Nu.303,200	+ Nu.140,000	+ Nu.134,400	+ Nu.168,000	+ Nu.450,000	= Nu.462,000	+ -Nu.39,200	+ Nu.22,400	+ Nu.560,000	+ Nu.112,000		

Total Assets = Nu. 1,195,600
Total Liabilities & Equity = Nu. 1,195,600

Home Repair Service Ltd
Statement of Financial Position
As at 31st Jan. 2019

Assets		Nu.
Cash	303,200	
Accounts Recv.	140,000	
Prepaid Inc.	134,400	
Equipment	168,000	
Alto Car	450,000	
	1,195,600	
Liabilities		Nu.
Bank Loan	462,000	
Accounts payable	39,200	
Unearned revenue	22,400	
	523,600	
Shareholders' Equity		Nu.
Share Capital	560,000	
Retained Earnings	112,000	
	1,195,600	

The components of equity are shown here

Home Repair Service Ltd
Statement of Income
For the month ended 31st Jan. 2019

Particulars	Nu.
Revenue	
Home repairs revenue	560,000
Expenses	
Rent	89,600
Salaries	224,000
Supplies	84,000
Car operating expenses	39,200
Total Expenses	436,800
Net income	123,200

Net Income becomes part of retained earnings

Home Repair Service Ltd
Statement of change in Equity
For the month ended 31st Jan. 2019

Share Capital	Retained Earnings	Total Equity
Opening Balance	000	000
Shares Issued	560,000	560,000
Net Income	123,200	123,200
Dividends	-11,200	-11,200
Ending Balance	560,000	112,000

**ACTIVITY 1**

Instruction: Read the transactions carefully to solve the problem.

Ms Norbu commenced a business by making an investment of Nu.800, 000 in cash. Make an analysis, find out the effect and record the transactions in an accounting equation using the information given below.

Purchased goods in cash Nu.100,000

Purchased goods on credit for Nu. 50,000

Purchased plant for Nu.150,000

Paid cash to creditor Nu. 30,000

Borrowed loan from PNB Bank Nu.200,000

Paid house rent Nu.10,000.

Sold goods costing Nu. 50,000 for Nu.80,000

Repaid bank loan Nu.50,000 including interest Nu.10,000

**ACTIVITY 2**

Read the case study carefully and use accounting equation to show the effect of the transaction given below.

Case study

The twin brothers Tashi and Pema took a loan of Nu. 100,000 from Bank of Bhutan to start a grocery shop. They both made a cash contribution of Nu, 120,000 each. The first trading started one week after obtaining a trade licence from the Ministry where they purchased inventories of sorted grocery items of Nu. 70,000. The inventories were sold quickly and they recorded Nu. 95,000 sales.

After a month, they filled their shop with second lot of purchases for Nu. 115,000 basically to meet the demand of the customers. The sales forecast wasn't done so well this time that they had to clear the inventories at 12% loss on the purchase price.

Required: State the changes in assets, liabilities and owner's equity with the use of accounting equation for all transactions that took place at Tashi and Pema's shop.



ACTIVITY 3

Study the statement of financial position of M/s Rinchen’s trading business as at 31st December 2019 and answer the questions that follow:

Particular		Amount (Nu.)
Asset:		
Cash		50,000
Building		150,000
Trade receivables (Dema)		50,000
	Total	250,000
Liabilities:		
Capital		220,000
Trade payable (Kezang)		30,000
	Total	250,000

Is the proprietor the only person who has share in the assets?

Who owes money to the business?

To whom does the business owe money and how much?



ACTIVITY 4

Analyse the given transactions and show its effects in accounting equation. Justify your answer. The first one is done as an example.

Sl.No	Transactions	Assets	Liabilities	Owners' equity	Justify
1	Started business with cash Nu. 500,000	Cash 500,000	0	Capital 500,000	Since the owner has invested capital, it increases the capital and assets of the business.
2	Purchased goods on credit Nu. 50,000				
3	Received dividend on shares Nu. 20,000				
4	Sold goods for cash Nu. 40,000				
5	Paid to creditor Nu.30,000				
6	Cheque received from Pema Nu.30,000				
7	Drew cash for personal use Nu.30,000				



Summary

- Business transactions means exchange of goods and/or services for value and any other financial activity undertaken in the course of the business.
- Every transaction is recorded on the basis of Accounting Equation.
- Every transaction satisfies the Dual Aspect Concepts.
- To record the transactions Separate Legal Entity Concepts should be taken into account.
- Accounting Equation is a statement showing the equality of assets on one hand and the capital (owner’s equity) and liability (outside equity) on the other:
- $Assets = Capital + liabilities (A= C+L)$
- Every business transaction has its effect on the Accounting Equation.
- Business owns nothing and owes nothing. What it owns it owes.
- Under and circumstance, equality of the Accounting Equation remains same.
- The effect of expenses and revenue is always on the Capital Account, adjusted through Retained Earnings. Revenue increases retained earnings and expenses decreases retained earnings.
- Any Increase or decrease in one element of the Accounting Equation has a corresponding increase or decrease on the other element or itself.



Self-check for Learning

Show the treatment of the following transactions for the month of October using the accounting equation and also show the net balance in the Financial Position as the end of the month.

- Commenced business with cash Nu.75,000
- Purchased goods for cash Nu. 30,000
- Purchased goods on credit from Dukar for Nu.10,000
- Rent paid for the month Nu.5,000
- Borrowed loan from BOBL Nu. 50,000
- Sold goods costing Nu.40,000 for Nu. 55,000
- Received cash to supply goods next month Nu.5,000
- Paid prepaid house insurance Nu. 3,000 to BIL

Find the missing amount from the given data.

Sl.no	Assets	Liabilities	Owner’s equity	Justification
	100,000	?	85,000	
	?	150,000	200,000	
	550,000	50,000	?	

Generate an accounting equation to show the effect on assets, liabilities and owner's equity as on 31st January 2020.

Kinley Chokey decided to start a business in her village after resigning from her job to generate income to look after her parents. She started business with cash Nu. 300,000 on 1st January 2020. She purchased inventories (goods) for Nu.150,000 and sold the same for Nu. 200,000. She paid Nu. 15,000 as wages out of which Nu. 5,000 was the wage for the month of February. She received rent of Nu. 25,000 (5,000 for the month February 2020). She purchased a laptop from Sangay Gyelmo for cash Nu.35,000 and furniture from Nalay Pema for cash Nu. 50,000.

ARTS STREAM

1. MEDIA STUDIES

1.1. NATURE OF MEDIA MESSAGES AND ANALYSING MEDIA REPRESENTATION

Learning Objectives



- List the nature of media messages.
- Understand the nature of media messages.
- Explain media representation.
- Identify different types of representations in media.
- State the need for different types of media representations in Bhutan.

Introduction

McLuhan pointed to the bulb as an example. A light bulb does not have content in the way that a newspaper has articles or a television has programs, yet it is a medium that has a social effect; that is, a light bulb enables people to create spaces during night time that would otherwise be enveloped by darkness. He described the light bulb as a medium without any content. McLuhan states that “a light bulb creates an environment by its mere presence”.

What is a media message?

Media are channels of communication. Books, newspapers, photographs, songs, and movies are all types of media. Because they contain stories of one kind or another, whether fiction or nonfiction, these media also contain a message. Think of the media message as the moral of the story.

Advertisements such as billboards and TV commercials typically present easily recognizable media messages. Ad designers have a clear picture in their minds of what they want the consumer to do-to buy a product. Ads attract your interest by showing you something you want, even if you didn't think you wanted it before you saw the ad.

For example, the bright-colored lipstick ad suggests lipstick will make a woman more confident. Of course, the lipstick can't do this all by itself, but the media message implies that the product can affect the consumer's attitude and social reality. Media messages are effective when they build on assumptions viewers hold about the world and the people around them.

**ACTIVITY 1**

1. Explain the concept of a media message.

When we say that all media messages are constructed, we mean that all media messages have been assembled by someone. That "someone" could be a single person, or it could be a large

organization. The messages and values embedded in this particular piece of media are those of the people who created it.

Nature of Media Messages

"It is the learning, practicing and, mastering of the Five Key Questions-over time- that leads to a deep understanding of how media are created and what their purposes are along with an informed ability to accept or reject both explicit and implicit messages." Tessa Jolls, CML president.

Do you ever question why the media message exists rather than simply depending on it for information or entertainment?

Media is a channel of communication, a path that we take to convey our message to others in a way that fulfills our motive. Therefore, there are many different paths and many different purposes for different media messages. But all of the media messages share common features that are listed as the Nature of Media Messages. There are 6 common features as per Scheibe and Rogow. You would find that on page 47 of class XI, Media Studies textbook.

1. All media messages are constructed

Media texts such as newspaper articles, TV shows, video games are not natural, they are all constructed. Just like a building is constructed.

Magazines are constructed with words of different font, color, and sizes, pictures, layout, and location.

Videos are constructed with camera angles, lighting, music, sound effects, and actors.

Every media message is constructed after selecting the best-suited materials by a few creators. We as the audience only see or hear what was accepted and selected by them and we normalize that media message without ever questioning it.



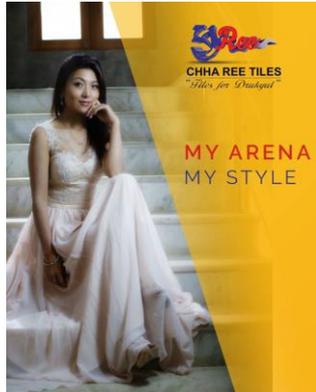
Picture; Courtesy: <https://www.google.com>

The above picture is from the popular Star Wars franchise the Mandalorian series. The costumes, scenes, and backgrounds are all fake and it is created using huge LED screens. Though all of it is fake, and we know it yet we enjoy it. The success of a media message is in constructing it to be as natural as possible.

2. Media messages are constructed using a creative language with its own rules

Each form of communication has its creative language:

Listen to a Bhutanese song (Rigsar) -The creator would have used the Bhutanese musical instrument giving the song Bhutanese vibe. The soothing tune would be used to forecast a romantic song. The lyrics would be metaphorical and poetic. Thus many listeners love and appreciate the art.



Picture courtesy: <https://www.facebook.com/chhareetiles/photos>

In the picture given above different colors have been used to emphasize their slogan, "My arena, My style." The Logo is unique and artistic for a tiles company just highlighting the range of styles they can offer. Their model is the very popular actress Sherab Lhamo. She is cast to show us how they are trusted by known people. And the matching of her dress to the tiles on the stairs just tells you that they can offer tiles that match your style, in other words, be your extension.

3. Media messages are produced for particular purposes. Most media messages are organized to gain profit and/ or power

Most media are produced to make money and are a commercial business. E.g: Magazines and news layout their pages with ads, T.V shows have commercials.

Commercials in the TV shows sell advertise products to the audience while the program sells the audience to the Advertisers. Thus the purpose of the programs in TV shows and articles in the magazine is to create an audience ready to buy the product. TRP (target rating point)



(The above picture is a flying penguin from a scene created by IPlayer)

Picture courtesy: <https://www.google.com>

The creators of this ad have used the high audience reach of BBC (higher TRP) and their image of being one of the best in world news to sell us the IPlayer and why we would need to have that app in your devices. It has nothing to do about penguins and penguins don't fly.

4. Media have embedded values and points of view

Media, because they are constructed, carry a subtext of who and what is important – at least to the person or persons creating the construction. Media are also storytellers (even commercials tell a quick and simple story) and stories require characters and settings and a plot. Every choice made for the story construction such as the characters' gender, age; race, lifestyle, actions, and the setting are ways to embed values in a media.

For example: Bmobile ad.



The above stills are from the Bmobile ad. The advertisement depicts two highlanders, shows the geographical terrain of our country and tells us how hard it is for people to meet each other. The traditional music and the mule caravan help in showing how difficult it used to be in the past. While the calls happen without any interruption only telling us that Bmobile is the mobile network for Bhutan that connects all the corners of the country.

5. Media and media messages can influence beliefs, attitudes, values, behaviors, and democratic processes.

Bhutanese in general are known to be timid and shy people but with the coming up of Tiktok it has made everyone actors and dancers.

Korean series have changed how Bhutanese youth dress and behave.

Hollywood spy movies have made us believe that Russia is the antagonist in world peace.

Media and media messages are very influential in democratic processes. The simple decision of whom to cover and whom not to cover by popular media houses during an election can impact the results and decisions of people.

6. Different people experience the same message differently

The audience can interpret the same media message differently depending on their own experience.

That's why some song hits you harder than it hits others because you can relate to it.





ACTIVITY 2

Ask these questions to yourself.

- Media displaying inaccurate information (stereotypes/misconceptions)
- Media messages – messages that the media wants you to believe

(Sometimes, media display inaccurate information. It is an individual who created a media message. So, we must understand that media always make us believe and we must have media skills to decode media messages accurately and meaningfully).

Now let's understand media representation by answering the 3Ws; What, Who and Why about media representation. You will find this on page 80 of the class 11 Media Studies textbook.

What is Media Representation?

Media representations are how the media portrays particular groups, communities, experiences, ideas, or topics from a particular ideological or value perspective.

Who should the media represent?

The subject/nature of the focus of representation differs as per the nature of the media house. That's why it is not wise in a democratic setup for the government to own media houses. However, all media must represent those areas and issues that need immediate attention.

Why representation in media matter?

Representation in media is very important. It is catalytic in changing existing mindsets. For years women were not allowed to play the so-called men games or their participation in politics has also been very less. Now they have *khuru* tournament, and women are encouraged to participate in politics as well, because of media empowering them. What media depicts shape what we believe, and it is very influential on adolescent. Media representation challenges established structures of society questions the norms and break long-standing taboos.

Now, let's have a look at how media houses in general and those in Bhutan make a representation of certain issues and tackle them.

1. Individual representation: includes a person, family, group, political party, community, etc.
2. Media must cover all sides to it are covered to ensure fairness and accuracy based on fairness, accuracy, non-prejudices, and biases.
3. Gender Representation: focusing too much on gender has the risk of discriminatory attitudes and stereotyping. For instance, if a media house focuses on women, it would make men feel they are being discriminated against. Thus, there must be a balanced gender representation.

4. Suicide, violence, and sex Representation: Such cases are very sensitive issues. One must avoid glorifying ones involved in violence and think of the impact before implying/referring to sexual activity.
5. Region/Race representation: Should avoid focusing on a particular region or race as it can cause an adverse effect. Regionally balanced coverage and equal representation of ethnicity and race promote harmony.
6. Religion Representation: While representing religion, never engage in promoting one and disparaging the other. All religions must be respected.



ACTIVITY 3

Discussion on the concept of media representation

Your list includes: -----

- Representing individuals
- Representing gender
- Representing issues like suicide/violence/sex
- Representing religion/race
- Representation of religion

Analyzing MEDIA Representation

The most important thing is to deconstruct and analyze the representations. There are a few things we need to consider while deconstructing and analyzing media representations.

IMAGES – Images can create either a positive or negative portrayal of a situation, like photographs, in particular, are very literal and can show exactly what taking place is, and drawings can illustrate a mood well.

The picture on your right side shows one lone house. If we change the lighting and color of the picture we can either have a happy house or not so happy house to live in.



Sound/music – often media texts represent social 'words' through their use of music. Music is used most often in media texts to represent an area of the world and relies on the audience's prior knowledge of certain types of music to be able to make a connection.

Intertextuality – Media representations also depend on the audience's knowledge of intertextuality links between the current texts and other previous texts using the same images, language, sound, or logos. For example if we have read William Wordsworth's poem we are certain to know that it is about nature.



Summary

Headlines – Headlines are the lives behind every story. Headlines, presented through canny words and larger fonts should lure readers to stories. Headlines indicate the content and tone of stories based on which readers decide whether to move further into the story.

While exploring media messages we must keep in mind that 'all media messages are constructed' using a creative language with its own rules. Each form of communication has its creative language: scary music heightens fear, camera close-ups convey intimacy, and big headlines signal significance.

The next concept was on the key concept of a media message. The origin as we all know came from Canada. It was the result of discussion and debate among educators, media advocates, and government agencies. The goal was to address issues such as commercialism, propaganda, censorship, media ownership, and stereotyping in the media. These frameworks are still relevant today, and also can be applied in our day to day life experiences. All key concepts are equally important but the first concept "All media messages are constructed" is the most important. The media do not simply reflect external reality. Rather, they present carefully crafted constructions that reflect many decisions and are the result of many determining factors.

Representations in media are a key part of society, as they shape, to a certain degree, the way we think and what we believe. This is particularly true for adolescents, who are heavily influenced by the media in this day and age and are still in a phase of learning, and so absorb what the media portrays.

Media representations are how the media portrays particular groups, communities, experiences, ideas, or topics from a particular ideological or value perspective. Rather than examining media representations as simply reflecting or mirroring "reality," we examine how media representations serve to "re-present" or to create a new reality. The issue of representation is especially important given the increasing presence of TV shows and movies around us and how much the media we consume can affect our society. After all, stories inform both how we see and how we characterize those around us and especially how we see ourselves.



Self-check for Learning

1. What are media messages?
2. How do you evaluate media messages?
3. How are media message messages constructed?
4. What is media representation?
5. How are people represented in the media?
6. What is a representation and why is it important?

2. GEOGRAPHY

2.1. SETTLEMENT: RURAL SETTLEMENT

Learning Objectives



- Define settlement in your own words.
- List four differences between rural and urban settlement.
- Explain any five patterns of settlement.
- Explain four factors that determine the types of rural settlement.

Introduction

Think Time: We can see houses everywhere either single or in a group. What could be the term used for it?

The term used is a **settlement**. So, settlement refers to a cluster of dwellings of any type or size where human population live and use the area to fulfil their needs.

OR it is a place where people live and carry out a variety of activities such as trade, agriculture, and manufacturing and for leisure.

A **house** is the basic unit of residence. Two or more houses may be collected together as a **hamlet**. Settlements can be of various shapes and sizes.



ACTIVITY 1

1. Explain the meaning of settlement in your own words?

Do you know the types of settlement? List them.

Types of Settlement

Base on the occupation of the majority of residents and availability of facilities, settlement can be categorized into two as:

1. Rural Settlement
2. Urban Settlement

1. Rural settlement

It is a settlement where the majority of the people residing there are engaged in primary activities and do not have much of modern facilities. They are closely linked to the farmlands and countrysides.



Figure: A Rural Settlement

2. Urban Settlement

It is a settlement where the majority of the people reside. People in the urban area are engaged in secondary or tertiary activities and have modern facilities.



Figure: An Urban Settlement

Differences between Rural and Urban Settlements.

Rural Settlement	Urban Settlement
1. People are engaged in primary activities	1. People are engaged in secondary or tertiary activities
2. Few modern facilities	2. Modern facilities are readily available
3. Population is small	3. Population is large
4. Density of population is low	4. Density of population is high
5. Settlement is generally small in size	5. Settlement is generally bigger in size

How many types of rural settlements do you know? Think for few seconds and list them.

Types of Rural Settlement

Generally, there are three **types** of **settlements**: nucleated, semi-nucleated, and dispersed. Each is based on its population density. However, in Bhutan, we have four types. They are:

1. Nucleated settlement.
2. Semi-nucleated settlement.
3. Dispersed settlement.
4. Semi-nomadic settlement.

1. Nucleated/ Clustered/Agglomerated Settlement

It is a settlement in which houses are built close to each other? Settlements are surrounded by cultivated land, where farmers travel to their field in the morning and return mostly by evening. Compact settlements usually have the highest density of population. This type of settlement is common mostly in high altitude areas due to cold climate. E.g. Ura in Bumthang.

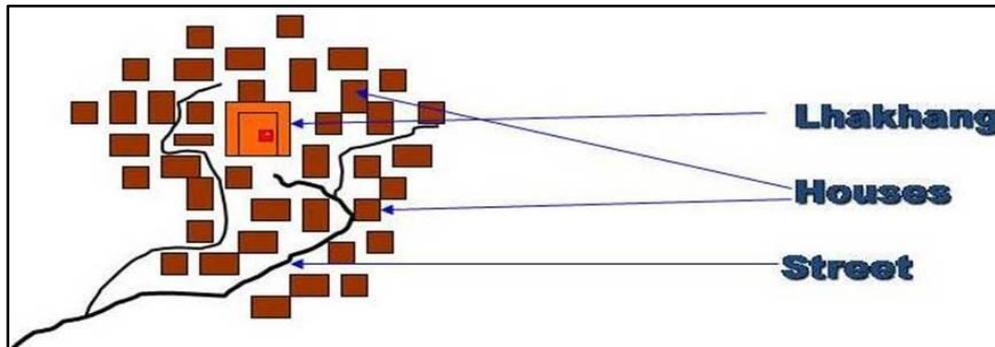


Figure: A nucleated pattern

2. Semi-Nucleated Settlement

A settlement that is characterized by small and compact nucleus around which the other houses are dispersed forming a ring around the main settlement. E.g. Gangtey Goenpa settlement (Wangdue Phodrang)

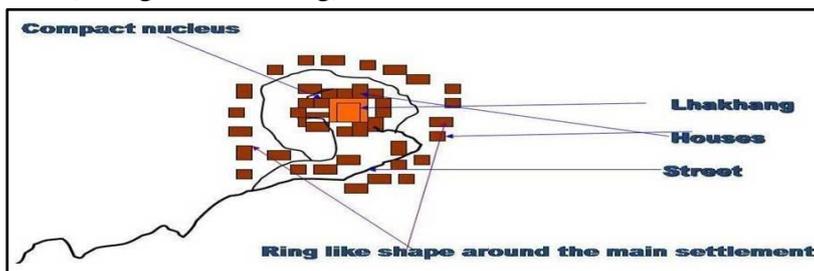


Figure: A semi-nucleated pattern

3. Dispersed Settlement

Settlement in which the houses are scattered or spread widely over a vast area. Such settlement is mainly found in low altitude areas like Samtse, Pemagatshel and Sarpang.

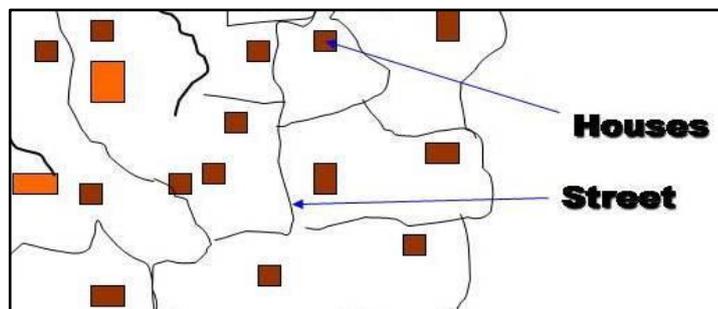


Figure: A Dispersed Pattern

4. Semi-Nomadic Settlement

Is a seasonal or temporary settlement in which people live in tents or huts during some parts of the years when they take their animals like yaks and sheep to the pastures. It is most common in high altitudes like Laya in Gasa and Merak Sakteng in Trashigang, where the climatic conditions are quite harsh.

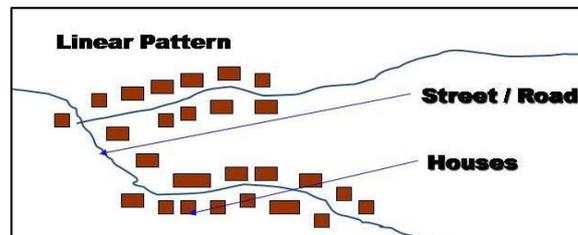


Settlement Patterns

The spatial organization of houses in a place defines its pattern. Settlement pattern means the spatial organization of houses that describes the overall shape, appearance and identification of the settlement. They are of the following types;

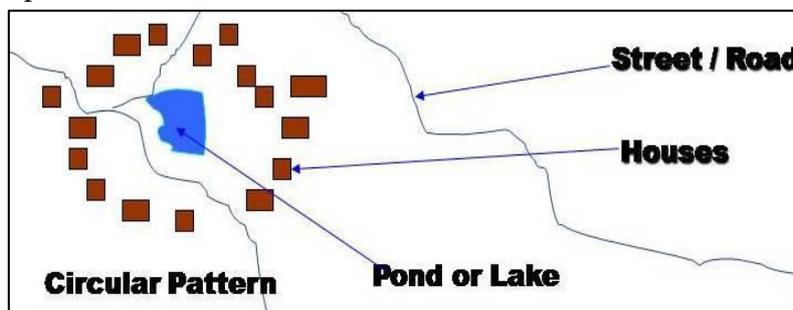
1. Linear Pattern

A pattern where the houses are built along the sides of major motorways and river banks usually in a line.



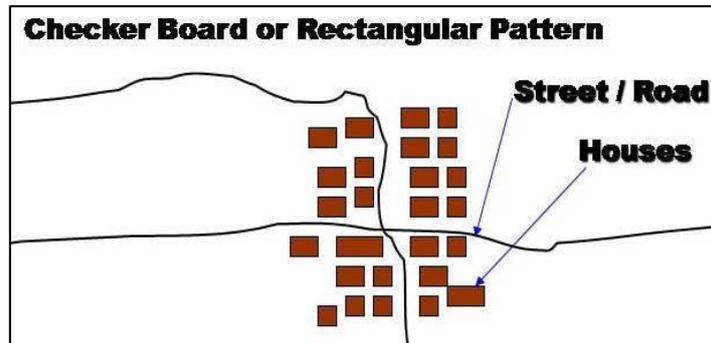
2. Circular Pattern

A pattern where the houses are constructed around a pond or a monastery forming a circular shape or pattern.



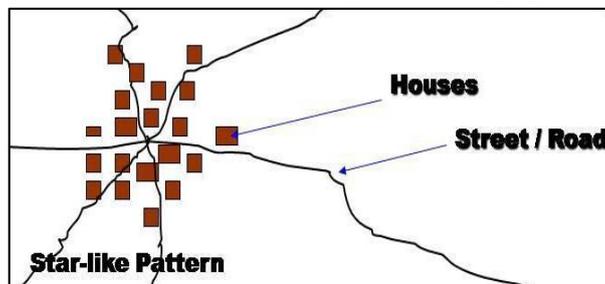
3. Checker Board or Rectangular Pattern

Patterns formed where houses are built around the meeting place of two or more roads/streets that are either parallel or perpendicular to each other.



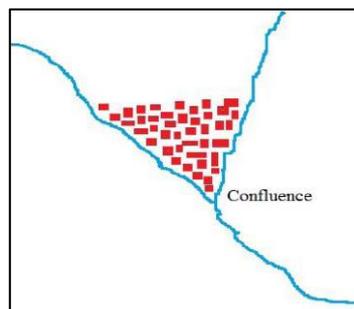
4. Star-like Pattern/

Starlike patten formed where houses are built around the roads/streets that radiate from a common centre. Expansion of such settlement may be due to population growth.



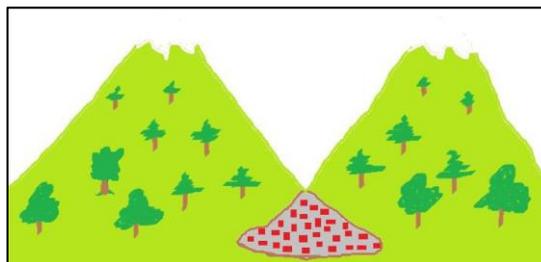
5. Triangular/Arrowhead Pattern:

Patterns formed where the houses are built at a junction or confluence of a river or road.



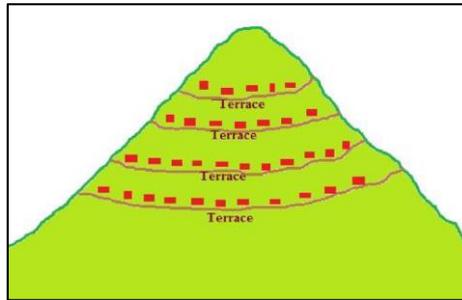
6. Fan Pattern

It is a pattern formed where houses are built in deltaic or foothill areas forming a fan shape.



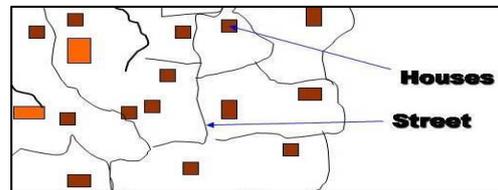
7. Terrace or Contour Pattern

These types of patterns are formed where the houses are constructed along the terraces following the contour lines usually on the hill slopes.



8. Shapeless or Amorphous Pattern

It is a name given to a pattern without having any particular shape or form. It is formed where houses are built haphazardly having the mixed form or pattern of settlement in the rural areas.



ACTIVITY 2

1. Select the type of settlement you would prefer to live? Give five reasons.
2. Under which pattern of settlement does your village fall?

Factors Determining the Pattern of Rural Settlement

1. Physical factors:

- a. *Nature of Terrain*- Dispersed settlements are found on ridges, remote jungles, small hills whereas compact settlements are found in highly productive alluvial plains.
- b. *Altitude* –Dispersed settlements are found usually in lower altitude and clustered and semi-clustered in higher altitude.
- c. *Climate*- Hamleted settlement is common in the cold climatic region and also where there is frequent drought.
- d. *Availability of Water*- Settlements are compact where the water source is a pond.
- e. *Availability of Fertile Soil*- Nucleated settlement is found in the area having fertile soil.

2. Cultural and Ethnic Factors:

- a. *Caste and tribal structure*-leads to fragment and hamlet-ed settlement.
- b. *Religion*- people of same religion prefer to live together making a settlement large or small but compact.

3. Security Factor:

Defence from invasions and wild animals often lead to clustered/compact settlement.

4. Historical Factors:

Several areas have for a long time been subjected to conflicts, such as the Tibetan and other invasions, as well as internal conflicts between governors of various districts. The immediate vicinity of dzongs proved a strong magnet for villagers and other settlements, whose population could take shelter in the dzongs during the troubled times. In this way, the settlements tend to group around them forming nucleated settlement.

**ACTIVITY 3**

1. What factors must have had determined the settlement pattern of your village?
2. Which factor do you think is becoming dominant these days? Why?

**Summary**

- Settlement refers to a cluster of dwellings of any type or size where humans live and use the area to fulfill their needs.
- On the basis of occupation of the majority of residents and availability of facilities, settlement can be categorized into rural and urban settlement.
- Types of rural settlement based on the population density are nucleated settlement, semi-nucleated settlement, dispersed settlement and semi-nomadic settlement.
- Linear Pattern, Circular Pattern, Checker Board or Rectangular Pattern, Star-like Pattern, Triangular/Arrowhead Pattern, Fan Pattern, Terrace or Contour Pattern, Shapeless or Amorphous Pattern are the different settlement patterns.
- The patterns of rural settlement are determined by physical factors: Nature of Terrain, Altitude, Climate, Availability of Water and Availability of Fertile Soil, Cultural and Ethnic Factors: Religion, Caste and tribal structure, Security Factor: invaders (enemies and wild animals) and Historical Factors: conflict with Tibet and amongst the governors.

**Self-check for Learning**

Answer the following questions in your notebook.

1. Define settlement in your own words.
2. Distinguish between rural and urban settlement.
3. Explain four types of rural settlement.
4. Describe any four patterns of rural settlement. Explain the factors that determine the types of rural settlement.
5. “Dispersed settlement is the best settlement to live in”. Do you agree? Support your stand on it.

2.2. URBAN SETTLEMENT

Learning Objectives



- Define urbanization in your own words.
- List four differences between rural and urban settlements.
- Explain any four factors that determine the location and growth of urban centres.
- Explain concentric zone theory postulated by E.W. Burgess.
- Identify four different types of urban centres based on functions.
- Explain four negative impacts and four positive impacts of urbanization.
- Suggest some solutions for the problems of urbanization.

Introduction

In our previous lesson, we learnt about the cluster of dwellings of any size and shape in the rural areas. So, today we are going to discuss the cluster of dwellings in the urban areas.

What is the term used for the cluster of dwellings in the urban areas? Take few seconds to recall.

Urban Settlement

The functional aspect of the settlements distinguishes urban from rural settlements. It is the settlement in which the majority of the residents are engaged in secondary and tertiary sectors and has much of modern facilities.

Did you hear the word urbanization in the lower classes? What is it? Think for few seconds and note it.

Urbanization

Urbanization is the process of transforming traditional society into modern society or increase in the total population living in urban areas either due to rural-urban migration or more birth than death. It has the characteristic of crowds of people, tall concrete multistoried buildings, criss-cross of roads and with wide varieties of goods and services.

The word 'urbanization' is derived from a Latin, 'urbs' is a term used for cities by the Romans.

What must have determined the location of urban centres? Think and note down.

Factors Determining the Location and Growth of Urban Centres

Urban centres are centres of production, collection and distribution where economic and social conditions are favourable. Therefore, the location and growth of urban centres depends upon the following factors;

1. Mode of Transportation

Availability of different means of transportation will favour trade and commerce leading to the growth of urban centres. The growth of Thimphu as a major urban centre started only after the construction of the national highway between Thimphu and Phuntsholing. Other urban centres also started mainly after the development of a transport network system.

2. Availability of Agricultural Resources

Agriculture resource is another factor that has resulted in the development of urban centres in Bhutan. E.g. Paro has become an urban centre because of suitable climatic conditions and fertile wide plains that boosted and attracted people to live there. This large number of people created market for business and hence shops, restaurants, hotels, etc have come up.

3. Availability of Mineral Resources

Availability of mineral resources has resulted in mining activities because of which people get flocked in either as a mining labourer or setting up business activities. E.g. Gomtu and Nganglam have grown as urban centres mainly because of availability of limestone minerals.

4. Availability of Educational Facilities

Educational institutions like schools, colleges and training institutes provide job facilities to a large number of people. Due to a large number of students and people working in the institutions, shops, and other business-related activities have come up resulting in the growth of the urban centre. Kanglung, Lobesa and Gedu are some of the examples.

5. Industrialization

Industrialization is the main cause of urbanization. The industrialization has generated a lot of employment opportunities and has encouraged many people to carry out business in such areas resulting in urban centres. For example, Gomtu and Pasakha have become urban centres due to the growth of industries.



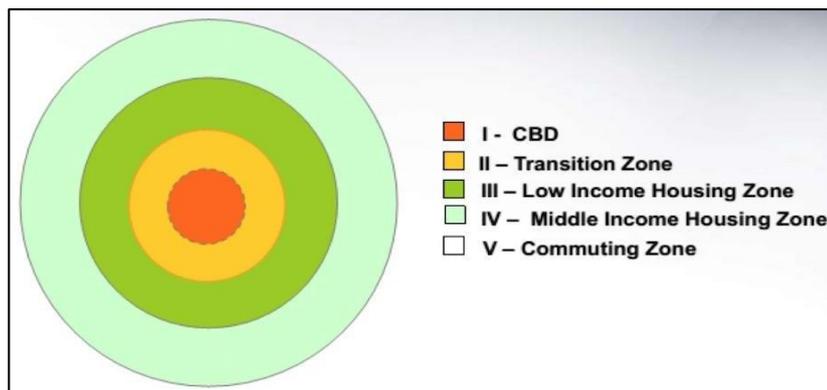
ACTIVITY 1

Answer the following question.

1. Which factor must have determined the growth of the town in the *Dzongkhag* where you are currently studying? Justify.

Urban Land Use Model/Concentric Zone Theory

This theory was written by an American sociologist Ernest Watson Burgess in 1925. He explains the urban social structures and land usage in concentric rings. Concentric zone theory states that the growth of towns takes place outwards from its central area to form a series of concentric zones. The model assumes a relationship between the socio-economic status (mainly income) of households and the distance from the Central Business District (CBD). The further the place from the CBD, the better the quality of housing but longer the commuting time. Thus, accessing better housing is done at the expense of longer commuting time and cost. The different zones in the model are:



1. **CBD:** This area is called downtown in the U.S. and city centre in Europe. Due to the high cost of land in this area, a lot of skyscrapers are built to make optimum use of that land. Most government institutions, businesses, stadiums and restaurants choose this area due to a better market. This area is full of people during day time, while at night the area is almost deserted as this zone is expensive for residential use. This zone is commuted to by the residents of the other zones. The Clock tower in Thimphu is the best example of CBD of Thimphu town.
2. **Zone of Transition/ Factory Zone:** It consists of industries and has poorer-quality housing and infrastructure. This zone has the highest rate of people moving in and out. It has a high percentage rent and the crime rate is also very high here. Slums and squatter settlement are the other features. This zone is known as the transition zone because, as the CBD expands, it is going to be captured under it.
3. **Zone of Working Class:** This area contains modest older houses occupied by stable, working class families with low income but can afford to move out to zone two. The Second generation immigrants live here.
4. **Zone of better Residence:** This zone contains newer and more spacious houses. Most families in the middle-class with better incomes live in this zone because it is expensive for low-income group to commute quite a long distance.
5. **Commuter's Zone:** This area is located beyond the built-up area of the city. It is mostly occupied by upper-class residents who can afford to commute into the city for work or entertainment. Hence, this zone is known as the higher class zone or outermost part of the city. This area is also known as the suburbs in the United States.

The paradox of the poorest people living on expensive land is due to their need to be close to the source of employment. Wealthier people are residing in the outer areas, in lower density housing, where they can commute to work.

According to Burgess, urban growth is a process of **expansion and reconversion of land uses**, with a tendency of each inner zone to expand in the outer zone.

Is concentric zone theory postulated by E.W. Burgess applicable in Bhutan? Justify your stand.

If you want to migrate to urban centre, which zone will you choose and why?

Based on the functions, how many types of urban centres do you know and what are they? List them.

Classification of Urban Centres in Bhutan

Based on the functions and services urban centres can be classified as follows:

1. **Administrative Town:** Are the towns that have developed as a result of administrative function. All towns developed in and around the *dzongkhag* headquarters due to administrative functions come under such town.
2. **Educational/Institutional Town:** Are towns that have developed due to educational/institutional facilities like schools, colleges or institutions. Kanglung town has developed because of the establishment of Sherubtse College. Gedu and Lobesa are also educational towns.
3. **Trade Town:** Are towns that have developed as a result of trade facilities. Example, Phuntsholing, Samdrup Jongkhar and Gelephu.
4. **Industrial Town:** Are towns that have developed due to industrial development. Nganglam town is an example.

Impact of Urbanisation

Positive Impact

1. Availability of better and diversified job opportunities.

Variety of activities carried out in urban areas has resulted in better and diversified job opportunities.

2. Availability of better-quality services

Urban centres are supplied efficiently with basic amenities like safe drinking water, electricity, garbage disposal facilities, health and education, transport, communication, etc.

3. Availability of diverse goods and services in huge quantity

A huge market in urban centres attracted varied goods and services in huge quantity.

4. Availability of better and variety of entertainment facilities

Better and variety of entertainment facilities are also available in urban centres as there are lots of customers.

5. Improvement in living standards

The living standard in urban centres is much better because of better income and efficient supply of basic amenities and infrastructure.

6. Social integration

Since people of different castes and religions live and work together in urban centres, this creates better understanding and harmony thereby breaking down social and cultural barriers.

Negative Impacts**1. Unemployment**

As more people from rural areas are attracted to urban areas, the jobs available are not sufficient. Moreover, immigrants are generally unskilled, illiterate or semi-literate, hence, it results in unemployment. In addition, employment opportunities have drastically reduced due to automation and computerization in several sectors of the economy.

2. Urban Sprawl

It is the spreading of built-up areas outward into farmland. As the population in urban centres grow in size, they encroach into the surrounding areas such as agricultural land, forest land, and pasture land resulting in the reduction in agricultural or pasture or forest resources.

3. Traffic Congestion

Due to the increase in the population size in urban centres, the traffic volume has increased that has resulted in traffic congestion.

4. Pollution

Increase in the size of the population, a number of industries and vehicles have led to unprecedented land, water and air pollution in the urban centres.

5. Growth of Slums and Squatter Settlements

Unemployment and low income have resulted in the growth of slums and squatter settlement that are substandard in housing, overcrowding, and inadequate access to safe water, inadequate access to sanitation and other infrastructure and insecure residential status. Slums are the eyesores of the urban centres as they do not look good and lead to many problems like source of many diseases and centre of social crimes.

6. Provision of Social Services

Unemployment among immigrants results in poverty and this aggravates the problems of providing social services such as safe drinking water, housing facilities, health, and education facilities, sanitation, sewage disposals, etc. by the municipal or government.

7. Disease Outbreaks

Unhealthy environments and overcrowded housing in slums expose the urban poor to high risks of infectious diseases like Pneumonia, TB, Diarrhoea, Cholera, Covid-19, etc. Urban population is more vulnerable to diseases such as HIV/AIDS, Malaria and STI's.

8. Social Problems

Unemployment and low income have resulted in social problems like theft, burglary, vandalism, gang fights, drugs abuse, alcoholism, etc. *Think time: Can we have some solutions for these problems? Discuss and list some.*

Solutions:

- i) Provide facilities in rural areas.
- ii) Disperse the location of industries.
- iii) Develop satellite towns and other existing towns.
- iv) Vertical expansion of buildings and low-income housing scheme.
- v) Treatment of sewage by setting up sewerages.
- vi) Recycling of solid wastes.
- vii) Discourage rural-urban migrations.



ACTIVITY 2

1. Under which category does the urban centre in the dzongkhag you are studying currently fall? Give justification.
2. “Urbanization has more benefits than the adverse impacts”. Do you agree? Write four justifications.



Summary

- Urban settlement refers to the settlement in which the majority of the residents are engaged in secondary and tertiary sectors and has much of modern facilities.
- Urbanization is the process of transforming traditional society into modern society or increase in the total population living in urban areas either due to rural-urban migration or more birth than death.
- Factors determining the location and growth of urban centres are mode of transportation, availability of agricultural resources, availability of mineral resources, availability of educational facilities and industrialization.
- Urban Land Use Model/Concentric Zone Theory written by Ernest Watson Burgess in 1925, explains the urban social structures and land usage in concentric rings. The different zones in the model are central business district, transitional zone/ factory zone, Zone of working class, zone of better residence and commuter’s zone.
- Based on the functions and services rendered by the urban centres, they can be classified as Administrative town, Educational/Institutional town, Trade Town and Industrial Town.
- Urbanization has both positive impacts and negative impacts.
- Positive impacts are availability of better and diversified job opportunities, availability of better-quality services, availability of diverse goods and services in huge quantity, availability of better and variety of entertainment facilities, improvement in living standards and social integration.
- While negative impacts are unemployment problem, urban sprawl, traffic congestion, pollution, growth of slums and squatter settlements, provision of social services, disease outbreaks and social problems.

- Problems of urbanization can be addressed through provision of facilities in rural areas, dispersion of the location of industries, development of satellite towns and other existing towns, vertical expansion of buildings and low-income housing scheme, treatment of sewage by setting up sewerages, recycling of solid wastes and discouragement of rural-urban migration.



Self-check for Learning

Answer the following questions in your notebook.

1. Define urbanization in your own words.
2. List four differences between rural and urban settlement.
3. Explain four factors that determine the location and growth of urban centres in Bhutan.
4. Explain concentric zone theory postulated by E.W Burgess.
5. Identify four different types of urban centres based on the function.
6. Explain four negative impacts and four positive impacts of urbanization.
7. Urbanisation has led to several social and environmental problems in a place. However, it has numerous advantages to the people living in and around urban centres. Describe any four such advantages.
8. Mention three differences and three similarities between squatter settlement and slum.
9. How do you think urban sprawl is environmentally unsound?
10. How would you solve some of the problems faced by urban centres? Explain any four measures?

3. ENVIRONMENTAL SCIENCE

3.1. BIOMES AND ECOSYSTEM

Learning Objectives



- Explain the characteristics of biomes.
- Differentiate between biome and an ecosystem.

Introduction

Biomes

Large geographical areas with a similar climatic conditions and vegetation, usually classified based on the dominant flora and fauna found in the area is termed as Biome. Biomes form the largest divisions of the Biosphere which consist of broad types of biological communities. The large regions within biomes have similar biotic and abiotic components. The interaction between these components determine the characteristics of biomes.

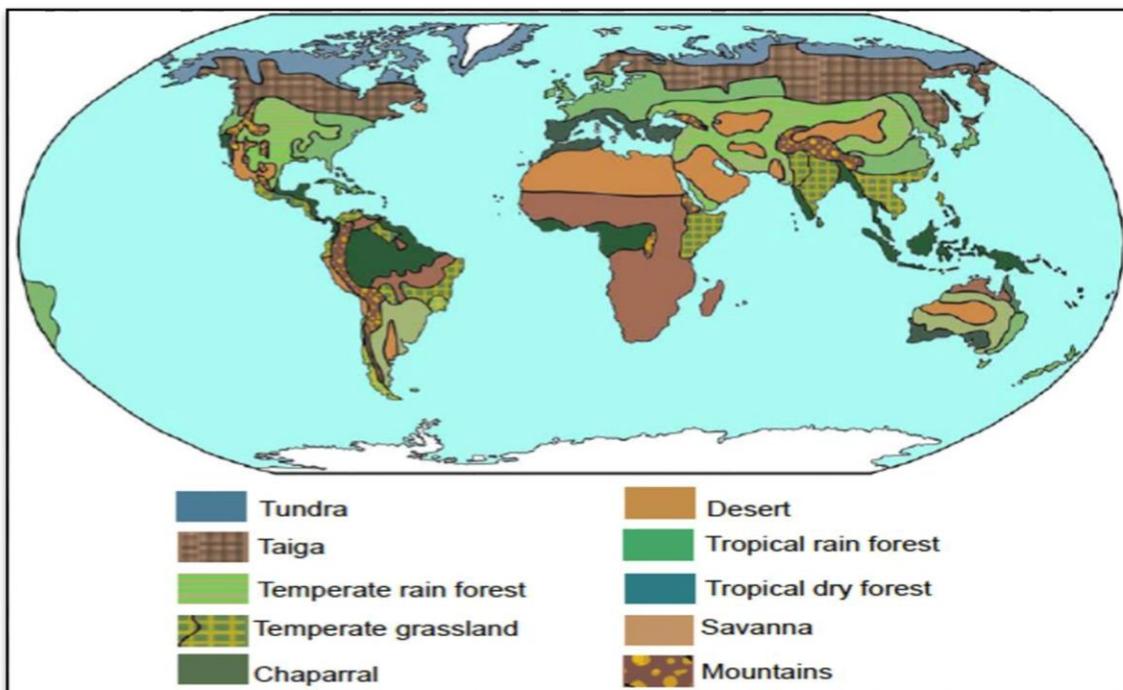


Figure: Location of world's major terrestrial biomes.

An important characteristic of each biome is its biodiversity, or the number and variety of different biological species that live in a particular place. Other important factors that influence the biomes are latitude, ocean currents, elevations, and prevailing winds in the area.

Types of Biomes

The Earth's biomes can be grouped into two broad categories – terrestrial biomes and aquatic biomes.

1. Terrestrial Biome

The terrestrial or land biomes are categorised and termed according to the climatic conditions and the climax vegetation of the region in which they are found. The climax vegetation is also called the biological community of plants, animals, birds and other living species that is stable and dominant after numerous years of evolutionary development.

The major types of terrestrial biomes in the world are as follows:

i. Tropical Rainforest

The rainforest covers about 7% of the Earth's surface. They are found all over the world but the majority of the tropical rainforest lies in South America. The weather in the tropical rainforest is hot and wet year round with an average temperature ranging in between 20°C to 34°C and receives an annual rainfall of about 125cm to 660cm. Tall trees form canopies while shorter trees and vines form understory. The soil is thin, acidic and nutrient poor due to fast absorption of nutrients by plants.

ii. Taiga

It is the largest terrestrial biome and extends across Europe, North America, and Asia. It is located right below the tundra biome. The taiga biome is also known as coniferous forest or boreal forest. This biome typically has short, moist and moderately warm summer for three to five months with an average temperature of 20°C while it has long, cold, dry winters extending up to 6 months with an average temperature of -30°C. Precipitation varies between 40cm to 100cm which mostly occurs in summer. The soils are generally acidic and poor in nutrient content. It gets plenty of snow during the winter and plenty of rainfall during the summer.

iii. Temperate Forests

This biome contains a mixture of deciduous and coniferous trees with deciduous being more dominant. Precipitation ranges from 75cm to 150cm throughout the year with temperature between -30°C to 30°C with cold to moderate winters and warm summers. Soils are often rich in humus due to thick layer of leaf litter on forest floor. This makes the soil fertile for plant growth. The temperate forest biome are found in the Eastern United States, South Eastern Canada, most of Europe, and parts of Japan, China and Australia. China, and Japan.

iv. Desert

The desert biome forms due to the low level of rainfall it receives each year. The annual precipitation is less than 25cm. The temperature ranges between 10°C to 43°C. The soil is

bare and dry, rich in minerals but poor in organic material due to absence of vegetation and water for decay to occur. There are four major types of desert - hot and dry, semiarid, coastal, and cold. Plants are adapted to tolerate heat and dry condition with water storing leaves and stems, thick epidermal layer and spines to reduce water loss. Desert biome are found in Africa, Asia, Middle East, United States, Mexico, South America and Australia.

v. **Grassland**

The biome consist of perennial grasses and herbs which are resistant to drought, fire and cold. The annual precipitation is between 25cm to 75cm. The temperature ranges with over 30°C in summer and as low as -40°C in winter. The soil is dark brown with thick layer of humus, making soil fertile. Because of high fertility, large part of grasslands are converted into agriculture and pasturelands. Grassland biome are found in Central Asia, North America, Australia, Central Europe, and Upland Plateaus of South America.

vi. **Tundra**

Tundra is considered the simplest biome in terms of species composition. This is due to its very harsh environmental conditions with extremely low temperature, low precipitation, poor nutrients and short growing seasons. Tundra can be divided into two types: Arctic Tundra and Alpine Tundra.

The Arctic Tundra is very cold with average temperature of -34°C in winter and about 12°C in summer. The annual precipitation ranges between 15cm to 25cm. Soil is usually acidic due to high organic matter content and poor in nutrients because the very slow process of decomposition inhibits the recycling of nutrients. Arctic Tundra stretches across Northern America, Northern Europe and Siberia.

The Alpine Tundra falls on mountain region throughout the world at high altitude where trees cannot grow. The temperature goes below freezing point in winter and rise to approximately 10°C in summer which is too low to support the growth of the trees. It is found in the Rocky Mountains of North America, the Alps of Europe and the Plateau of Tibet.

2. **Aquatic Biomes or Water Biomes**

Water is the most important and essential element among the biological community. The total earth's surface is covered by water which is nearly 70 to 80 per cent. Therefore, aquatic biomes are the largest and widest biome in the world. There are numerous species of aquatic plants and animals, both large and small. According to the taxonomy records, the marine habitats are older than the terrestrial habitats, as life originated in the oceans about billions of years ago.

The aquatic biome provides a vast array of habitats, which support a staggering diversity of species. As much as 80 to 85 percent of the atmospheric oxygen and the food and production (photosynthesis) takes place in water. There are two major types of aquatic biomes in the world:

- Marine biomes.
- Freshwater biomes.

**ACTIVITY 1**

Complete the table below.

Biome	Temperature	Precipitation	Soil type	Geographical Distribution

Ecosystem

The ecosystem is the structural and functional unit of ecology where the living organisms interact with each other and with their surrounding environment. An ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles. There are two types of ecosystem; Terrestrial Ecosystem and Aquatic Ecosystem.

Terrestrial Ecosystems

Terrestrial ecosystems are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones. In Bhutan, terrestrial ecosystem can be classified into forest and agriculture ecosystem.

Forest Ecosystem

Forest ecosystem is most dominant ecosystem in the country with about 70.46% of the total area under forest cover.

Agriculture Ecosystem

Bhutan has six major agro-ecological zones corresponding with altitudinal range and climatic conditions such as Alpine (3600 – 4600 masl), Cool Temperate (2600-3600 masl), Warm Temperate (1800-2600 masl), Dry Sub-Tropical (1200-1800 masl), Humid Sub-Tropical (600-1200 masl) and Wet Sub-Tropical (150-600 masl).

Aquatic Ecosystem

Aquatic ecosystem consists mainly of rivers, lakes, marsh land and hot spring.

Functions of Ecosystem

The functions of the ecosystem are as follows:

- It regulates the essential ecological processes, supports life systems and renders the stability.
- It is also responsible for the cycling of nutrients between biotic and abiotic components.
- It maintains a balance among the various trophic levels in the ecosystem.
- It cycles the minerals through the biosphere.
- The abiotic components help in the synthesis of organic components that involves the exchange of energy.

Differences between Biome and Ecosystem

Biome	Ecosystem
It is a large land area with a distinct climate and plants and animal species.	It refers to the interaction of biotic and abiotic components.
The geographical area is large.	The geographical area is small.
It depends upon the climatic factors such as rainfall, ice, snow, temperature, etc.	It does not depend upon the climatic factors.
It comprises multiple ecosystems.	It is a part of biome comprising biotic and abiotic factors.
It abounds in plant and animal species.	It is smaller in size and has fewer species of plants and animals.
All the organisms in a biome do not interact with each other.	All the organisms in an ecosystem interact with each other in trophic levels and food web.
It is affected by the latitude.	It is not influenced by the latitude.
Desert, grasslands, tundra, and tropical rainforest are some examples of biomes.	An ecosystem includes ponds, coral reefs, etc.



Summary

- Biomes form the largest divisions of the biosphere which consist of broad types of biological communities.
- The Earth’s biomes can be grouped into two broad categories – terrestrial biomes and aquatic biomes.
- An ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles.



Self-check for Learning

1. Write down some of the differences between biomes and ecosystem.
2. What type of ecosystem is present in your locality? List down some of the biotic and abiotic components you observe in your locality.
3. Describe how we interact with the abiotic components in the ecosystem?
4. Why do you think it is important to understand biomes and ecosystem?

3.2. ENERGY FLOW IN THE ENVIRONMENT

Learning Objectives



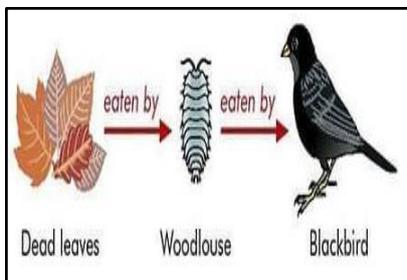
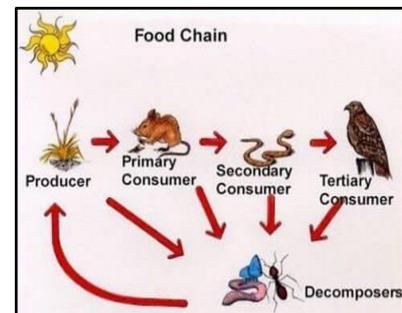
- Explain the types of ecological pyramids –number, mass, and energy.
- Explain the energy flow across the trophic levels in an ecosystem.
- Relate energy flow and self-sustenance of an ecosystem.

Introduction

A food chain is a basic network that shows the linear flow of nutrients and energy from one trophic level to another. However, in a food web, there is a multitude of food chains interconnected at many trophic levels. So, a food web represents all the various food chains that exist in an ecosystem.

There are basically two different types of food chains in the ecosystem:

Grazing food chain (GFC) – This is the normal food chain that we observe in which plants are the producers, and the energy flows from the producers to the herbivores (primary consumers), then to carnivores (secondary consumers) and so on.



Saprophytic or Detritus food chain (DFC) – In this type of food chain, the dead organic matter occupies the lowermost level of the food chain, followed by the decomposers and so on.

The producers and consumers in the ecosystem can be arranged into different feeding groups and are known as trophic level or the feeding level.

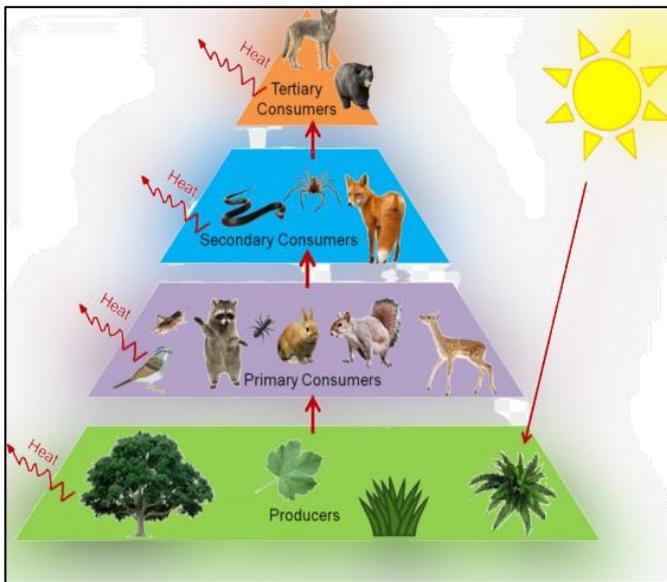
- The producers (plants) represent the first trophic level.
- Herbivores (primary consumers) present the second trophic level.
- Primary carnivores (secondary consumers) represent the third trophic level.
- Top carnivores (tertiary consumers) represent the last level.



ACTIVITY 1

1. Draw a detritus food chain describing the role of organism in each trophic level.
2. Why is it important to have food chain in an ecosystem?

Ecological Pyramid



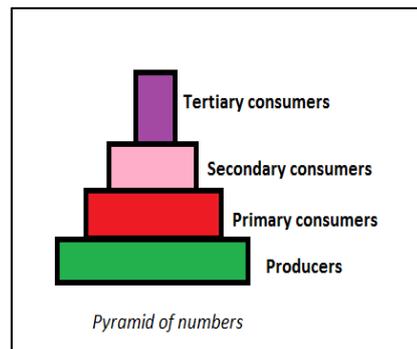
An ecological pyramid is a graphical representation of the relationship between the different living organisms at different trophic levels. It can be observed that these pyramids are in the shape of actual pyramids with the base being the broadest, which is covered by the lowest trophic level, producers. The next level is occupied by primary consumers and so on.

Types of Ecological Pyramid

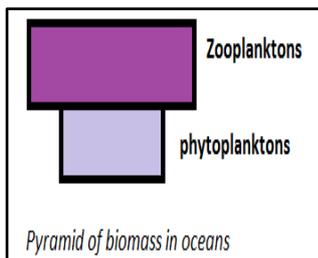
Three types of ecological pyramid exist. They are as follows:

Pyramid of Numbers

In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. The pyramid of numbers is usually upright except for some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal.



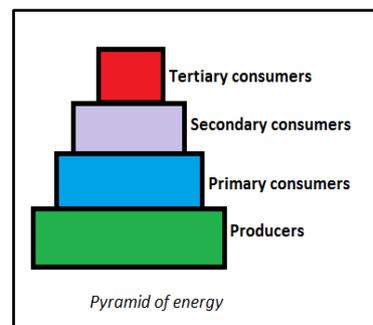
Pyramid of Biomass



In this particular type of ecological pyramid, each level takes into account the amount of biomass produced by each trophic level. The pyramid of biomass is also upright except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons.

Pyramid of Energy

Pyramid of energy is the only type of ecological pyramid, which is always upright as the energy flow in a food chain is always unidirectional. Also, with every increasing trophic level, some energy (about 10%) is lost into the environment.



Importance of Ecological Pyramid

Some of the importance of ecological pyramid are:

1. They show the feeding relationships between different organisms in different ecosystems.
2. It shows the efficiency of energy transfer.
3. The condition of the ecosystem can be monitored, and any further damage can be prevented.

Energy Flow

The chemical energy of food is the main source of energy required by all living organisms. This energy is transmitted to different trophic levels along the food chain. This energy flow is based on two different laws of thermodynamics:

- First law of thermodynamics, that states that energy can neither be created nor destroyed, it can only change from one form to another.
- Second law of thermodynamics, that states that as energy is transferred, more and more of it is wasted.

Energy Flow in Ecosystem

The energy flow in the ecosystem is one of the major factors that support the survival of great number of organisms. The primary source of energy is solar energy. Most of the sun's radiation that falls on the earth is usually reflected back into space by the earth's atmosphere. The energy flow takes place via food chain and food web. During the process of energy flow in the ecosystem, plants being the producers absorb sunlight with the help of the chlorophyll and a part of it is transformed into chemical energy during the process of photosynthesis.

This energy is stored in various organic products in the plants and passed on to the primary consumers in the food chain when the herbivores consume (primary consumers) the plants as food, and convert chemical energy accumulated in plant products into kinetic energy, degradation of energy will occur through its conversion into heat.

When these herbivores are consumed by carnivores of the first order (secondary consumers) further degradation will occur. Finally, when tertiary consumers consume the carnivores, again energy will be degraded. Thus, the energy flow is unidirectional in nature.

Moreover, in a food chain, the energy flow follows the 10 percent law. According to this law, only 10 percent of energy is transferred from one trophic level to the other; rest is lost into the atmosphere.

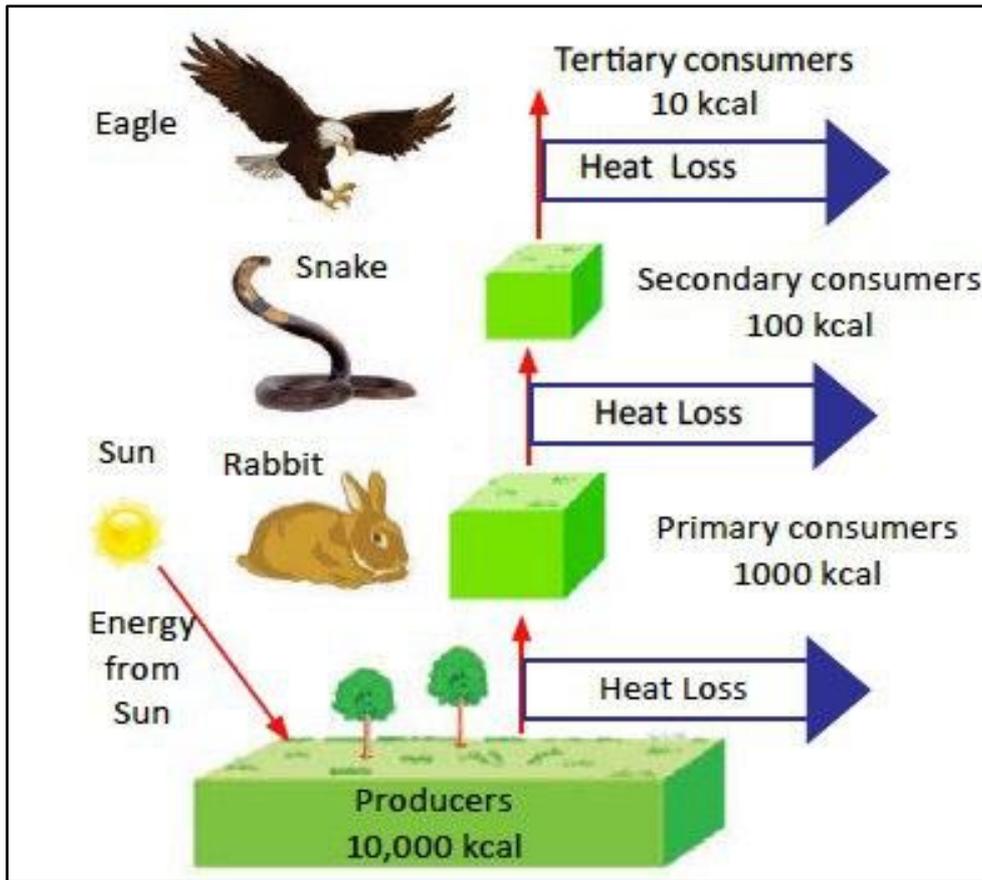


Figure: Energy flow through trophic levels



ACTIVITY 2

1. Construct a pyramid of numbers considering a big banyan tree supporting a population of insects, small birds and their predators.



Summary

- Food chain is a basic network that shows the linear flow of nutrients and energy from one trophic level to another.
- Detritus food chain begins with dead organic matters.
- There are three types of Ecological Pyramid: pyramid of numbers, pyramid of biomass and pyramid of energy.
- Energy flow happens in trophic levels as one organism feeds on another.



Self-check for Learning

1. Explain the energy flow across the trophic levels in an ecosystem.
2. How will energy flow in trophic levels help in the sustenance of ecosystem?
3. State the two laws of thermodynamics that energy flow in trophic levels follow.

3.3. RICH BIODIVERSITY AND ECOSYSTEM SERVICES

Learning Objectives



- Identify three levels of Biodiversity.
- List down various Ecosystem services.
- Differentiate between direct and indirect value.

Introduction

Biological diversity or biodiversity refers to the variety of life forms expressed as the number of species, or the number of genetic types in an area. An ecosystem which has a greater biodiversity are more stable and healthier than the one with lesser biodiversity. When a variety of animals and plants lives in an area, the supply of food increases, and competition decreases. This increases the survival of plants and animals. The higher number of plants and animals in the same area also increases the chance of survival during disease outbreak, habitat destruction, etc. An area that has multiple ecosystems provides variety of habitats for plants and animals to survive. This biodiversity is determined by species, genetic and ecosystem diversity.

Levels of Biodiversity

The variability among the living organisms in an ecosystem is observed under three levels, which includes the diversity within genes, species and ecosystems.

(i) Genetic Diversity

Genetic diversity refers to the variations of genes within a species. Each species is composed of individuals that have their own particular genetic composition. Within a species there may also be discrete populations with distinctive genes. For example, in human species, the huge variety of people's physique and physical appearances react each person's genetic individuality. The term genetic diversity also covers distinct populations of a single species, such as the thousands of breeds of dogs.

(ii) Species Diversity

The variety of plant and animal species and their relative abundance in a given area is called species diversity. The elements of species diversity are species richness, species evenness and species dominance.

Species richness is the count of the different species in a given ecosystem, region or particular area. The species richness does not consider the abundances of the species. For example, if there are three different types of organisms like pigeon, cypress and takin in an area, the species richness would have a value of three irrespective of the number of individual organism. More the species present in an area, richer is the species diversity of an area.

Species evenness is the measure of the relative abundance of the different species making up the species diversity of the area. For example, Community 1 and Community 2 have four species (A, B, C and D). In community 1, it has equal number of individuals of all the four species whereas in community 2, species A dominates the others. Although both communities have the same species richness, however, community 1 is considered even.

(iii) Ecosystem Diversity

An ecosystem provides many kinds of habitats. The biotic and the abiotic component of an environment interacts constantly in a simple or complex way. Organisms can survive in isolation, but have to interact with its environment. Ecosystem diversity refers to variations in ecosystems in terms of biotic and abiotic components and their physical sizes. An ecosystem can be as simple as a pond, a piece of log or as complex as a tropical rainforest, desert and grassland.

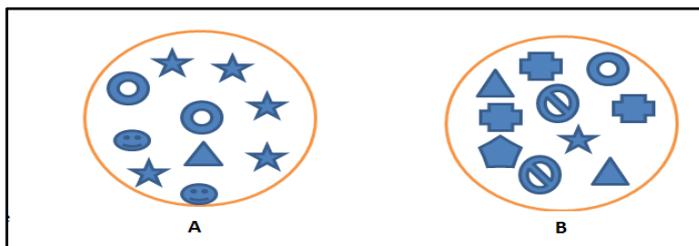
In Bhutan, the forest ecosystem is the most dominant one with the largest percent of the total land area under forest cover. Forest ecosystem in Bhutan mainly comprises ecosystems like lake, fresh water ecosystem, etc.

Ecosystem diversity helps to produce more productive and stable communities, which can tolerate various stresses due to the anthropogenic and natural pressure. Complex ecosystems with a wide variety of plants and animals tend to be more stable. A highly diverse ecosystem is a sign of a healthy environment.



ACTIVITY 1

Following figure represents two types of ecosystems 'A' and 'B' with different species of biotic components. Use the figure to solve the sub question a-c.



- Ecosystem having more species richness is
- Ecosystem having more species evenness is.....
- Species dominance in community 1 is (draw the symbol of species).....
- Which of these ecosystems you will consider as having more species diversity? Support your answer with good justification.

Values of Biodiversity

Biodiversity is the foundation of ecosystems. It provides ecosystem services to all living organisms. Humans depend greatly on biodiversity as it provides the following services:

- Provisioning services such as food, water, timber, and fibre.
- Regulating services such as the regulation of climate, floods, disease and water quality;
- Cultural services such as recreation, aesthetic enjoyment, and spiritual fulfillment; and
- Supporting services such as soil formation, photosynthesis, and nutrient cycling.

The use values of biodiversity are categorized into direct use values and indirect use values.

a. Direct use values

Direct use values are those values assigned to products harvested by people. Direct use value is categorized into two types namely consumptive use values and productive use values.

- Consumptive use values:** These are products which are consumed directly without any commercial activities. Since these products are consumed locally, these do not figure in national and international market. For example, the firewood collected directly from the forest does not involve business transactions. Therefore, this firewood has consumptive use values.
- Productive use values:** These are values put on the products of nature which are consumed and have commercial values. For example, if we buy firewood from the market, then it is said to have productive value. Similarly, fungus *Penicillin notatum* has productive values as it is used to produce the penicillin drug that is sold in the market.

b. Indirect use values

Biodiversity provides values that are intangible and have no specific commercial values. These values include cultural values, aesthetic values and ecological values.

- Cultural values:** These values are associated with the cultural, spiritual and religious aspects of the human lives. Many plants and animals have significant place in religion and is of great importance. For example, in some cultures, lakes, trees, animal and mountains are considered sacred and worshipped. Thus, biodiversity has distinctive social and cultural values attached with different societies.
- Aesthetic values:** The natural landscapes are a delight to watch and are inspiration for various art works. It also provides opportunities for recreational activities like birding, photography, hiking, etc.
- Ecological values:** The biodiversity provides regulating services such as:
 - Carbon dioxide fixation through photosynthesis.
 - Maintaining essential nutrients by biochemical cycles.
 - Maintaining water cycle and recharging the ground water.
 - Soil formation and protection from erosion.
 - Regulating climate by recycling moisture into the atmosphere.

These services that support the proper functioning of an ecosystem are the ecological values provided by the biodiversity. These services ensure the stability of the environment.



Summary

- Biodiversity refers to the variety of life forms expressed as the number of species, or the number of genetic types in an area.
- Biodiversity can be seen within genes, species and ecosystems.
- Direct use values are those values assigned to products harvested by people.
- Cultural values, aesthetic values and ecological values are examples of indirect use values.



Self-check for Learning

1. Explain three levels of biodiversity with an example.
2. List down some of the values (direct and indirect values) that your community derives from the biodiversity.
3. Why it is important to have diverse species in an ecosystem?

3.4. BIOGEOCHEMICAL CYCLE

Learning Objectives

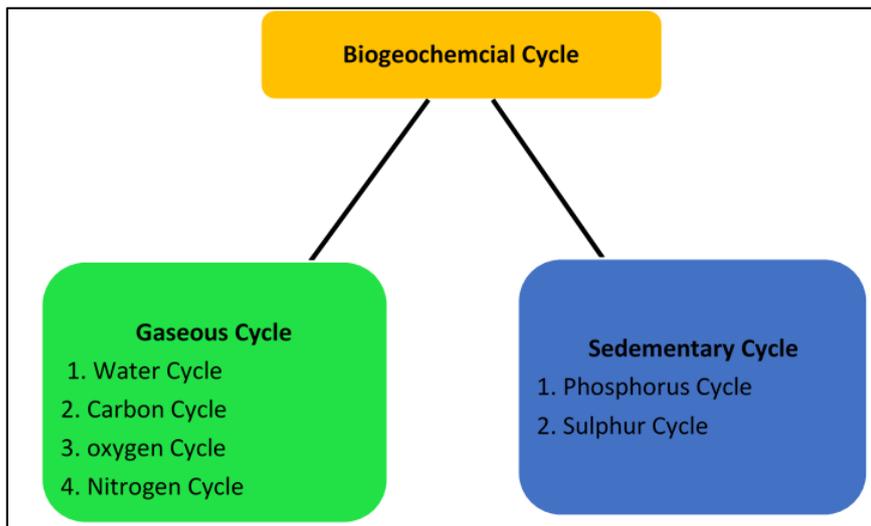


- Explain biogeochemical cycles with illustrations.
- Explain how the biogeochemical cycles are affected by anthropogenic activities.
- Explain how each component of the Earth's global system is involved in the biogeochemical cycle.

Introduction

The natural process such as biological, geological, and chemical cycles which facilitate the circulation of nutrients and elements throughout the biosphere are known as Biogeochemical Cycles. The process involves the movement of elements and compounds continuously between the Earth and its Organisms.

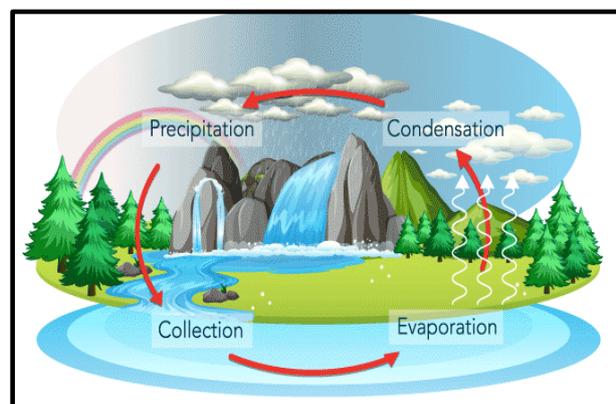
Biogeochemical cycle can be divided into two groups, gaseous cycle, in which the reservoir is the air or the oceans (via evaporation), and sedimentary cycle, in which the reservoir is Earth's crust.



Water Cycle

The water from the surface of the Earth (Water bodies and vegetation) evaporates, cools, condenses and falls back to the earth as rain.

This biogeochemical cycle is responsible for maintaining weather conditions. The water in its various forms interacts with the surroundings and changes the temperature and pressure of the atmosphere.



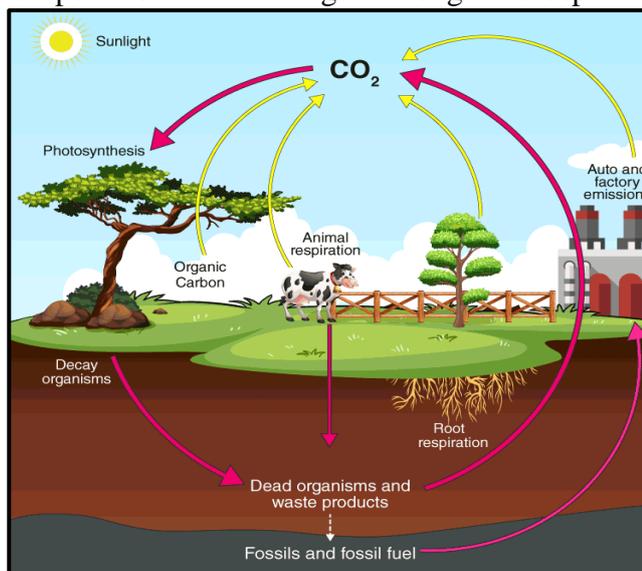
Carbon Cycle

Carbon cycle is the process where carbon compounds are interchanged among the biosphere, geosphere, pedosphere, hydrosphere, and atmosphere of the earth.

All green plants use carbon dioxide and sunlight for photosynthesis. Carbon is thus stored in the plant. The green plants, when dead, are buried into the soil that gets converted into fossil fuels made from carbon. These fossil fuels when burnt, release carbon dioxide into the atmosphere.

Also, the animals that consume plants, obtain the carbon stored in the plants. This carbon is returned to the atmosphere when these animals

decompose after death. The carbon also returns to the environment through cellular respiration by animals.



Huge carbon content in the form of carbon dioxide is produced that is stored in the form of fossil fuel (coal & oil) and can be extracted for various commercial and non-commercial purposes. When factories use these fuels, the carbon is again released back in the atmosphere during combustion.

Steps of the carbon cycle

- Carbon present in the atmosphere is absorbed by plants for photosynthesis.
- These plants are then consumed by animals, and carbon gets accumulated in their bodies.
- These animals and plants eventually die, and upon decomposing, carbon is released back into the atmosphere.
- Some of the carbon that is not released back into the atmosphere eventually becomes fossil fuels.
- These fossil fuels are then used for human activities, which pumps more carbon back into the atmosphere.



ACTIVITY 1

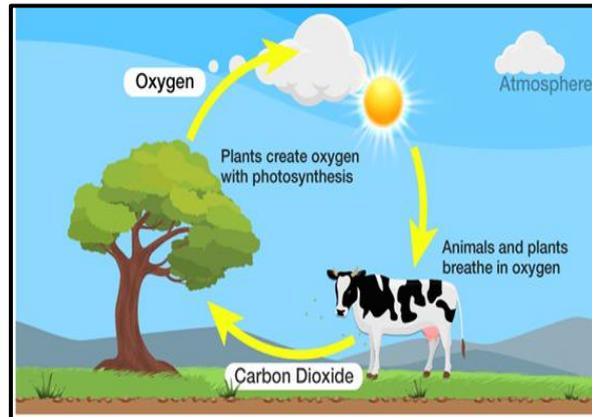
Answer the questions in your notebook.

1. How does the occurrence of water cycle benefit the livelihood of farmers?
2. Identify some of the anthropogenic activities that contribute in disturbing carbon cycle.

Oxygen Cycle

This biogeochemical cycle moves through the atmosphere, the lithosphere and the biosphere. Oxygen is a very abundant element. It is found in the elemental form in the atmosphere to the extent of 21%.

Oxygen is released by the plants during photosynthesis. Humans and other animals inhale oxygen and exhale carbon dioxide which is used by the plants. They utilize this carbon dioxide during photosynthesis to produce oxygen, and the cycle continues.



Steps of the Oxygen Cycle

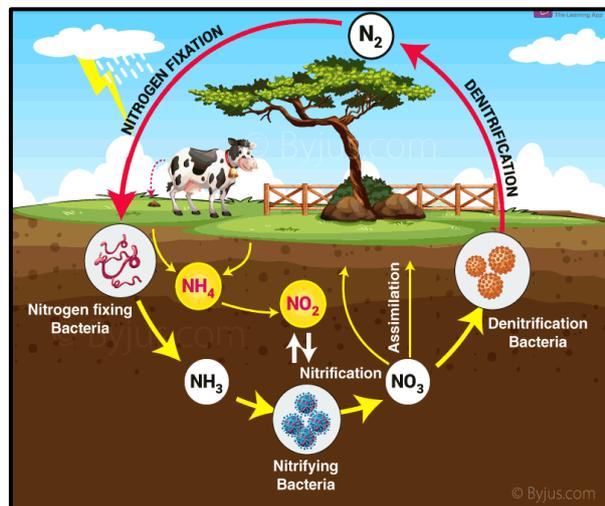
- All green plants during the process of photosynthesis, release oxygen back into the atmosphere as a by-product.
- All aerobic organisms use free oxygen for respiration.
- Animals exhale carbon dioxide back into the atmosphere which is again used by the plants during photosynthesis. Now oxygen is balanced within the atmosphere.

Nitrogen Cycle

It is a biogeochemical cycle by which nitrogen is converted into several forms as it circulates through the atmosphere, terrestrial and marine ecosystems.

Nitrogen is an essential element of life. The nitrogen in the atmosphere is fixed by the nitrogen-fixing bacteria present in the root nodules of the leguminous plants and made available to the soil and plants.

The bacteria present in the roots of the plants convert this nitrogen gas into a usable compound called ammonia. Ammonia is also supplied to plants in the form of fertilizers. This ammonia is converted into nitrites and nitrates. The denitrifying bacteria reduce the nitrates into nitrogen and return it into the atmosphere.



Steps of Nitrogen Cycle

1. Nitrogen fixation

Atmospheric nitrogen (N_2) is converted into ammonia (NH_3).

Types of Nitrogen Fixation

- **Atmospheric fixation:** A natural phenomenon where the energy of lightning breaks the nitrogen into nitrogen oxides and is then used by plants.
- **Industrial nitrogen fixation:** Is a man-made alternative that aids in nitrogen fixation by the use of ammonia in the form of fertilizers such as urea.
- **Biological nitrogen fixation:** Nitrogen is not usable directly from the air for plants and animals. Bacteria like *Rhizobium* and blue-green algae transform the unusable form of nitrogen into other compounds that are more readily usable. These nitrogen compounds get fixed in the soil by these microbes.

2. Nitrification

In this process, the ammonia is converted into nitrate by the presence of bacteria in the soil. Nitrites are formed by the oxidation of Ammonia with the help of *Nitrosomonas* species. Later, the produced nitrites are converted into nitrates by *Nitrobacter*. This conversion is very important as ammonia gas is toxic for plants.

The reaction involved in the process of Nitrification is as follows:



3. Assimilation

Primary producers – plants take in the nitrogen compounds from the soil with the help of their roots, which are available in the form of ammonia, nitrite ions, nitrate ions or ammonium ions and are used in the formation of the plant and animal proteins. This way, it enters the food web when the primary consumers eat the plants.

4. Ammonification

When plants or animal die, the nitrogen present in the organic matter is released back into the soil. The decomposers such as bacteria or fungi present in the soil convert the organic matter back into ammonium ion. This process of decomposition produces ammonia which is further used for other biological processes.

5. Denitrification

Denitrification is the process in which the nitrogen compounds makes their way back into the atmosphere by converting nitrate (NO_3^-) into gaseous nitrogen (N). This process of the nitrogen cycle is the final stage and occurs in the absence of oxygen. Denitrification is carried out by the denitrifying bacterial species- *Clostridium* and *Pseudomonas*, which will process nitrate to gain oxygen and give out free nitrogen gas as a by-product.



ACTIVITY 2

1. Draw a diagram to represent nitrogen cycle.
2. How are plants beneficial for the survival of animals?

Phosphorus Cycle

In this biogeochemical cycle, phosphorus moves through the hydrosphere, lithosphere and biosphere. Phosphorus is extracted by the weathering of rocks. Due to rains and erosion phosphorus is washed away in the soil and water bodies. Plants and animals obtain this phosphorus through the soil and water, and grow. Microorganisms also require phosphorus for their growth. When the plants and animals die, they decompose, and the stored phosphorus is returned to the soil and water bodies which is again consumed by plants and animals and the cycle continues.

Steps of Phosphorus Cycle

Weathering

Phosphorus cycle starts in the earth's crust. The phosphate salts are broken down from the rocks. These salts are washed away into the ground where they mix in the soil.

Absorption by Plants

The phosphate salts dissolved in water are absorbed by the plants. The aquatic plants absorb inorganic phosphorus from lower layers of water bodies. Since phosphate salts do not dissolve in water properly, they affect plant growth in aquatic ecosystems.

Absorption by Animals

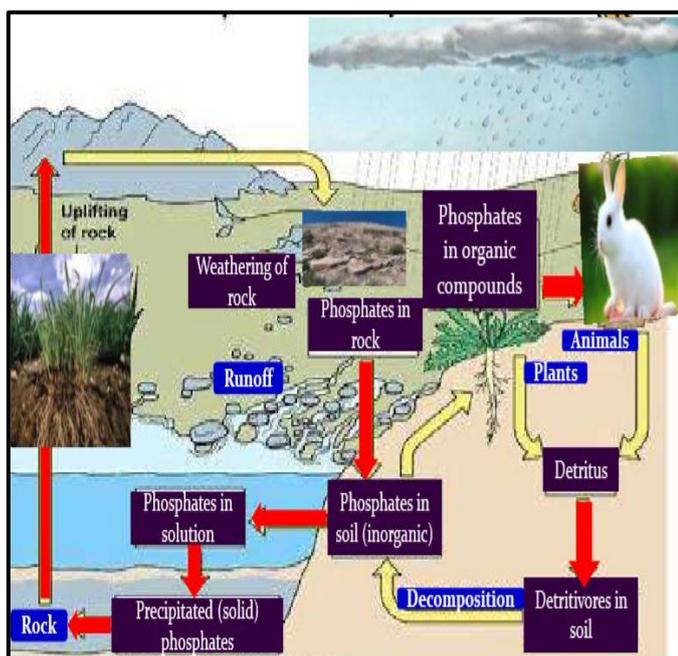
The animals absorb phosphorus from the plants or by consuming plant-eating animals.

Return of Phosphorus Back to the Ecosystem

When the plants and animals die they are decomposed by microorganisms. During this process, the organic form of phosphorus is converted into the inorganic form, which is recycled to soil and water. Soil and water will end up in sediments and rocks, which will again release phosphorus by weathering. Thus, the phosphorus cycle starts over.

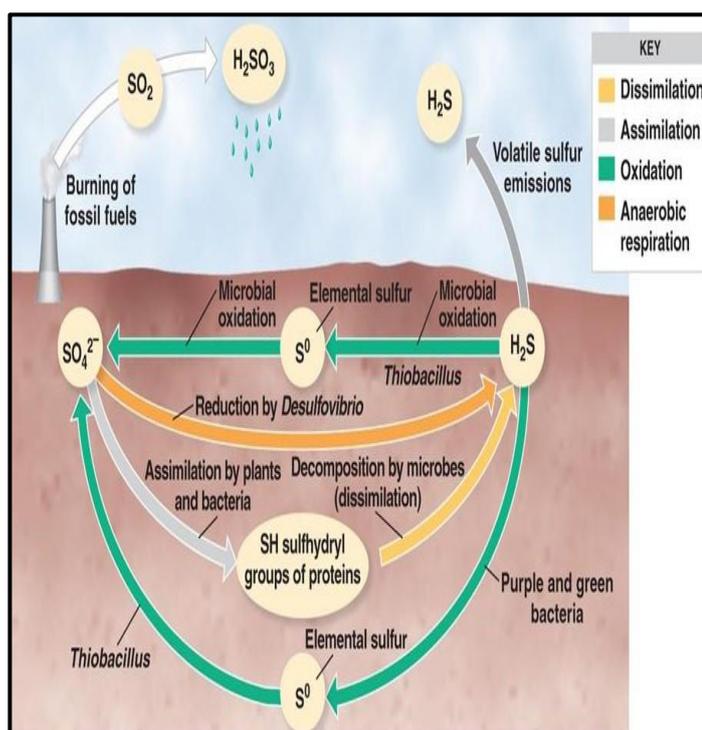
Sulphur Cycle

This biogeochemical cycle circulates through the rocks, water bodies and living systems. Sulphur is released into the atmosphere by the weathering of rocks and is converted into sulphates. These sulphates are taken up by the microorganisms and plants and is converted into organic forms. Organic sulphur is consumed by animals through food. When the animals die and decompose, sulphur is returned to the soil which is again obtained by the plants and microbes, and the cycle continues.



Steps of Sulphur Cycle

- The sulphur is released by the weathering of rocks.
- Sulphur comes in contact with air and is converted into sulphates.
- Sulphates are taken up by plants and microbes and are converted into organic forms.
- The organic form of sulphur is then consumed by the animals through their food and thus sulphur moves in the food chain.
- When the animals die, some of the sulphur is released by decomposition while some enter the tissues of microbes.
- There are several natural sources such as volcanic eruptions, evaporation of water, and breakdown of organic matter in swamps, that release sulphur directly into the atmosphere. This sulphur falls on earth with rainfall.



Summary

- Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic and abiotic factors.
- Biogeochemical cycles are divided into two types: gaseous and sedimentary cycle.
- Anthropogenic activities can affect biogeochemical cycles.
- Each biogeochemical cycle involves various steps.



Self-check for Learning

1. While energy flows in a linear manner, the nutrients follow a circular pathway. Explain.
2. How will developmental activities affect the hydrological cycle?
3. Human activities can alter the Sulphur cycle. Suggest two ways to minimize the effects.

3.5. DISTURBANCE AND ECOLOGICAL SUCCESSION

Learning Objectives



1. Explain ecological disturbance.
2. Discuss the consequences of ecological disturbance to the ecosystem.
3. Explain the causes of ecological succession.
4. Analyse the type of ecological succession prevailing in your area.

Introduction

Ecological Disturbance

Ecological disturbance refers to an event of intense environmental stress occurring over relatively short period of time and causing large changes in an affected ecosystem.

Disturbance can be caused by physical stressors such as volcanic eruptions, hurricanes, tornadoes, earthquakes, and over geological time, glacial advance, and retreat. Humans can also cause physical disturbances, for example, through construction activities. Forest fire, which is one of the common form of disaster observed in Bhutan often causes mortality of the dominant species of the community such as trees. Forest fires can ignite naturally, usually through a lightning strike, or humans can start the blaze. Events of unusually severe pollution by toxic chemicals, nutrients, or heat may also be regarded as a type of disturbance if they are severe enough to result in substantial ecological damages. Disturbance can also be biological, as when a severe infestation of defoliating insects causes substantial mortality of trees in a forest, or of crops in agriculture. The harvesting of forests and other ecosystems by humans is another type of biological disturbance.

Ecologic disturbance can occur at a variety of spatial scales. The most extensive disturbances involve landscape-scale events, such as glaciation, which can affect entire continents. Tornadoes, hurricanes and wildfires can also affect very large areas; sometimes wildfires extend over millions of acres.

Types of Ecological Disturbance

- a. *Natural Disturbance*: Disturbance as a result of natural cause.
- b. *Anthropogenic Disturbance*: Disturbance as a result of human activities.

Impacts of Ecological Disturbances

Whenever an ecosystem is affected by a substantial disturbance event, individuals and even entire species may be weakened or killed off. Other ecological damages can also occur, such as changes in hydrologic processes or soil contamination. Following are some of the impacts due to ecological disturbances:

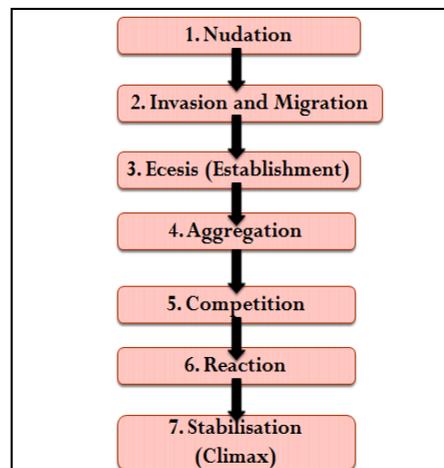
- Change the equilibrium of ecosystems and communities; and also change the size of species population.
- Severe ecological disturbances can cause permanent changes to an ecosystem which leads to ecological succession.

Ecological Succession

In a number of regions around the world, human activities are producing dramatic ecological disturbances. Clear-cutting of tropical rainforests, the damming or polluting of rivers and streams, the introduction of various chemicals and particulates into the atmosphere from industrial facilities are all human processes that have major effects on many ecosystems. Once the actual disturbance event is finished, a process known as succession begins, which may eventually produce a similar ecosystem to the one that existed prior to the disturbance. In cases where the ecological disturbance is ongoing, succession is forestalled, and the damaged ecosystems may fail to recover their complex and sophisticated functions.

A process by which an ecological community undergoes gradual and progressive change following a disturbance or after the initial colonization of a new habitat.

Process of Ecological Succession



1. Nudation

Nudation is a development of a barren area without any form of life. The causes of nudation are:

1. Topographic Factors
2. Climatic Factors
3. Biotic Factors

2. Invasion or Migration

Establishment of species in barren area from other area. Seeds, spores and other plant propagules reach the area by water, air and various other agents.

3. Ecesis

The process of successful establishment of the species by adjusting with the environmental conditions prevailing in the area. If establishment is complete, the species will reproduce sexually in the area.

4. Aggregation

The successful establishment of species, as a result of reproduction increases the population size of the species as compared to the earlier stages. The species population in the community comes closer to each other.

5. Competition

Increase in population size of species leads to intra-specific and inter-specific competition among individuals for various resources like water, nutrient, radiant energy, air, space, etc. Competition results in the elimination of unfit species from the ecosystem

6. Reaction

The process involves the modification of the environment through the influence of living organisms by replacing the existing community by another species community.

7. Stabilization (Climax stage)

The final step of ecological succession. The community established is more stabilized for a longer period and maintains itself in equilibrium with the climax of the area and not replaced by any other community.



ACTIVITY 1

1. Identify any site in your locality where the process of ecological succession is occurring. You need to write a short report about your observation.

Types of Ecological Succession

1. Primary Succession

Primary succession is the process in which plants and animals first colonize a barren habitat. On a newly created volcanic island, for example, after the rock cools, seeds blown by the wind may lodge in crevices. There they can germinate and take root. Often these first colonizing plants are weedy species, such as fast-growing grasses, that do not grow tall but do reproduce quickly. After these plants germinate and grow, they die and decompose, and their remains create pockets of soil from which other plants as well as fungi can grow. Over time, as vegetation covers more and more of the island, seeds from other plants arrive (possibly transported by birds that begin to use the island as a stopover during migration). As the plant community develops, hardier, taller-growing species begin to shade out the first colonizers and eventually dominate. More plants and animals arrive (the latter rafting over on flotsam or flying from nearby islands or the mainland), and the ecosystem changes with each new arrival. Over several decades, as populations of different species become established, the ecosystem's structure becomes more stable.

2. Secondary succession

It differs from primary succession in that it begins after a major disturbance such as a devastating flood, wildfire, landslide, lava flow, or human activity (farming, road or building construction, or the like)—wipes away part of a landscape. The stages of secondary succession are similar to those of primary succession: insects and weedy plants (frequently from surrounding ecosystems) are often the first to colonize the disturbed area, and these species are replaced by hardier plants and animals as time goes on. If this landscape remains

undisturbed for a long enough time, the evolving biological community can once again attain a stable ecological structure.

Although wildfires and other disturbances can certainly bring ruin to a landscape, the soil often retains a bank of seeds that can sprout shortly after the effects of the disturbance pass, so ecosystems within the landscape can recover through secondary succession. Sometimes, catastrophic disturbances, such as massive volcanic eruptions or advancing glaciers, effectively eliminate all of the biological activity in a landscape. In these cases, any seeds that survive the disturbance are covered with large amounts of ash, rock, or ice, which isolates them from the landscape's future development. Consequently, the landscape can return to life only through primary succession.



Summary

- Ecological Succession may be initiated either by formation of new, unoccupied habitat, such as from a lava flow or from a severe land slide.
- Ecological succession may be initiated in an already established ecosystem due to some sudden ecological disturbances like wild fire, flooding, severe climatic actions, etc.
- Ecological succession involves a progression from communities with lower species diversity (less stable) to communities with higher species diversity (more stable).



Self-check for Learning

1. How do major disturbance and minor disturbance affect ecological succession?
2. What are the advantages of ecological succession to the ecosystem?
3. Write down the differences between Primary and Secondary succession

ANSWERS

MATHEMATICS

Trigonometric Functions**Activity 1**

$$i. -\frac{1}{\sqrt{2}} \qquad ii. \frac{1+\sqrt{3}}{1-\sqrt{3}}$$

Activity 2

$$i. \frac{1}{\sqrt{2}} \qquad ii. \frac{\sqrt{3}-1}{\sqrt{3}+1}$$

Activity 3

$$i. \sin 60^\circ + \sin 36^\circ$$

$$ii. \cos 12^\circ - \cos 120^\circ$$

$$iii. 2 \sin 8A \cos 4A$$

$$iv. 2 \cos 45^\circ \cos 34^\circ$$

Activity 4

$$i. \sin 30^\circ = \frac{1}{2} \qquad ii. \cos 315^\circ = \frac{1}{\sqrt{2}} \qquad iii. \cos \frac{\pi}{6} = \frac{\sqrt{3}}{2}$$

Activity 5

$$i. 4 \cos^3 A - 3 \cos A$$

Trigonometric Equations**Activity 2**

$$1.a) \theta = 2n\pi \pm \frac{\pi}{4}, n \in I$$

$$b) \theta = n\pi + (-1)^n \left(-\frac{\pi}{3} \right)$$

$$2. a) \theta = 0, \frac{\pi}{6}, \frac{5\pi}{6}, \pi$$

$$b) \theta = \frac{\pi}{6}, \frac{5\pi}{6}$$

Self-check for Learning

1. The solution of a trigonometric equation are those angles which satisfy the given trigonometric equation
2. A solution generated by means of periodicity is known as general solution whereas the solution lying between 0° to 360° is called principal solution
3. A particular solution is obtained from a general solution by substituting $n=1$.

$$4. \theta = \frac{\pi}{2}$$

COMPOUND AND MULTIPLE ANGLES**Activity 1**

i. $-\frac{1}{\sqrt{2}}$

ii. $\frac{1+\sqrt{3}}{1-\sqrt{3}}$

Activity 2

i. $\frac{1}{\sqrt{2}}$

ii. $\frac{\sqrt{3}-1}{\sqrt{3}+1}$

Activity 3

i. $\sin 60^\circ + \sin 36^\circ$

ii. $\cos 12^\circ - \cos 120^\circ$

iii. $2 \sin 8A \cos 4A$

iv. $2 \cos 45^\circ \cos 34^\circ$

Activity 4

i. $\sin 30^\circ = \frac{1}{2}$

ii. $\cos 315^\circ = \frac{1}{\sqrt{2}}$

iii. $\cos \frac{\pi}{6} = \frac{\sqrt{3}}{2}$

Activity 5

i. $4 \cos^3 A - 3 \cos A$

Properties of Inverse Trigonometric Functions

Activity: Question 1: i) 0 ii) 60° or $\frac{\pi}{3}$ iii) -45 or $-\frac{\pi}{4}$

Question 2: i) 130 ii) $\frac{\pi}{10}$ iii) $\frac{5}{4}$

Self-check for Learning:

1) $\frac{3}{4}\pi$ 2) $\frac{5\pi}{6}$ 3) 3

Algebra: Application of Determinants**Activity 1**

i. 37.5 sq. unit

ii. 46 sq. unit

Activity 2ii. $k=-7$ **Activity 3**

i. 13.5 sq. units

Activity 4

i. $x=-3, y=-7$

ii. $x=1, y=-1, z=-1$

Self-check for Learning

i. $x=-2$

iii. $x=-2, y=-3, z=-4$

BIOLOGY

Photosynthesis

For think time 1

- i. Thylakoid membrane of chloroplast.
- ii. ATP, NADPH and Oxygen.
- iii. The products of light reactions are used I dark reaction to reduce CO_2 .

For think time 2

- i. 3 molecules of ATP and 2 molecules of NADPH
- ii. Stroma of chloroplast.

For self-check for Learning

- i. (a) In thylakoid membrane of chloroplast.
(b) Replace the lost electron from PS II.
- ii. 2 molecules of 3-PGAL is used to synthesis Glucose, remaining 10 molecules of glucose is used to regenerate Ribulose 1, 5-biphosphate.
- iii. (a) A
(b) CO_2 or temperature
(c) Optimum light intensity at which the rate of photosynthesis is maximum.
- iv. All living being are directly or indirectly dependent on plants for energy. Without chlorophyll plants will not be able to convert light energy to chemical energy (food), hence existence of live on earth would be difficult.
- v. CO_2 is one of the gas responsible for global warming. Plants uses CO_2 from atmosphere for preparing food, hence remove CO_2 from atmosphere.

DNA Finger Printing

For think time: Suspect 2

For self-check for Learning

1. Choose the most appropriate answer.
 - vi. B. Amplifies DNA
 - vii. C. Dad 3
 - viii. C. Leucocytes
2. Answer the following questions.
 - a. VNTR probes hybridize with VNTRs of DNA which on exposing to X-ray shows a visible band on the X-ray film.
 - b. Suspect B, because the DNA finger print in the crime scene matches precisely with suspect 2.
 - c. DNA needs to be digested with restriction endonuclease enzyme.

- d. No, identical twins will not have same DNA fingerprints. Although monozygotic twins have essentially the same DNA, epigenetic factors brings minute differences in identical twins DNA fingerprints.

DNA Replication

For think time

This because DNA polymerase can acts only on the 3'OH of existing strand for adding new nucleotide.

For self-check for Learning

1. The two strands of DNA separates and each strand serves as a template on which a new complementary strand is synthesised. The daughter DNA formed conserves one of the parental strand. This is known as semiconservative method of replication.
2. Okazaki fragments are formed on 5' → 3' DNA template strand. *DNA polymerase III* synthesise new DNA strand in 5' → 3' direction which against the replication fork.
3. The errors are repaired by *DNA polymerase I*.
4. Because the lagging strand needs to be replicated in the opposite direction of the way the replication fork is proceeding. And DNA polymerase can proceed only in 5' to 3' direction.
5. By *topoisomerase* enzyme
6. *Helicase*: Unwinds the two strands of DNA.
Single strand binding proteins (SSB): stabilises the Single-stranded DNA.
Topoisomerase: release tension developed on DNA strand due to unwinding.

Evolution

For think time

The continuous creeping through the holes and creeps made the limbs continuously useless for locomotion and in due course of time they were completely lost in snakes.

But maybe according to Darwin, there were variable ancestors of snake, the ancestors of snake with limbs were not able to creep through the holes and creek and whereas ancestors without limb were far better at surviving by hiding in holes and creeps.

For Activity 2

- i. White moth laid egg which developed in to caterpillar and then adult moth.
- ii. A moth might be born with a variation that makes it black in colour.
- iii. Predators spotted the white moth easily than the black moth. Black moth survived to reproduce while the white one died.
- iv. Eventually, moth with black colour made up the larger part of population than white.

For self-check for learning

1. Genetic variability ensures the survival of species in different environment.

2. Interspecific competition. Intraspecific competition is more severe. As the organism competes for same resources.
3. Intraspecific competition.
4. Natural selection differs from artificial selection in the following ways

Natural selection

- i. exerted by nature
- ii. Operates in natural population.
- iii. Is a slow process, takes millions of years.

Artificial selection

- i. exerted by man
- ii. Operates in domestic population.
- iii. Is a fast process and its results is immediate.

5. The original population of mosquitoes might have DDT resistant individuals which did not show any advantage in absences of DDT. But when DDT was sprayed, the sensitive one died and the DDT resistant ones survived and reproduce. Soon the whole population of mosquitoes was that of DDT resistant.
6. (a) Natural Selection
 (b) A- mutant form of bacteria, B- Population of antibiotic resistant bacteria.
 (c) Because they might have developed resistance against antibiotics due to mutation.
 (d) Occurrence of mutant variations
 Selection favours useful variations
 Natural selection leads to higher reproduction rate and gradual abundance of resistant variety.

SPECIES AND SPECIATION*For Self-check for Learning*

1. Allopatric speciation.
2. Genetic drift
3. Gene flow ensures that new genes are brought under cultivation which results in variability in crops cultivated.
4. In absences of reproductive isolation, then the mutant form will freely interbreed with normal forms which will either lead to mixing of genotype or loss of mutant form. Thus, no new species will be formed.

Muscles*For self-check for learning*

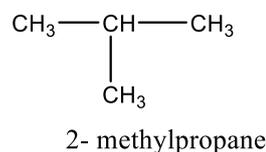
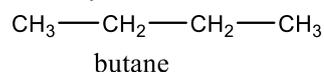
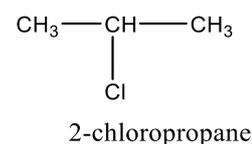
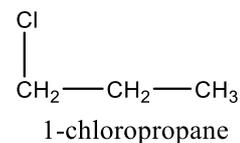
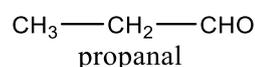
1. Troponin and tropomyosin masks the active binding site on actin filament.
2. Muscles fibres lengthens due to restoration of sarcomere to its original form.
3. It may lead to cause from mild to severe muscle tetany (Muscle cramps).
4. Exercise improves blood supply to muscles and increase their capacity to use oxygen. Exercise builds and strengthens muscles which can protect bones from injury.

Transmission of Nerve Impulse*For Activity 1*

- 1- Dendrites
- 2- Synaptic knob
- 3- Cyton
- 4- Axon

For self-check for learning

1. Transmission of a nerve impulse involves the movement of ions across the membrane. It is thus a chemical change. When the ions are exchanged across the membrane, they produce an action potential that involves a change in the membrane voltage. The chemical change therefore produces an electrical change.
2. Because in myelinated the impulse jump from one node of Ranvier to another, hence the conduction is faster.
3. Because neurotransmitter is present only in axon terminals and not in dendrites or cell body.
4. It will show decreased permeability for K^+ ions and increased permeability for Na^+ ions or for both.
5. When in danger, the parasympathetic nervous system increase breathing process, increase heartbeat, whereas parasympathetic nervous system brings back the normal rate of breathing and heartbeat.
6. The concentration gradient of potassium ions is the most important factor controlling resting membrane potential. If the concentration of potassium in the fluid around a nerve cell is too high, potassium ions cannot be pushed out of the cell and the normal membrane potential cannot be maintained. In extreme cases this would mean that action potentials could not be generated.

CHEMISTRY*Isomerism**Activity 2**Activity 3**Activity 4**Activity 5*

$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3-\text{C}-\text{CH}_3 \\ \text{2- propanone} \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{O}-\text{HC} \\ \\ \text{CH}_3 \\ \text{2-methoxy propane} \end{array}$
<p><i>Activity 6</i></p> $\begin{array}{ccc} \text{CH}_3-\text{CH}_2-\text{N} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{O} \end{array} & \rightleftharpoons & \text{CH}_3-\text{CH}=\text{N} \begin{array}{l} \nearrow \text{OH} \\ \searrow \text{O} \end{array} \\ \text{nitro form} & & \text{aci-form} \end{array}$	
<p><i>Activity 7</i></p> <div style="display: flex; justify-content: space-around;"> <div> $\begin{array}{c} \text{COOH} \quad \text{COOH} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \\ \text{Cis-but-1,4-dioic acid} \end{array}$ </div> <div> $\begin{array}{c} \text{COOH} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{COOH} \\ \text{Trans-but-1,4-dioic acid} \end{array}$ </div> </div> <div style="display: flex; justify-content: space-around;"> <div> $\begin{array}{c} \text{COOH} \quad \text{COOH} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \\ \text{cis -ethen-1,4-dioic acid} \end{array}$ </div> <div> $\begin{array}{c} \text{COOH} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{COOH} \\ \text{trans -ethen-1,4-dioic acid} \end{array}$ </div> </div>	
<p><i>Activity 8</i></p> <ol style="list-style-type: none"> i. CCl_2F_2 – optically inactive ii. 2- methyl butane – optically inactive iii. Butan-2-ol ----optically active <div style="display: flex; justify-content: center; align-items: center; margin-top: 20px;"> <div style="text-align: center;"> $\begin{array}{c} \text{OH} \\ \\ \text{H}_3\text{C}-\text{C} \\ / \quad \backslash \\ \text{H} \quad \text{C}_2\text{H}_5 \end{array}$ </div> <div style="border-left: 1px dashed black; height: 100px; margin: 0 20px;"></div> <div style="text-align: center;"> $\begin{array}{c} \text{OH} \\ \\ \text{C}_2\text{H}_5-\text{C} \\ / \quad \backslash \\ \text{H} \quad \text{CH}_3 \end{array}$ </div> </div>	

Amines*Activity 2***Answers**

- Primary amine since the compound has only one alkyl group (propyl) attached to the nitrogen atom
- Primary amine since the compound has one alkyl group attached directly to the nitrogen atom
- Tertiary amine since the compound has all three hydrogen atoms being replaced by alkyl group.

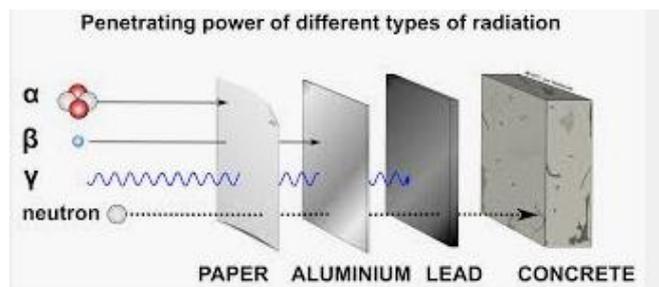
Activity 3**Answers:**

a. 2-Propanamine

b. N,N-dimethylmethanamine

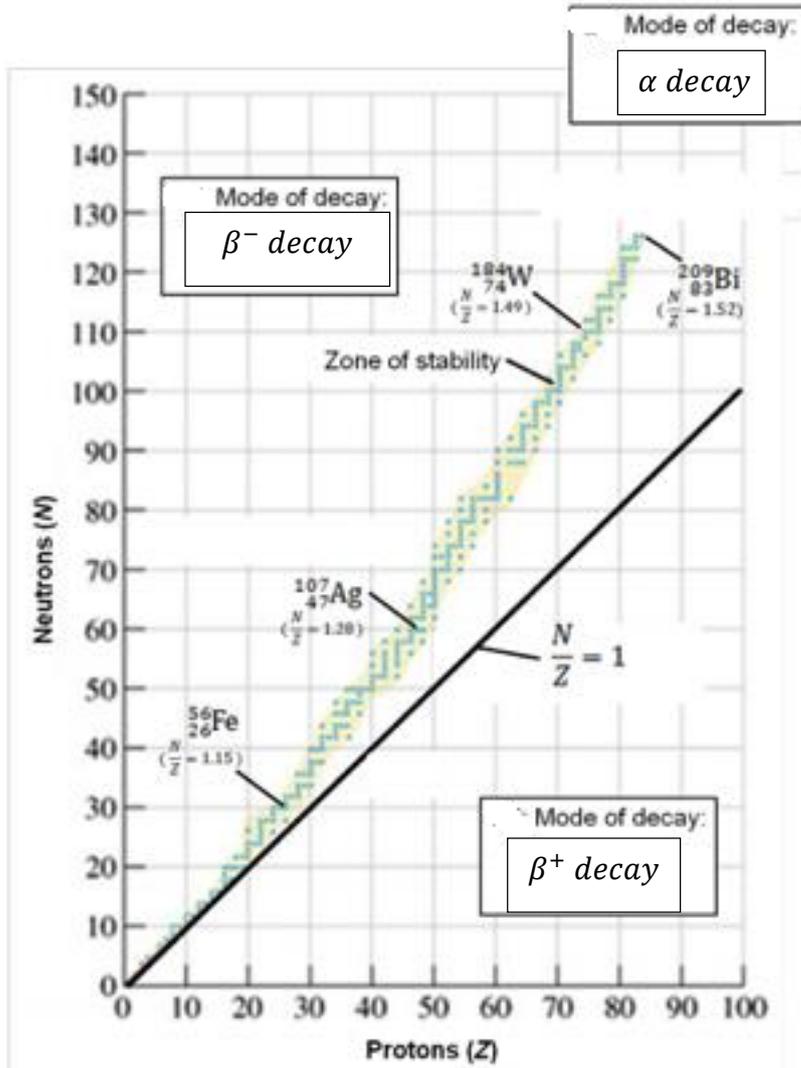
Radio Activity

2



3.

b. ${}^5_5\text{B}^{12}$ Answer: $N/Z=6/5=1.2$ c. ${}_{92}^{234}\text{U}$ Answer: $N/Z=142/92=1.54$ d. ${}_{57}^{127}\text{La}$ Answer: $N/Z=70/57=1.2$ e. ${}_{63}^{153}\text{Eu}$ Answer: $N/Z=90/63=1.4$



Answers to Self-check for Learning

1) X-ray, MRI and CT scan.

Advantages:

1. It can trace the disease disorder.
2. It can kill the excessive growing cells

Disadvantages:

1. Gene mutation can take place
2. It can damage the cells and organs that get exposed to these radiations

2) $N = ?$, $N_0 = 16\text{gm}$, $t = 5$ days, $t_{1/2} = 140$ days

$$N = N_0 \left(\frac{1}{2}\right)^n$$

$$n = \frac{t}{t_{1/2}} = \frac{5}{140} = 0.007$$

$$N = 16 \times \left(\frac{1}{2}\right)^{0.007} = 15.92\text{gm}$$

4

- a. ${}^5\text{B}^{12}$
 $N/Z=6/5=1.2$
- b. ${}_{92}\text{U}^{234}$
 $N/Z=142/92=1.54$
 Alpha decay
- c. ${}_{57}\text{La}^{127}$
 $N/Z=70/57=1.2$
 β^+ decay
- d. ${}_{63}\text{Eu}^{153}$
 $N/Z=90/63=1.4$
 β^+ decay

Acid-Base Equilibra

Activity 2

- 60%
- Almost 1 Or 100%
- No

Activity 3

HCl and KOH, because they are strong electrolyte and tend to dissociate completely.

Activity 4

- HCO_3^-
 CO_3^{2-}
 HS^-
- H_2O
 H_2SO_4
 HSO_4^-

Activity 5

$0.63 \times 10^{-9} \text{ mol/L}$

Activity 6

Cucumber juice.

Self –check for learning

- $\text{HCl} + \text{NaHCO}_3$ and $\text{HCOOH} + \text{NaCl}$
- 1.0

PHYSICS

Resolution of Vectors

1. B
2. 43.3 m/s and 25 m/s
3. 8 units and 13.85 units
4. 0° and 90°

Simple Harmonic Motion (SHM)

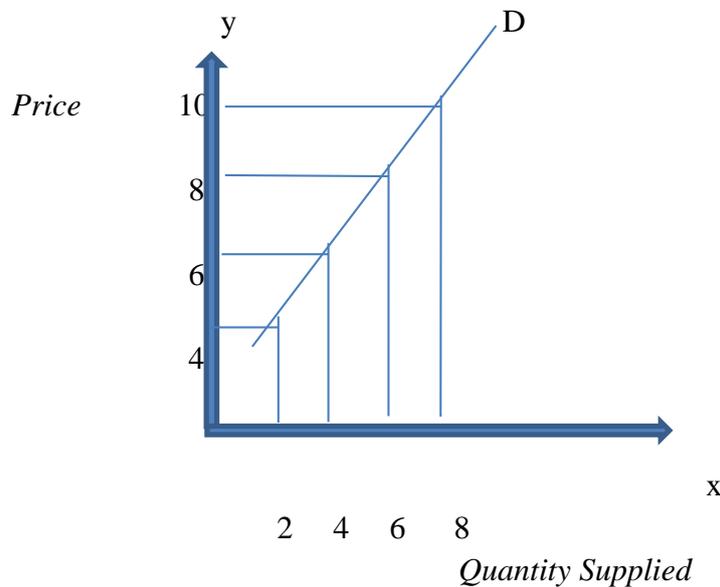
Answers for Self-Check for Learning

1.0.4 N, 2.37.8 m/s², 3. 3.7×10^{-2} J

ECONOMICS

Supply, Its Determinants and Law of Supply

Answer for learning activity 1.1



Supply curve sloped upward or it's a positively sloping curve

Answer for learning activity 1.2

1. Technology improves
2. an increase in the price of leather
3. decrease
4. supply would decrease in the economy as there is lockdown all over the country affecting the goods coming in and going out
5. When the supply of a commodity decreases, the price of that commodity will increase. Sellers will take advantage of shortage of goods in the market and raise the price. The purchasing power of the consumer will decrease.

Determination of Market Price*Activity 1.1*

1. When decrease in demand is less than decrease in supply, equilibrium price will increase but equilibrium quantity will decrease.
2. Equilibrium price of a commodity will not change when decrease in demand equals decrease in supply.

Market Structure*Activity 1.1*

Perfect Competition

- **Large number of buyers and sellers:** There are a large number of buyers and sellers, each too small to influence the price of the commodity. A firm is called as price taker rather than a price maker.
- **Homogenous product:** All firm produce homogenous or same commodities. The commodities are homogeneous in terms of shape, size, colour, taste etc. The products of various firms under the perfect competition are perfect substitutes of one another. Thus, if one firm tries to increase price of their product, it would lose all its customers to other firm selling the product.
- **Freedom of entry and exit:** New firms are free to enter the industry and existing firms are free to leave the industry. There are no barriers, be it, legal, man-made and natural to enter and leave the market. The condition of free entry and exit ensures that all the firms will end up earning only normal profits in the long-run.
- **Perfect knowledge:** Each firm has perfect knowledge about the price prevailing in the market and it would not sell the commodity below the market price. Similarly, each buyer has perfect knowledge about the market price and is not prepared to pay higher than the market price.

Monopoly

- **Single seller:** Since there is only one seller, any change in the amount of output produced by the monopolist would influence the market price. It is the case of one firm controlling the supply of the product. However, the number of buyer is too large and therefore no buyer can influence the price of the product under monopoly.
- **No close substitute:** An essential condition for the existence of monopoly is that no close substitute should be available for the product. Monopoly is the market without any competition.
- **Closed entry:** There are some restrictions on the entry of the new firms into the monopoly industry. The closed entry may result from natural, legal or man-made restrictions.
- **Price maker:** A monopoly firm is a price maker or price setter. Since, it is the only producer of the product, the price of the commodity is fully controlled by the monopolist.
- **Possibility of price discrimination:** Price discrimination refers to a situation when a producer sells the same product to different buyers at

SELF-INSTRUCTIONAL MATERIAL

- | | |
|--|--|
| <ul style="list-style-type: none"> ● Perfect mobility of the resources: Perfect mobility of the resources ensures that resources can enter or quit a firm or industry at will. This means that resources are able to switch over from one use to another without any restriction. ● Absence of transport cost: This assumption is necessary to maintain uniform price throughout the market. Otherwise, prices for identical goods would differ. | <p>different prices. A Monopolist may charge different prices from different consumers</p> |
|--|--|

Open ended question: You can try answering the questions by writing the positive features of any markets to justify your answer. For an example: I would say Perfect Competition seems to enjoy more advantage over Monopoly because Perfect Competition has the freedom of entry and exit while Monopoly does not have this advantage

Activity 1.2

- Monopolistic Competition deals with differentiated product whereas Oligopoly deals with either homogeneous or differentiated product Sunilk shampoo, Dove shampoo, Patene shampoo, and head and shoulder shampoo for Monopolistic competition

ACCOUNTANCY**Accountancy Theory**

1. Economic benefit
2. Obligation, events
3. Liabilities
4. Business operations, increase, decrease
5. Business operation, decrease, increase
6. Separate
7. Realization
8. Consistency
9. Business Entity
10. Indefinite
11. Cash and capital
12. Objective Evidence

Accounting Statement and Financial Statement

Self-check for Learning

Solution to question No. 1.

Transactions	Assets (Nu) =	Equity (Nu.) +	Liabilities (Nu.)
a. Commenced business with cash Nu.75,000	Cash 75,000	Capital 75,000	Nil
b. Purchased goods for cash Nu. 30,000	Cash 45,000 (75,000-30,000) +Goods 30,000	Capital 75,000	Nil
c. Purchased goods on credit from Dukar for Nu.10,000	Cash 45,000+ Goods 40,000 (30,000+10,000)	Capital 75,000	Dukar 10,000
d. Rent paid for the month Nu.5,000	Cash 40,000 + Goods 40,000	Capital 70,000	Dukar 10,000
e. Borrowed loan from BOBL Nu. 50,000	Cash 90,000 + Goods 40,000	Capital 70,000	Dukar 10,000 + BOBL 50,000
f. Sold goods costing Nu.40,000 for Nu. 55,000	Cash 145,000 + Goods Nil	Capital 85,000	Dukar 10,000 + BOBL 50,000
g. Received cash to supply goods next month Nu.5,000	Cash 150,000 (145,000+5,000)	Capital 85,000	Dukar 10,000 + BOBL 50,000+ Unearned Revenue 5,000
h. Paid prepaid house insurance Nu. 3,000 to BIL	Cash 147,000 (150,000 – 3,000) + Prepaid Rent 3,000	Capital 85,000	Dukar 10,000 + BOBL 50,000+ Unearned Revenue 5,000
Total	150,000	85,000	65,000

Financial position (Balance sheet) as on end of October

Particular	Amount (Nu.)
Assets:	
Cash	147,000
Prepaid rent	3,000
Total	150,000
Liabilities:	
Capital	85,000
Dukar (Account Payable) (CL)	10,000
BOBL Loan (NCL)	50,000
Unearned Revenue (CL)	5,000
Total	150,000

Solution to question No. 2

Sl.no	Assets	Liabilities	Owner's equity	Justification
	100,000	? 15,000	85,000	Total resource of the firm is Nu.100,000 and the amount that firm owes to owner is Nu.85,000. Therefore, the balance amount firm owes to outsider i.e. Nu.15,000. Assets = Capital + Liability or Liability = Assets – Capital
	? 350,000	150,000	200,000	Assets = Capital + Liability What it Owes, It Owns.
	550,000	50,000	? 500,000	Out of the total resources of the firm Nu. 500,000, firm owes Nu.50,000 to outsider. Therefore, Nu.500,000 is the amount that firm owes to owner. Assets = Capital + Liability or

$$\text{Capital} = \text{Assets} - \text{Liability}$$

Solution to question No. 3

Transactions	Assets (Nu) =	Equity (Nu.) +	Liabilities (Nu.)
a. Commenced business with cash Nu.300,000	Cash 300,000	Kinley's Capital 300,000	Nil
b. Purchased goods for Nu.150,000 and sold for Nu.200,000	Cash 350,000 (300,000-150,000+200,000) +Goods Nil (150,000-150,000)	Capital 350,000 (300,000+50,000)	Nil
c. Paid wages Nu.15,000 including prepaid wages Nu.5,000.	Cash Nu. 335,000 (350,000 - 15,000) + prepaid wages Nu.5,000	Capital 340,000 (350,000+10,000)	
d. Received rent Nu. 25,000 (including Nu.5,000 for next month)	Cash Nu. 360,000 (335,000 - 25,000) + prepaid wages Nu.5,000	Capital 360,000 (340,000 + 20,000)	Unearned Revenue 5,000
e. Purchased laptop for Nu. 35,000	Cash Nu. 325,000 (360,000 - 35,000) + prepaid wages Nu.5,000 + Equipment 35,000	Capital 360,000	Unearned Revenue 5,000
f. Purchased furniture for cash Nu. 50,000	Cash Nu. 275,000 (325,000 - 50,000) + prepaid wages Nu.5,000 + Equipment 35,000 + Furniture 50,000	Capital 360,000	Unearned Revenue 5,000
Total	365,000	360,000	5,000

Self-check for Learning

Question 5:

- i. Debit- asset
- ii. Credit- liability
- iii. Debit- asset
- iv. Credit- capital
- v. Debit- Asset
- vi. Credit- Revenue
- vii. Debit- expenses
- viii. Credit- Revenue