GOVERNMENT OF TAMILNADU

STANDARD NINE

TERM - II

VOLUME 3

SCIENCE

Untouchability is Inhuman and a Crime

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C.A

CPT
↓
ATC IPCC
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ITT
(100 Hours)
↓
Articleship
(Work under in CA)
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- Bank Management
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PREFACE

This book is developed in a holistic approach which inculcates comprehending and analytical skills. It will be helpfull for the students to understand higher secondary science in a better way and to prepare for competitive exams in future. This textbook is designed in a learner centric way to trigger the thought process of students through activities and to make them excel in learning science.

HOW TO USE THE BOOK

- This term-II science book has 9 units.
- Each unit has simple activities that can be demonstrated by the teacher and also few group activities are given for students to do under the guidance of the teacher.
- Infographics and info-bits are added to enrich the learner's scientific perception.
- The "Do you know?" and "More to know" placed in the units will be an eye opener.
- Glossary has been introduced to learn scientific terms.
- ICT corner and QR code are introduced in each unit for the digital native generation.

How to get connected to QR Code?

QR GUIDE

- Download the QR code scanner from the google play store/
  apple app store into your smartphone
- Open the QR code scanner application
- Once the scanner button in the application is clicked, camera opens and then bring it closer to the QR code in the textbook.
- Once the camera detects the QR code, a URL appears in the screen. Click the URL and go to the content page.

UNIT 1

Heat

Learning Objectives

BKLGIH

After completing this chapter, the students will be able to:

- Understand the nature of Heat.
- Identify the effects of heat.
- Differentiate the conducting powers of various substances.
- List out good and bad conductors of heat and their uses.
- Explain conduction using kinetic theory.
- Describe the experiments to show convection in fluids.
- Understand the concept of radiation.
- Define specific heat capacity.
- Define thermal capacity.
- Solve problems on specific heat capacity.
- Describe the concept of change of state.
- Define specific latent heat of fusion and specific latent heat of vaporisation.

Introduction

All the substances in our surrounding are made up of molecules. These molecules are generally at motion and posses kinetic energy. At the same time each molecule exerts a force of attraction on other molecules and so they posses potential energy. The sum of the kinetic and potential energy is called the internal energy of the molecules. This internal energy, when flows out, is called heat energy. This energy is more in hot substances and less in cold substances and flows from hot substances to cold substances. In this lesson you will study about how this heat transfer takes place. Also you will study about the effect of heat, heat capacity, change of state and latent heat.

1.1 Effects of heat

When a substance is heated, the following things can happen.

Expansion

When heat is added to a substance, the molecules gain energy and vibrate and force other molecules apart. As a result expansion takes place. You would have seen some space being left in railway tracks. It is because, during summer time, more heat causes expansion in tracks. Expansion is greater for liquids than for solids and maximum in case of gases.

Figure 1.1 Gap in railway track

Change in temperature

When heat energy is added to a substance, the kinetic energy of its particles increases and so the particles move at higher speed. This causes rise in temperature. When a substance is cooled, that is, when heat is removed, the molecules lose heat and its temperature falls.

Change in state

When you heat ice cubes, they become water and water on further heating changes into vapour. So, solid becomes liquid and liquid becomes gas, when heat is added. The reverse takes place when heat is removed.

Chemical changes

Since heat is a form of energy it plays a major role in chemical changes. In some cases, chemical reactions need heat to begin and also heat determines the speed at which reactions occur. When we cook food, we light the wood and it catches fire and the food particles become soft because of the heat energy. These are all the chemical changes taking place due to heat.

1.2 Transfer of heat

Heat does not stay where we put it. Hot things get colder and cold things get hotter. Heat is transferred from one place to another till their temperatures become equal. Heat transfer takes place when heat energy flows from the object of higher temperature to an object with lower temperature. It is shown in Fig. 1.2.

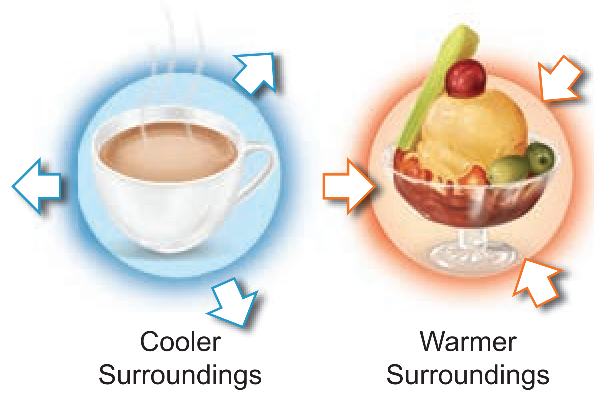


Figure 1.2 Hot and cold surroundings

Activity 1

Aim: To know about transfer of heat.

Take a glass of water and put some ice cubes into it. Observe it for some time. What happens? The ice cubes melt and disappear. Why did it happen? It is because heat energy in the water is transferred to the ice.

DO YOU KNOW?

When a dog keeps out its tongue and breathes hard, the moisture on the tongue turns into water and it evaporates. Heat energy is needed to turn a liquid into a gas, so heat is removed from dog's tongue in the process. This helps to cool the body of the dog.

Heat transfer takes place in three ways:

i. Conduction, ii. Convection, iii. Radiation

1.2.1 Conduction

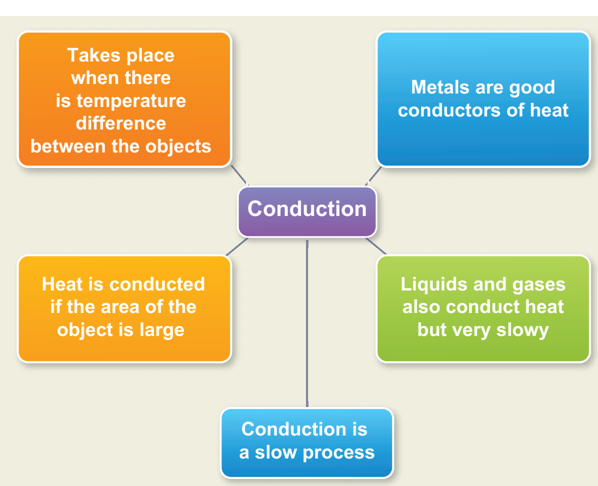
Activity 2

Aim: To know about conduction of heat.

Take a cup of hot water in a glass and leave a silver spoon in it for some time. You can feel that the spoon has become hot. Do you know why it happened? It is because of the transfer of heat from the bottom of the spoon to the top.

In solids, molecules are closely arranged so that they cannot move freely. When one end of the solid is heated, molecules at that end absorb heat energy and vibrate fast at their own positions. These molecules in turn collide with the neighboring molecules and make them vibrate faster and so energy is transferred. This process continues till all the molecules receive the heat energy.

The process of transfer of heat in solids from a region of higher temperature to a region of lower temperature without the actual movement of molecules is called conduction.



Activity 3

Aim: To compare the conducting powers of various metals.

Take metal rods of copper, aluminium, brass and iron. Fix a match stick to one end of each rod using a little melted wax. When the temperature of the far ends reach the melting point of wax, the matches drop off. While conducting the experiment, it is observed that the match stick on the copper rod would fall first, showing copper as the best conductor followed by aluminum, brass and then iron.

Conduction in daily life

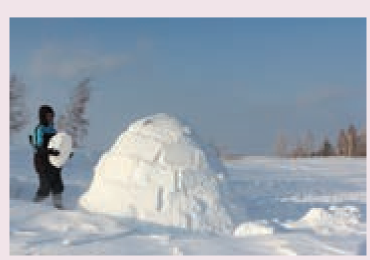
i. Metals are good conductors of heat. So, aluminium is used for making utensils to cook food quickly.

ii. Mercury is used in thermometers because it is a good conductor of heat.

iii. We wear woolen clothes is winter to keep ourselves warm. Air, which is a bad conductor, does not allow our body heat to escape.

DO YOU KNOW?

Snow's effective insulating properties enable the inside of the igloo to remain relatively warm. In some cases, a single block of clear ice is inserted to allow light into the igloo. Animal skins are used as door flaps to keep warm air in. Igloos used as winter shelters had beds made of ice and caribou furs. These 'ice beds' are unique to the region and Inuit culture.



1.2.2 Convection

Activity 4

Aim: To know about transfer of heat through convection in liquids.

Drop a few crystals of potassium permanganate down to the bottom of a beaker containing water. When the beaker is heated just below the crystals, by a small flame, purple streaks of water rise upwards and fan outwards.

In the above activity, water molecules at the bottom of the beaker receive heat energy and move upward and replace the molecules at the top. Same thing happens in air also. When air is heated the air molecules gain heat energy allowing them to move further apart. Warm air is less dense than cold air and will rise. Cooler air moves down to replace the air that has risen. It heats up, rises and is again replaced by cooler air, creating a circular flow.

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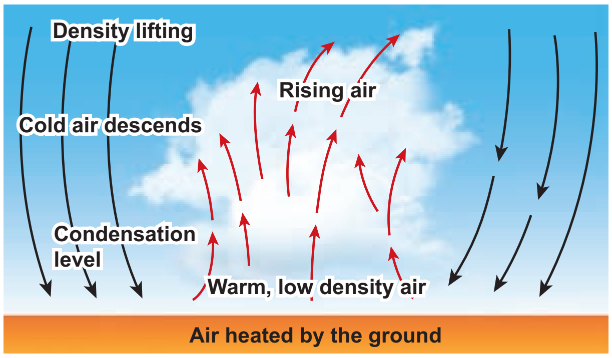


Figure 1.3 Convection in air

Convection is the flow of heat through a fluid from places of higher temperature to places of lower temperature by movement of the fluid itself.

Convection in daily life

Hot air balloons

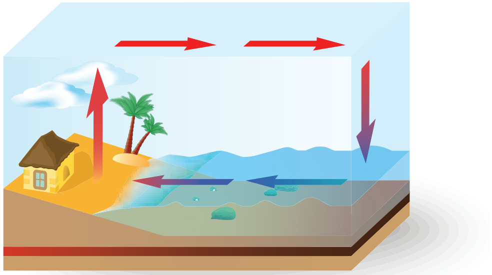
Air molecules at the bottom of the balloon get heated by a heat source and rise. As the warm air rises, cold air is pushed downward and it is also heated. When the hot air is trapped inside the balloon, it rises.

Figure 1.4 Hot air balloon

Breezes

During day time, the air in contact with the land becomes hot and rises. Now the cool air over the surface of the sea replaces it. It is called sea breeze. During night time, air above the sea is warmer. As the warmer air over the surface of the sea rises, cooler air above the land moves towards the sea. It is called land breeze.

Sea breeze



Land breeze

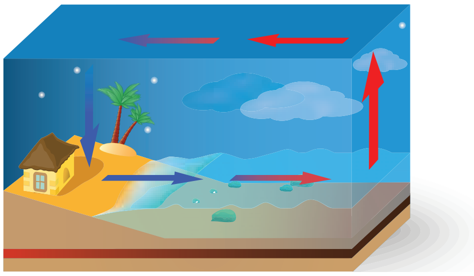


Figure 1.5 Land breeze and sea breeze

Winds

Air flows from area of high pressure to area of low pressure. The warm air molecules over hot surface rise and create low pressure. So, cooler air with high pressure flows towards low pressure area. This causes wind flow.

Chimneys

Tall chimneys are kept in kitchen and industrial furnaces. As the hot gases and smoke are lighter, they rise up in the atmosphere.

> **DO YOU KNOW?** Black marks often appear on the wall or ceiling above a lamp or fan. They are caused by dust being carried upwards in air convection currents produced by hot lamp or the running fan.

1.2.3 Radiation

Radiation is a method of heat transfer that does not require particles to carry the heat energy. In this method, heat is transferred in the form of waves from hot objects in all direction. Radiation can occur even in vacuum whereas conduction and convection need matter to be present. Radiation consists of electromagnetic waves travelling at the speed of light. Thus, radiation is the flow of heat from one place to another by means of electromagnetic waves.

Transfer of heat energy from the sun reaches us in the form of radiation. Radiation is emitted by all bodies above 0 K. Some objects absorb radiation and some other objects reflect them. This can be shown using the demonstration set up shown in Fig 1.6. In this figure the inside surface of one plate is shiny and of the other is dull black. Coins are stuck on the outside of each plate with candle wax. If the heater is midway between the plates they each receive the same amount of radiation. After few minutes the wax on the black plate melts and the coin falls off. The shiny plate stays cool and the wax on it is un-melted.

Figure 1.6 Black and shiny metal surface.

Radiation in daily life

i. White or light colored cloths are good reflectors of heat. They keep us cool during summer.

ii. Base of cooking utensils is blackened because black surface absorb more heat from the surrounding.

iii. Surface of airplane is highly polished because it helps to reflect most of the heat radiation from the sun.

> **DO YOU KNOW?** While firing wood, we can observe all the three ways of heat transfer. Heat in one end of the wood will be transfered to other end due to conduction. The air near the wood will become warm and replace the air above. This is convection. Our hands will be warm because heat reaches us in the form of radiation.

1.3 Concept of temperature

Temperature is the degree of hotness or coolness of a body. The hotter the body is higher is its temperature.

1.3.1 Unit of Temperature

The SI unit of temperature is ***kelvin*** **(K)**. For day to day applications, ***Celsius*** (°C) is used. Temperature is measured with a thermometer.

1.3.2 Temperature scales

There are three scales of temperature.

i. Fahrenheit scale

ii. Celsius or Centigrade scale

iii. Kelvin or Absolute scale

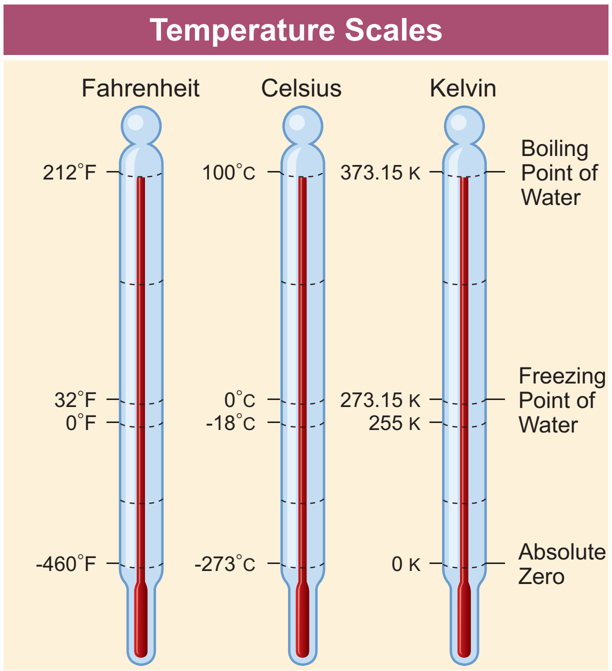


Figure 1.7 Types of temperature scales

Fahrenheit scale

In Fahrenheit scale, 32 °F and 212 °F are the freezing point and boiling points respectively. Interval has been divided into 180 parts.

Celsius temperature scale

In Celsius scale, also called centigrade scale, 0°C and 100 °C are the freezing point and boiling respectively. Interval has been divided into 100 parts. The formula for converting a Celsius scale to Fahrenheit scale is:

$$F=\frac{9}{5}C+32$$

The formula for converting a Fahrenheit scale to Celsius scale is:

$$C=\frac{5}{9}(F-32)$$

Kelvin scale (Absolute scale)

Kelvin scale is known as the absolute scale. On the Kelvin scale 0 K represents absolute zero, the temperature at which the molecules of a substance have their lowest possible energy. The solid, liquid, gaseous phases of water can coexist in equilibrium at 273.16 K.

Kelvin is defined as 1/273.16 of the triple point temperature.

The formula for converting a Celsius scale to Kelvin scale is:

$$K = C + 273.15$$

The formula for converting a Kelvin scale to Celsius scale is:

$$C = K - 273.15$$

Absolute zero

The temperature at which the pressure and volume of a gas theoretically reaches zero is called absolute zero. This is shown in Figure 1.8.

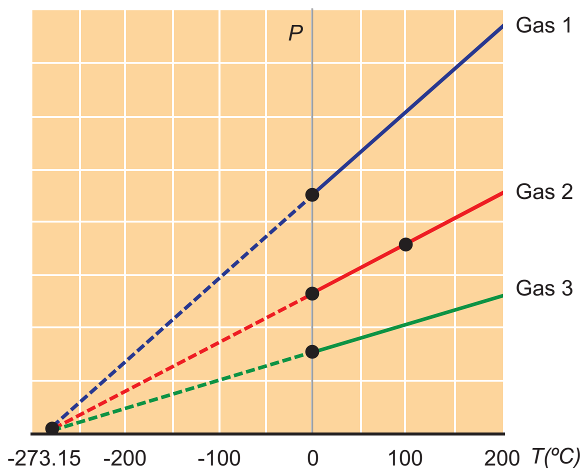


Figure 1.8 Variation of pressure (P) with temperature (T).

For all gases, the pressure extrapolates to zero at the temperature -273.15 ˚C. It is known as absolute zero or 0 K. Some base line temperatures in the three temperature scales are shown in Table 1.1.

Table. 1.1 Some baseline temperatures in the three temperature scales.

Temperature	Kelvins (K)	Degrees Celcius (°C)	Degrees Fahrenheit (°F)
Boiling point of water	373.15	100	212
Melting point of ice	273.15	0	32
Absolute zero	0	-273	-460

Exercise 1.1

Convert the following

i. 25 °C to Kelvin

ii. 200 K to °C

Solution:

i. $(T_K) = (T_{°C}) + 273.15$

$(T_K) = 25 + 273.15 = 298.15$ K

ii. $(T_{°C}) = (T_K) - 273.15$

$(T_{°C}) = 200 - 273.15 = -73.15$ °C

Exercise 1. 2

Convert the following

i. 35˚ C to Fahrenheit (°F)

ii. 14˚ F to ˚C

Solution:

i. T(°F) = T(°C) × 1.8 + 32

T(°F) = 25° C × 1.8 + 32 = 77° F

ii. T(°C) = (T(°F) – 32)/ 1.8

T(°C) = (14°F – 32)/ 1.8 = -10° C

1.4 Specific heat capacity

You might have felt that the land is cool in the morning and hot during day time. But, water in a lake will be almost at a particular temperature both in the morning as well as in the afternoon. Both are subjected to same amount of heat energy from the Sun, but they react differently. It is because both of them have different properties. In general the amount of heat energy absorbed or lost by a body is determined by three factors.

1. Mass of the body
2. Change in temperature of the body
3. Nature of the material of the body

We can understand this from the following observations.

Observation:1

Quantity of heat required to raise the temperature of 1 litre of water will be more than the heat required to raise the temperature of 500 ml of water. If Q is the quantity of heat absorbed and m is the mass of the body, then Q α m

Observation: 2

Quantity of heat energy (Q) required to raise the temperature of 250 ml of water to 100^{0}C is more than the heat energy required to raise the temperature to 50^{0}C. Here, Q α ΔT, where ΔT is the change in temperature of the body.

Hence, from the above two observations, heat lost or gained by a substance when its temperature changes by ΔT is:

$$Q \ \alpha \ m\Delta T$$

$$Q = mC\Delta T \qquad (1.1)$$

From the above equations, the absolute temperature and energy of a system are proportional to each other. The proportionality constant is the specific heat capacity (c) of the substance.

In order to understand the specific heat capacity of the substance, think of heating 500 ml of water and 500 ml of oil. Which will be heated first? Why? It is because heat gained by a body depends upon the nature of the substance. The capacity of a substance to gain heat energy is denoted by the term specific heat capacity. Mathematically it is derived from the equation (1.1) as, $C=Q/m\Delta T$

Thus, specific heat capacity of a substance is defined as the amount of heat required to raise the temperature of 1 kg of the substance by 1^{0}C or 1 K. The SI unit of specific heat capacity is $Jkg^{-1}\ K^{-1}$. The most commonly used units of specific heat capacity are J/kg^{0}C and J/g^{0}C.

Among all the substances, water has the highest specific heat capacity and its value is 4200 J/kg^{0}C. So, water absorbs a large amount of heat for unit rise in temperature. Thus, water is used as a coolant in car radiators and factories to keep engines and other machinery parts cool. It is because of the same reason the temperature of water in the lake does not change much during day time. Specific heat capacities of some common substances are given in Table 1.2.

DO YOU KNOW?

Water in its various form, has different specific heat capacities.

Water (liquid State) = 4200 $JKg^{-1}\ K^{-1}$

Ice (Solid State) = 2100 $JKg^{-1}\ K^{-1}$

Steam (gaseous State) = 460 $JKg^{-1}\ K^{-1}$

Table 1.2 Specific heat capacity of some common substances

Substance	Specific heat capacity in $JKg^{-1}\ K^{-1}$
Lead	130
Mercury	139
Brass	380
Zinc	391
Copper	399
Iron	483
Glass (flint)	504
Aluminium	882
Kerosene	2100
Ice	2100
Sea Water	3900
Water	4180

Exercise1.3

Calculate the heat energy required to raise the temperature of 2kg of water from 10°C to 50°C. Specific heat capacity of water is 4200 $JKg^{-1}\ K^{-1}$.

Solution:

Given m = 2 Kg, ΔT = (50-10) = 40°C

Or in terms of Kelvin (323.15-283.15) = 40K, C= 4200 J Kg^{-1} K^{-1}

$\therefore$ Heat energy required, Q = m $\times$ C $\times$ ΔT = 2 $\times$ 4200 $\times$ 40 = 3,36,000 J

Exercise 1.4

Some heat energy is given to 120g of water and its temperature rises by 10K. When the same amount of heat energy is given to 60g of oil, its temperature rises by 40K. The specific heat capacity of water is 4200JKg^{-1} K^{-1}. Calculate:

i) The amount of heat energy in joule given to water.

ii) The specific heat capacity of oil.

Solution:

i. Heat energy given to water = Mass of water $\times$ Specific heat capacity of water $\times$ rise in temperature.

= 120/1000 kg $\times$ 4200 JKg^{-1} $K^{-1}$$\times$ 10 K

= 5040 J.

ii. Since same heat energy is given to oil, heat energy given to oil = 5040 J

Let C in JKg^{-1} K^{-1} be the specific heat capacity of oil,

$$\text{Then C} = \frac{\text{amount of heat energy given to oil}}{\text{mass of oil} \times \text{rise in temperature}}$$

$$= \frac{5040 \text{ J}}{\frac{(60)}{(1000)}\text{kg} \times 40 \text{ K}}$$

= 2100 JKg^{-1} K^{-1}.

1.5 Heat capacity or Thermal capacity

Now, you are familiar with specific heat capacity. It is the heat required to raise the temperature of a unit mass of the body by 1^0C. But, heat capacity is the heat required to raise the temperature of a entire mass of the body by 1^0C. Thus, heat capacity or thermal capacity is defined as the amount of heat energy required to raise the temperature of a body by 1^0C. It is denoted by C'.

$$\text{Heat Capacity} = \frac{\text{Quantity of heat required}}{\text{Rise in temperature}}$$

$$C' = Q/t$$

SI unit of heat capacity is J/K. It is also expressed in cal/°C, kcal/°C or J/°C.

As we saw earlier, if C is the heat required to raise the temperature of unit mass of the body by 1^0C then the heat required to raise the temperature of 'm' mass of the substance is m C. So, heat capacity is also given as, $C' = m \times C$.

> Note: The symbol of specific heat capacity is C and that of Heat capacity is C'. It should not be confused with the unit of temperature degree Celsius (°C)

Exercise 1.5

An iron ball requires 5000 J heat energy to raise its temperature by 20°C. Calculate the heat capacity of the iron ball.

Solution:

Given, Q = 5000 J, ΔT = 20°C or 20 K

$$\text{Heat Capacity C} = \frac{\text{Heat energy required, Q}}{\text{Rise in temperature, } \Delta T}$$

$$= \frac{5000}{20}$$

$$= 250 \text{ JK}^{-1}$$

1.6 Change of state

Any matter around us can be in three forms: solid, liquid and gas. These forms of matter are called states of matter. Depending upon the temperature, pressure and transfer of heat, matter is converted from one state to another. The conversion of matter from one state to another is called change of state in matter. The process of changing of a substance from one physical state to another at a definite temperature is defined as change of state.

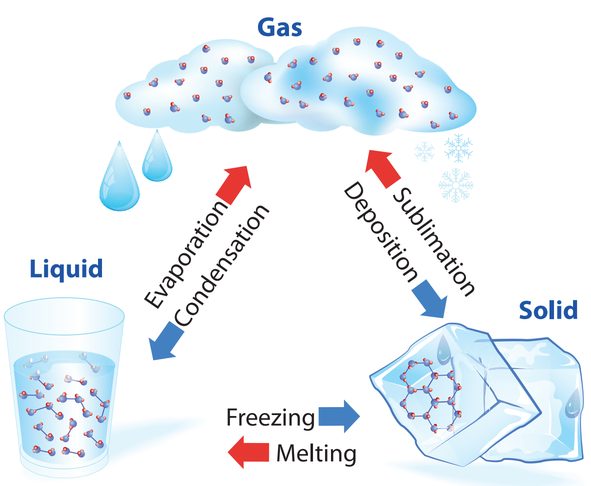


Figure 1.9 Change of state of matter

For example, water molecules are in liquid state at normal temperature. When water is heated to 100°C, it becomes steam which is a gaseous state of matter. On reducing the temperature of the steam it becomes water again. If we reduce the temperature further to 0°C, it becomes ice which is a solid state of water. Ice on heating, becomes water again. Thus, water changes its state when there is a change in temperature. There are different such processes in the change of state in matter. The figure 1.9 shows various processes of change state.

Melting – Freezing

The process in which a solid is converted to liquid by absorbing heat is called melting or fusion. The temperature at which a solid changes its state to liquid is called melting point. The reverse of melting is freezing. The process in which a liquid is converted to solid by releasing heat is called freezing. The temperature at which a liquid changes its state to solid is called freezing point. In the case of water, melting and boiling occur at 0°C.

Boiling-Condensation

The process in which a liquid is converted to vapor by absorbing heat is called boiling or vaporization. The temperature at which a liquid changes its state to gas is called boiling point. The process in which a vapor is converted to liquid by releasing heat is called condensation. The temperature at which a vapour changes its state to liquid is called condensation point. Boiling point as well as condensation point of water is 100°C.

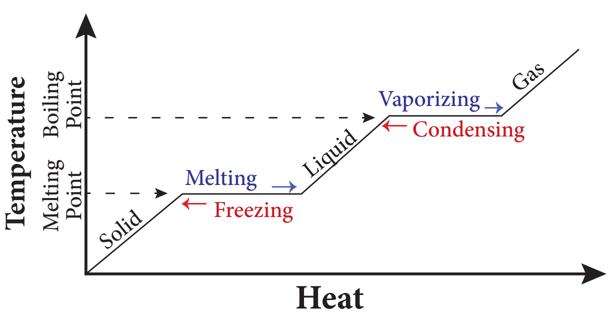


Figure 1.10 Various stages of conversion of state of matter

Sublimation

Some solids like dry ice, iodine, frozen carbon dioxide and naphthalene balls change directly from solid state to gaseous state without becoming liquid. The process in which a solid is converted to gaseous state is called sublimation.

Various stages of conversion of state of matter with heat with the corresponding change in temperature is shown in Figure 1.10

1.7 Latent heat

The word, 'latent' means hidden. So, latent heat means hidden heat or hidden energy. In order to understand latent heat, let us do the activity given below.

Activity 5

Aim:To know about latent heat of water..

Take some crushed ice cubes in a beaker and note down the temperature using thermometer. It will be 0^0C. Now heat the ice in the beaker. You can observe that ice is melting to form water. Record the temperature at regular intervals and it will remain at 0^0C until whole ice is converted to liquid. Now heat the beaker again and record the temperature. You can notice that the temperature will rise up to 100^0C and the temperature will be at 100^0C even after continuous heating until the whole mass of water in the beaker is vaporized..

In the above activity, the temperature is constant at 0^0C until entire ice is converted into liquid and again constant at 100^0C until all the ice is converted into vapor. Why? It is because, when a substance changes from one state to another, a considerable amount of heat energy is absorbed or liberated. This energy is called latent heat. Thus, latent heat is the amount of heat energy absorbed or released by a substance during a change in its physical sates without any change in its temperature.

Heat energy is absorbed by a solid during melting and an equal amount of heat energy is liberated by the liquid during freezing, without any temperature change. It is called latent heat of fusion. In the same manner, heat energy is absorbed by a liquid during vaporization and an equal amount of heat energy is liberated by the vapor during condensation, without any temperature changes. This is called latent heat of vaporization.

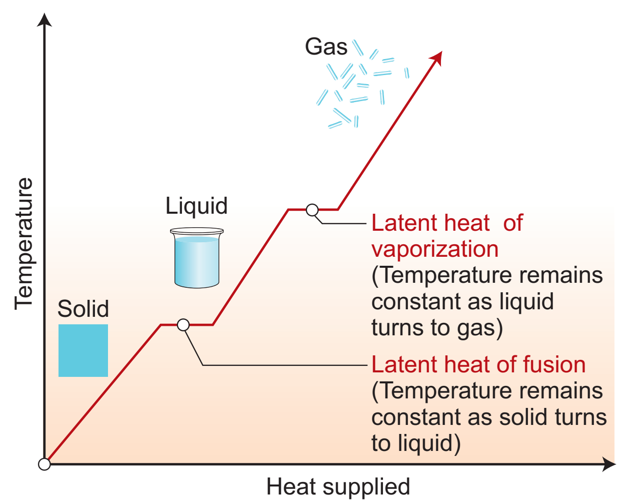


Figure 1.11 Latent heat

DO YOU KNOW?

Steam burn is more damaging than a burn with boiling water at the same temperature?

When steam hits our skin, it condenses to water and then cools down to the temperature of skin. Now, the energy released will be due to latent heat and fall in temperature. Whereas when boiling water hits our skin, there is no phase transition but only fall in temperature and the heat transferred to skin will be only due to cooling. Also, the loss of energy that is released from steam hitting our skin occurs quickly and in a small localized area, therefore causing damage to our cells.

Specific latent heat

Latent heat when expressed per unit mass of a substance, it is called specific latent heat. It is denoted by the symbol L. If Q is the amount of heat energy absorbed or liberated by m mass of a substance during its change of phase at a constant temperature, then specific latent heat is given as L = Q/m.

Thus, specific latent heat is the amount of heat energy absorbed or liberated by unit mass of a substance during change of state without causing any change in temperature. The SI unit of specific latent heat is J/kg.

Exercise 1.6

How much heat energy is required to melt 5 kg of ice? (Specific latent heat of ice = 336 Jg-1)

Solution:

Given, m = 5 Kg = 5000g, L = 336 Jg-1

Heat energy required = m x L

= 5000 x 336

= 1680000J or 1.68×10^6 J

Exercise 1.7

How much boiling water at 100°C is needed to melt 2kg of ice so that the mixture which is all water is at 0°C?

[Specific heat capacity of water = 4.2 JKg^{-1} and specific latent heat of ice = 336 Jg^{-1}].

Solution:

Given, Mass of ice = 2 kg = 2000 g.

Let m be the mass of boiling water required.

Heat lost = Heat gained.

m x c x Δt = m x L

m x 4.2 x (100-0) = 2000 x 336

$$m = \frac{2000 \times 336}{4.2 \times 100}$$

= 1600g or 1.6 kg.

Points to remember

- All the molecules have kinetic energy as well as potential energy.
- Expansion, change in temperature and change in state are the effects of heat.
- Heat is transferred from hot region to cold region.
- Heat is transferred in three forms: conduction, convection and radiation.
- Conduction takes place in solids and convection takes place in liquids and gases.
- Radiation takes place in the form of electromagnetic waves.
- The SI unit of temperature is Kelvin (K).
- Kelvin scale is known as the absolute scale.
- There are three scales of temperature: Fahrenheit scale, Celsius or Centigrade scale and Kelvin or Absolute scale.
- Amount of heat energy absorbed or lost by a body is determined by three factors: mass of the body, change in temperature of the body, nature of the material of the body.
- The SI unit of specific heat capacity is $Jkg^{-1} K^{-1}$.
- Among all the substances, water has the highest specific heat capacity.
- SI unit of heat capacity is J/K.
- The symbol of specific heat capacity is C and that of Heat capacity is C'.
- Depending upon the temperature, pressure and transfer of heat, matter is converted from one state to another.

A-Z GLOSSARY

Conduction	Process of transfer of heat in solids from a region of higher temperature to a region of lower temperature without the actual movement of molecules.
Convection	Flow of heat through a fluid from places of higher temperature to places of lower temperature by movement of the fluid itself.
Radiation	Flow of heat from one place to another by means of electromagnetic waves.
Temperature	It is the degree of hotness or coolness of a body.
Kelvin	It is defined as1/(273.16) of the triple point temperature.
Specific heat capacity	The amount of heat required to raise the temperature of 1 kg of the substance by 10^0C or 1 K.
Heat capacity or thermal capacity	The amount of heat energy required to raise the temperature of a body by 1^0C.
Melting or fusion	Process in which a solid is converted to liquid by absorbing heat.
Freezing	Process in which a liquid is converted to solid by releasing heat.
Boiling or vaporization	Process in which a liquid is converted to vapour by absorbing heat.
Condensation	Process in which a vapor is converted to liquid by releasing heat.
Latent heat	Amount of heat energy absorbed or released by a substance during a change in its physical sates without any change in its temperature.
Specific latent heat	Amount of heat energy absorbed or liberated by unit mass of substance during change of state without causing any change in temperature.

TEXT BOOK EXERCISES

BL58LS

I. Choose the correct answer:

1. Calorie is the unit of
   a) heat b) work
   c) temperature d) food

2. SI unit of temperature is
   a) fahrenheit b) joule
   c) celsius d) kelvin

3. The Specific heat capacity of water is
   a) 4200 $Jkg^{-1}K^{-1}$ b) 420 $Jg^{-1}K^{-1}$
   c) 0.42 $Jg^{-1}K^{-1}$ d) 4.2 $Jkg^{-1}K^{-1}$

4. Two cylindrical rods of same length have the area of cross section in the ratio 2:1. If

both the rods are made up of same material, which of them conduct heat faster?

a) Both rods b) Rod-2

c) Rod-1 d) None of them

5. Two cylinders of equal height and radius are made of copper and aluminium. Which of them conducts heat faster?

a) Copper rod b) Aluminium rod

c) Both of them d) None of them

6. In which mode of transfer of heat, molecules pass on heat energy to neighbouring molecules without actually moving from their positions?

a) Radiation b) Conduction

c) Convection d) Both B and C

7. A device in which the loss of heat due to conduction, convection and radiation is minimized is

a) Solar cell b) Solar cooker

c) Thermometer d) Thermos flask

II. Fill in the blanks:

1. The fastest mode of heat transfer is ______.
2. During day time, air blows from ____________ to ____________.
3. Liquids and gases are generally ____________ conductors of heat.
4. The fixed temperature at which matter changes state from solid to liquid is called ____________.

III. Assertion and Reason type questions:

Mark the correct choice as:

a. If both assertion and reason are true and reason is the correct explanation of assertion.
b. If both assertion and reason are true but reason is not the correct explanation of assertion.
c. If assertion is true but reason is false.
d. If assertion is false but reason is true.

1. **Assertion:** Food can be cooked faster in copper bottom vessels.

   Reason: Copper is the best conductor of heat.

2. **Assertion:** Maximum sunlight reaches earth's surface during the afternoon time.

   Reason: Heat from the sun reaches earth's surface by radiation.

3. **Assertion:** When water is heated up to $100^{\circ}C$, there is no raise in temperature until all water gets converted into water vapour.

   Reason: Boiling point of water is $10^{\circ}C$.

4. **Assertion:** Aluminium conducts heat faster than copper.

   Reason: Specific heat capacity of aluminium is higher than that of copper.

IV. Short answers questions:

1. Define conduction.
2. Ice is kept in a double-walled container. Why?
3. How does the water kept in an earthen pot remain cool?
4. Differentiate convection and radiation.
5. Why do people prefer wearing white clothes during summer?
6. What is specific heat capacity?
7. Define thermal capacity.
8. Define specific latent heat capacity.

V. Answer in detail:

1. Explain convection in daily life.
2. What are the changes of state in water? Explain.
3. How can you experimentally prove that water is a bad conductor of heat? How is it possible to heat water easily while cooking.

VI. Complete the missing terms in the following table:

Process	Phase I	Phase II
Sublimation	-	Vapour
Solidification	-	Solid
-	Solid	Liquid
Freezing	Liquid	-
Condensation	-	liquid

VII. Identify the answer for the following

O	N	E	L	A	T	E	N	T	S
Y	O	M	N	E	H	E	A	T	O
S	P	E	C	I	F	I	C	S	T
S	J	O	U	L	E	X	B	I	A
C	O	N	V	E	C	T	I	O	N

Clues:

1. A form of energy.
2. Unit for heat energy.
3. Hidden heat
4. If the mass of substance is mentioned, then heat capacity can be replaced with ------- heat capacity.
5. Process taking place in fluids due to heat exchange.

Problems:

1. What is the heat in joules required to raise the temperature of 25 grams of water from 0°C to 100°C? What is the heat in Calories?

   (Specific heat of water = 4.18 J/g°C)

   (Ans. 10450 J)

2. What could be the final temperature of a mixture of 100 g of water at 90°C and 600g of water at 20°C. **(Ans. 30°C)**

3. How much heat energy is required to change 2 kg of ice at 0°C into water at 20°C? (Specific latent heat of fusion of water = 3,34,000J/kg, Specific heat capacity of water = 4200$JKg^{-1}K^{-1}$). **(Ans. 8,36,000 J)**

4. A piece of aluminium of mass 0.5 kg is heated to 100°C and then placed in 0.4 kg of water at 10°C. If the resulting temperature of the mixture is 30°C, what is the specific heat capacity of aluminium? (SHC of water = 4,200J/Kg°C)

   (Ans. 960J/kg°C)

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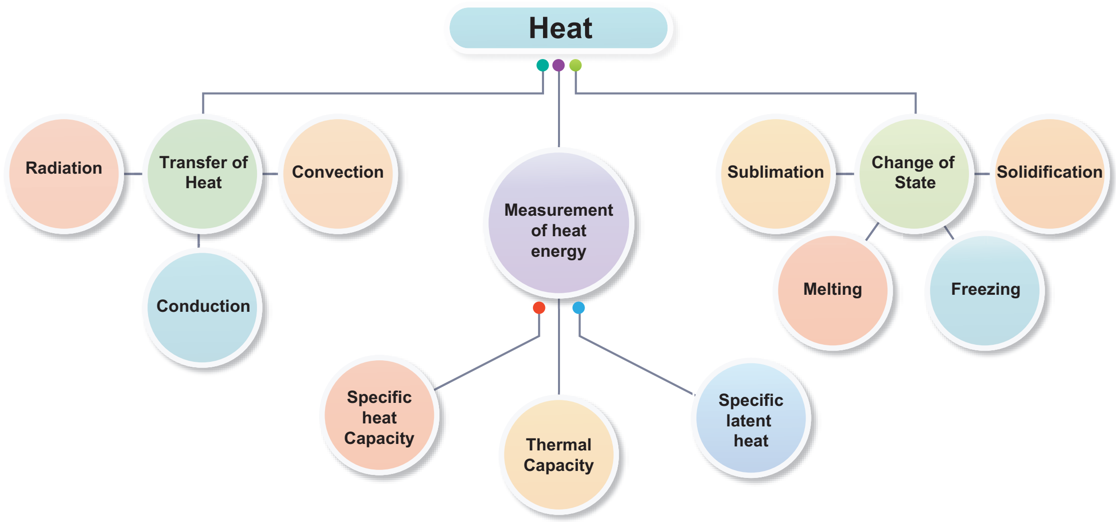
3. Goyal R.P., and Tripathi S.P (2016). Concise physics, Selena publishers, New Delhi.
4. Frank New Certificate Physics. Frank Bros & co, Chennai.

INTERNET RESOURCES

1. https://betterlession.com
2. http://www.britannica.com
3. http://study.com
4. http://www.sciencelearn.org



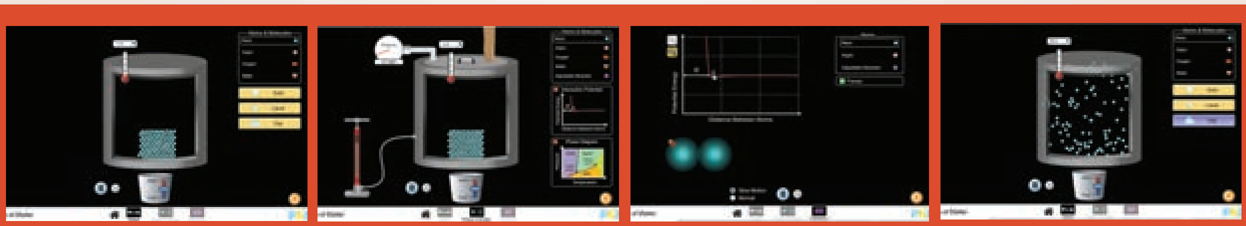
ICT CORNER

States of Matter - Effects of Heat changes

Explore this activity to know about the heat changes in the states of matter.

Steps

- Copy and paste the link given below or type the URL in the browser. Click the option States.
- You can find Atom & Molecules with four options – Neon, Argon, Oxygen and Water. You can also find Solid, Liquid and Gas options.
- Click any one of the Atoms & Molecules to stimulate by holding the Heat or Cool option under the simulation chamber.
- You can also try the simulation by changing the Solid, Liquid and Gas options too.
- The temperature option can be changed to Fahrenheit or Celsius.



Step1 Step2 Step3 Step4

Browse in the link:

URL: https://phet.colorado.edu/sims/html/states-of-matter/latest/states-of-matter_en.html

*Pictures are indicative only

B467_SCI_9_T2_EM

UNIT 2

Electric charge and electric current

BLE4NF

Learning Objectives

After completing this lesson, students will be able to:

- Understand the electric charge, electric field and Coulomb's law
- Explain concepts of electric current, voltage, resistance and Ohm's law
- Draw electrical circuit diagrams, series and parallel circuits
- Explain effects of electric current like heating or thermal effect , chemical effect , magnetic effect
- Understand direct and alternating currents
- Know safety aspects related to electricity

Introduction

Like mass and length, electric charge also is a fundamental property of all matter. We know that matter is made up of atoms and molecules. Atoms have particles like electrons, protons and neutrons. By nature, electrons and protons have negative and positive charges respectively and neutrons do not have charge. An electric current consists of moving electric charges. Electric current is the flow of charges just like water currents are due to the flow of water molecules. Water molecules tend to flow from areas of higher gravitational potential to lower gravitational potential. Similarly, electric current flows from higher electric potential to lower electric potential. Electricity is an important source of energy in the modern times.

2.1 Electric charges

We know that all matter is made up of tiny particles called, atoms. Inside each atom there is a nucleus with positively charged protons and chargeless neutrons and negatively charged electrons orbiting the nucleus. Usually there are as many electrons as there are protons and the atoms themselves are neutral.

As electrons are revolving in the orbits of an atom, they can be easily removed from an atom and also added to it. If an electron is removed from the atom, the atom becomes positively charged. Then it becomes a positive ion. If an electron is added in excess to an atom then the atom is negatively charged. This atom is called negative ion. More than one electron can also be removed from or added to atoms to make them accordingly more positive and more negative (Fig. 2.1).

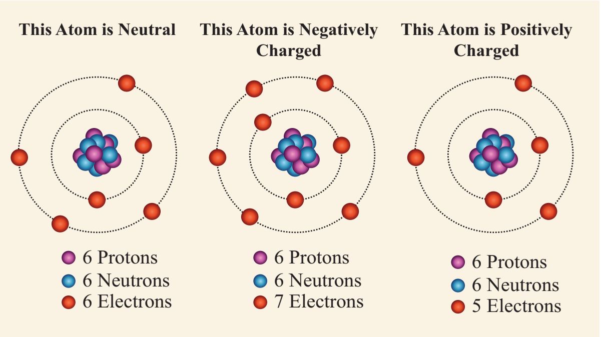


Figure 2.1 Atoms and charges

When you rub a plastic comb on your dry hair, the comb obtains power to attract small pieces of paper, is it not? When you rub the comb vigorously, electrons from your hair leave and accumulate on the edge of the comb. Your hair is now positively charged as it has lost electrons. The comb is negatively charged as it has gained electrons (Fig. 2.2).

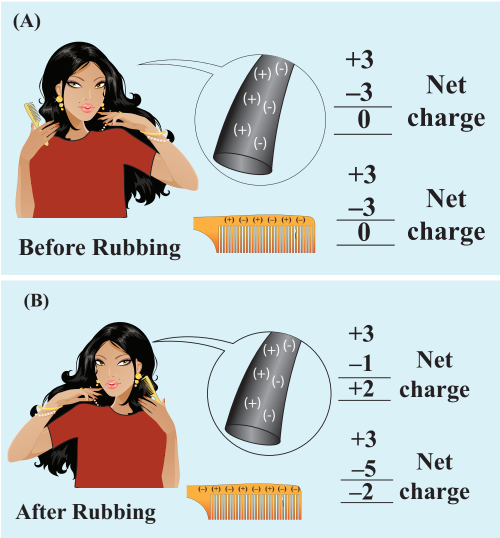
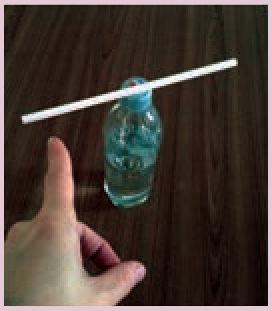


Figure 2.2 Frictional electricity

Activity 1

Take a straw which is used for drinking cool drinks. Cut a piece of it and place it on a plastic cap of a bottle as shown in the figure. Switch off the fan so that the piece does not fly away. Rub your fingers against a muslin or terri-cotton cloth and then bring it near the tip of the piece of straw. Observe what happens to it? It rotates because of deflection, doesn't it? Why does it deflect? Now instead of your finger bring another straw which is rubbed as said. The deflection is in the opposite direction. Can you give the reasons?




2.1.1 Measuring electric charge

Electric charge is measured in coulomb and the symbol for the same is C. The charge of an electron is numerically a very tiny value. The charge of an electron (represented as e) is the fundamental unit with a charge equal to 1.6×10^{-19} C. This indicates that any charge (q) has to be an integral multiple (n) of this fundamental unit of electron charge (e).

$$q = ne$$

here, n is a whole number.

DO YOU KNOW?

There is a wrong understanding that we need protons to get a positive charge. Actually, protons are well seated inside the nucleus of an atom. They cannot be easily removed from or added to the nucleus of an atom. We deal only with electrons for getting a negative as well as positive ions. The excess electrons make an object negative and deficit of electrons make it positive.

Can you guess how many electrons accumulate to make 1 C of electric charge?

Exercise 2.1

How many electrons will be there in one coulomb of charge?

Solution:

Charge on 1 electron, $e = 1.6 \times 10^{-19}$ C

$q=ne$ or $n=q/e$

∴ number of electrons in 1 coulomb

$$= \frac{1}{1.6 \times 10^{-19}} = 6.25 \times 10^{18} \text{ electrons}$$

Practically, we also have μC (micro coulomb) nC (nano coulomb)and pC (pico coulomb) as units of electric charge.

1 μC = 10^{-6} C, 1nC=10^{-9} and 1pC = 10^{-12}C

Electric charge is additive in nature. The total electric charge of a system is the algebraic sum of all the charges located in the system. For example, let us say a system has two charges +5C and −2C. Then the total or net charge on the system is, (+5C) + (−2C) = +3C.

2.1.2 Electric force

Among electric charges there are two types of electric force (F). One is attractive and another is repulsive. The like charges repel and unlike charges attract. **The force existing between the charges is called as 'electric force'.** These forces are non-contact forces, and hence can be experienced even when the charges are not in contact.

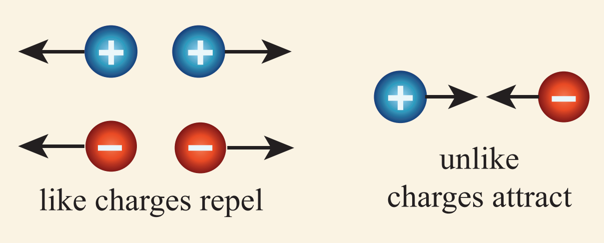


Figure 2.3 Electrostatic forces

The numerical value (magnitude) of electric force between two charges depend on the,

i. value of charges on them,
ii. distance between them and
iii. nature of medium between them.

DO YOU KNOW?

Electrostatic forces between two point charges obey Newton's third law. The force on one charge is the action and on the other is reaction and vice versa.

2.1.3 Electric field

The region in which a charge experiences electric force forms the 'electric field' around the charge. Often electric field (E) is represented by lines and arrowheads indicating the direction of the electric filed (Fig. 2.4). The direction of the electric field is the direction of the force that would act on a small positive charge. Therefore the lines representing the electric field are called 'electric lines of force'. **The electric lines of force are straight or curved paths along which a unit positive charge tends to move in the electric field.** Electric lines of force are imaginary lines. The strength of an electric field is represented by how close the field lines are to one another.

For an isolated positive charge the electric lines of force are radially outwards and for an isolated negative charge they are radially inwards.

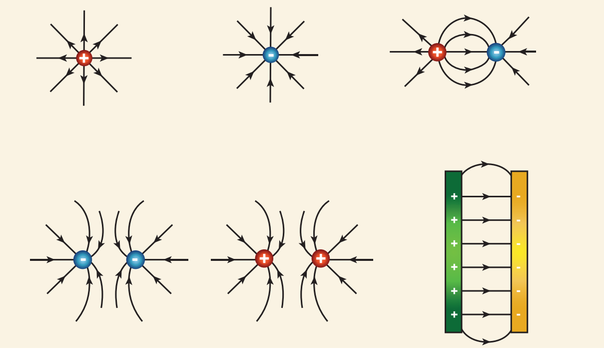


Figure 2.4 Electric lines of force

Electric field at a point is a measure of force acting on a unit positive charge placed at that point. A positive charge will experience force in the direction of electric field and a negative charge will experience in the opposite direction of electric field.

2.1.4. Electric potential

Though there is an electric force (either attractive or repulsive) existing among the charges, they are still kept together, is it not?. We now know that in the region of electric charge there is an electric field. Other charges experience force in this field and vice versa. There is a work done on the charges to keep them together. This results in a quantity called 'electric potential'.

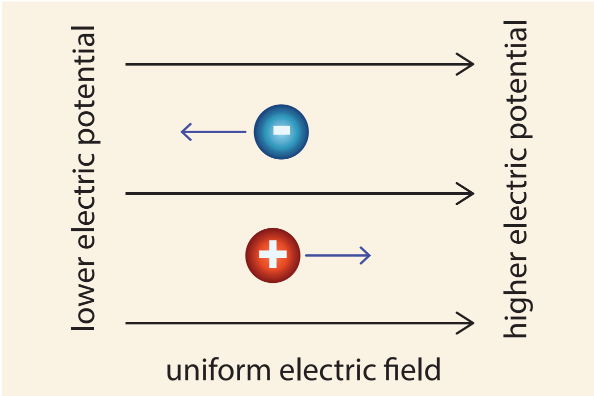


Figure 2.5 Electric potential and Electric field

Electric potential is a measure of the work done on unit positive charge to bring it to that point against all electrical forces. The electric potential (V) near positive charges is positive and near a negative charges is negative. Other positive charges have a tendency to move from higher potential to lower potential and negative charges the other way.

2.2 Electric current

When the charged object is provided with a conducting path, electrons start to flow through the path from higher potential to lower potential region. Normally, the potential difference is produced by a cell or battery. When the electrons move, we say that an electric current is produced. That is, an electric current is formed by moving electrons.

2.2.1 Direction of current

Before the discovery of the electrons, scientists believed that an electric current consisted of moving positive charges. Although we know this is wrong, the idea is still widely held, as the discovery of the flow of electrons did not affect the basic understanding of the electric current. The movement of the positive charge is called as 'conventional current'. The flow of electrons is termed as 'electron current'. This is depicted in Figure 2.6.

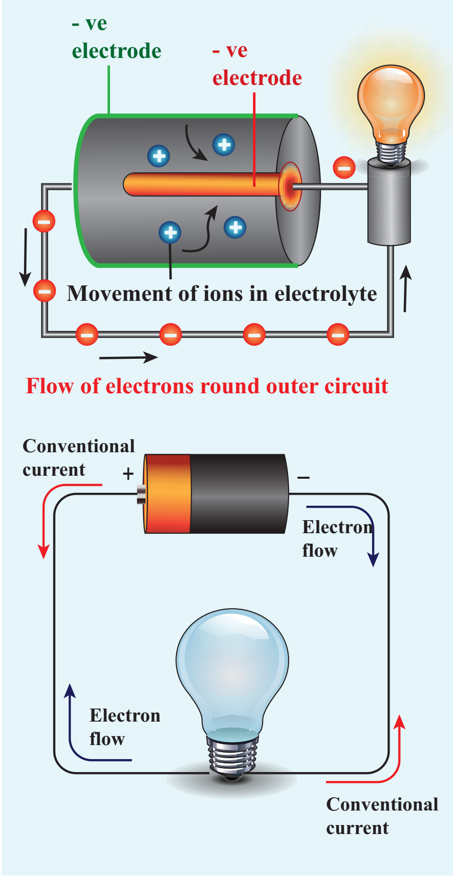


Figure 2.6 Electric current

In a battery, the potential of the positive terminal is maintained positive and the negative terminal is negative. Electrons are removed from the positive terminal and enriched at the negative terminal internally by means of chemical reaction or other processes. When a connection is given externally by a conducting wire, electrons flow from the negative terminal to the positive of the cell. Conventional current or simply the current, behaves as if positive charges cause the current flow. Although in reality it is the electron that moves in one direction, in equivalence, we consider as if it is the positive charges are moving in the opposite direction. This is taken as the direction of 'current'.

In electrical circuits the positive terminal is represented by a long line and negative terminal as a short line. Battery is the combination of more than one cell as shown in the Fig. 2.7.

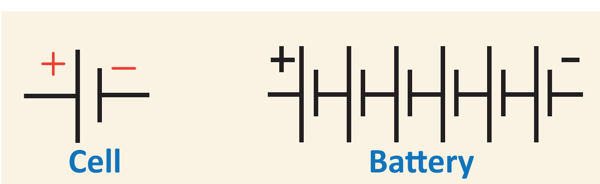


Figure 2.7 Cell and battery

2.2.2 Measurement of electric current

We can measure the value of current and express it numerically. **Current is the rate at which charges flow past a point on a circuit.** That is, if q is the quantity of charge passing through a cross section of a wire in a time t, quantity of current (I) is represented as,

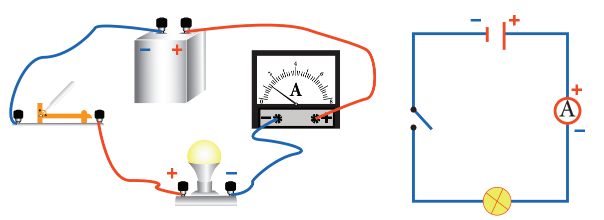
$$I = q/t$$

The standard SI unit for current is ampere with the symbol A. Current of 1 ampere means that there is one coulomb (1C) of charge passing through a cross section of a wire every one second (1 s).

1 ampere = 1 coulomb / 1 second (or)

$1\ A = 1\ C / 1\ s = 1CS^{-1}$

Ammeter is an instrument used to measure the strength of the electric current in an electric circuit.



(a) actual setup (b) Circuit diagram

Figure 2.8 Ammeter in a circuit

The ammeter is connected in series in a circuit where the current is to be found. . The current flows through the positive '+' red terminal of ammeter and leaves from the negative '–' black terminal.

Exercise 2.2

Suppose, 25 C of charge is determined to pass through a wire of any cross section in 50 s, what is the measure of current?

Solution:

$I = q / t = (25\ C) / (50\ s) = 0.5\ C/s = 0.5\ A$

Exercise 2.3

The current flowing through a lamp is 0.2A. If the lamp is switched on for one hour, What is the total electric charge that passes through the lamp?

Solution:

$I = q / t;\ q = I \times t$

Time has to be in second.

$\therefore 1hr = 1 \times 60 \times 60\ s = 3600\ s$

$q = I \times t = 0.2A \times 3600s = 720C$

2.2.3 Electromotive force (e.m.f)

Imagine that two ends of a water pipe filled with water are connected. Although filled with water, the water will not move or circle around the tube on its own. Suppose, you insert a pump in between and the pump pushes the water, then the water will start moving in the tube. Now the moving water can be used to produce some work. We can insert a water wheel in between the flow and make it to rotate and further use that rotation to operate machinery.

Likewise if you take a circular copper wire, it is full of free electrons. However, they are not moving in a particular direction. You need some force to push the electrons to move in a direction. The water pump and a battery are compared in Figure 2.9.

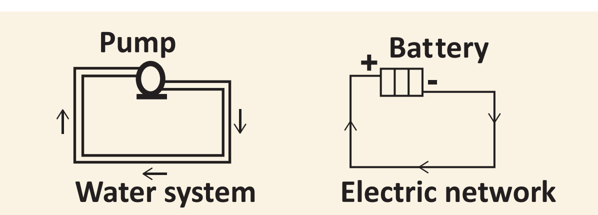


Figure 2.9 Battery is analogues to water pump

Devices like electric cells and other electrical energy sources act like pump, 'pushing' the charges to flow through a wire or conductor. The 'pumping' action of the electrical energy source is made possible by the 'electromotive force' (e.m.f). The electromotive force is represented as (ε). The e.m.f of an electrical energy source is the work done (W) by the source in driving a unit charge (q) around the complete circuit.

$$\varepsilon = W/q$$

where, W is the work done or the non-electrical energy converted into electrical energy measured in joules and q is the amount of charge. The SI unit of e.m.f is joules per coulomb (JC^{-1}) or volt (V). In other words **the e.m.f of an electrical energy source is one volt if one joule of work is done by the source to drive one coulomb of charge completely around the circuit.**

Exercise 2.4

The e.m.f of a cell is 1.5V. What is the energy provided by the cell to drive 0.5 C of charge around the circuit?

Solution: ε = 1.5V and q = 0.5C

$\varepsilon = W/q$; $W = \varepsilon \times q$; Therefore W = 1.5 x 0.5 = 0.75J

DO YOU KNOW?

Though the word force is present in electro motive force, it is not a force. Scientists who worked with electricity in earlier days thought that there is force acting on the electrons in moving them through the wire. But, instead of considering the force, considering the potential difference which produces the movement became easy for handling the concepts. But, the name still remains as such but e.m.f is still measured in volt.

2.2.4 Potential difference (p.d)

One does not just let the circuit connect one terminal of a cell to another. Often we connect, say a bulb or a small fan or any other electrical device in an electric circuit and use the electric current to drive them. This is how a certain amount of electrical energy provided by the cell or any other source of electrical energy is converted into other form of energy like light, heat, mechanical and so on. For each coulomb of charge passing through the light bulb (or any appliances) the amount of electrical energy converted to other forms of energy depends on the potential difference across the electrical device or any electrical component in the circuit. The potential difference is represented by the symbol V.

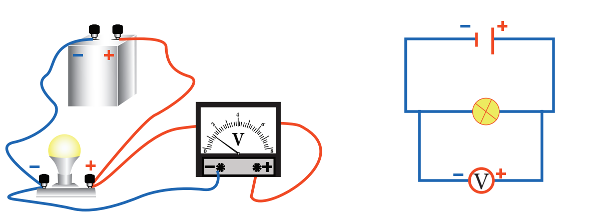
$$V = W/q$$

where, W is the work done, that is the amount of electrical energy converted into other forms of energy measured in joule and q is amount of charge measured in coulomb. The SI unit for both e.m.f and potential difference is the same in volt (V).

Note: Difference between e.m.f and potential difference:

As both e.m.f and potential difference are measured in volt, they may appear the same. But they are not. The e.m.f refers to the voltage developed across the terminals of an electrical source when it does not produce current in the circuit. Potential difference refers to the voltage developed between any two points (even across electrical devices) in an electric circuit when there is current in the circuit.

Voltmeter is an instrument used to measure the potential difference. To measure the potential difference across a component in a circuit, the voltmeter must be connected in parallel to it. Say, you want to measure the potential difference across a light bulb you need to connect the voltmeter as given in Figure 2.10.



(a) actual setup (b) Circuit diagram

Figure 2.10 Connection of voltmeter in a circuit

Note the positive ('+') red terminal of the voltmeter is connected to the positive side of circuit and the negative ('–') black terminal is connected to the negative side of the circuit across a component (light bulb in the above illustration).

Exercise 2.5

A charge of 2x10⁴ C flows through an electric heater. The amount of electrical energy converted into thermal energy is 5 MJ. Compute the potential difference across the ends of the heater.

$V = W/q$ that is 5×10^6 J / 2×10^4 C = 250 V

2.2.5 Resistance

The Resistance (R) is the measure of opposition offered by the component to the flow of electric current through it. The opposition to the flow of current is caused in terms of opposition to the flow of electrons by other electrons and the thermal vibrations. Different electrical components offer different electrical resistance.

Even the conducting wires offer resistance to the flow of electric current through it. But, it is very much negligible. Metals like copper, aluminium etc., have very much negligible resistance. That is why they are called good conductors. On the other hand, materials like nicrome, tin oxide etc., offer high resistance to the electric current. We also have a category of materials called insulators; they do not conduct electric current at all (Glass, Polymer, rubber and paper). All these materials are needed in electrical circuits to have usefulness and safety in electrical circuits.

The resistance offered by a material at a particular temperature depends on the,

i. geometry of the material and

ii. nature of the material.

The SI unit of resistance is ohm with the symbol (Ω). **One ohm is the resistance of a component when the potential difference of one volt applied across the component drives a current of one ampere through it.**

We can also control the amount of flow of current in a circuit with the help of resistance. Such components used for providing resistance are called as 'resistors'. The resistors can be fixed or variable.

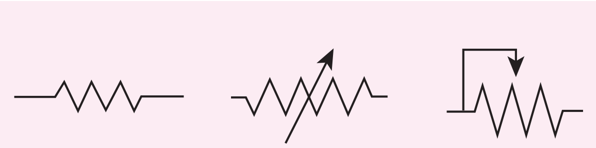


Figure 2.11 Circuit symbol for resistor

Fixed resistors have fixed value of resistance, while the variable resistors like rheostats can be used to obtain desired value of resistance as shown in Figure 2.11.

2.2.6 Ohm's law

Ohm's law states that electric potential difference across two points in an electrical circuit is directly proportional to the current passing through it. That is,

$$V \propto I$$

The proportionality constant is the resistance (R) offered between the two points.

Hence, Ohm's law is written as,

$$V = R\,I \quad \text{(or)} \quad V = I\,R$$

Where V is the potential difference across the component in volt(V), I is the current flowing through the component in ampere(A) and R is the resistance of the component in ohm (Ω).

Any appliance connected to the circuit offers resistance. We can measure it by measuring the current (I) flowing through them and the potential difference (V) across them. Once we measure these two quantities, we can compute R from the formula R=V/I. When we plot a graph by taking current (I) in the x-axis and voltage (V) in the y-axis, we get a straight line as shown in Fig 2.13. The slope of the line gives the value of resistance (R)

RESISTORS

Fixed resistor

A fixed resistor has a resistance of fixed value. Common types of fixed resistors include carbon film resistors and wire-wound resistors.

Some common fixed resistors

Variable resistors

A variable resistor has a resistance that can be varied. It is used to vary the amount of current flowing in a circuit.

A rheostat is a type of variable resistor.

Figure 2.12 Types of resistors

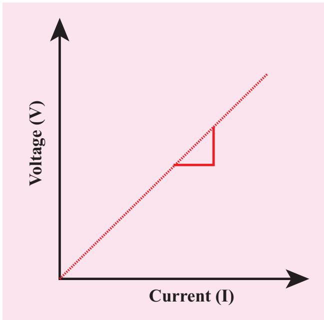


Figure 2.13 Relation between Current and Voltage

Example 2.6

A potential difference of 230 V applied across the heating coil drives a current of 10 A through it. Calculate the resistance of the coil.

V = 230 V; I = 10A

R = V/ I that is 230/10 = 23Ω

Know your Scientist

Georg Simon Ohm, is a well-known German physicist who discovered the relation between potential difference, current and resistance. This relation is named after him, as Ohm's law. The ohm, the physical unit measuring electrical resistance, also was named after him.

He was born in March 16, 1789, at Erlangen, Bavaria in Germany. Ohm became professor of mathematics at the Jesuits' College at Cologne in 1817. His work greatly influenced the theory and applications of current electricity. Georg Ohm resigned his post at Cologne. He accepted a position at the Polytechnic School of Nürnberg in 1833. In 1841 he was awarded the Copley Medal of the Royal Society of London and was made a foreign member a year later. He died on July 6, 1854, in Munich.

2.3 Electric circuit diagram

To represent an electrical wiring or solve problem involving electric circuits, the circuit diagrams are made.

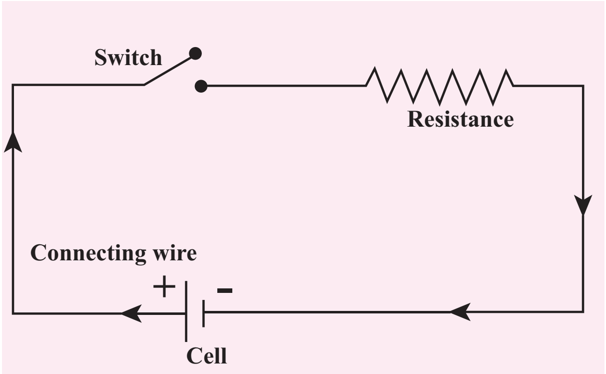
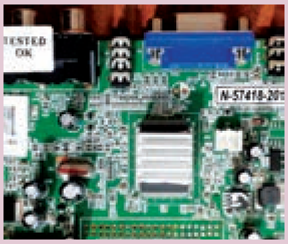


Figure 2.14 Typical electric circuit

The four main components of any circuits namely the, (i) cell, (ii) connecting wire, (iii) switch and (iv) resistor or load are given above. In addition to the above many other electrical components are also used in an actual circuit. A uniform system of symbols has been evolved to describe them. It is like learning a sign language, but useful in understanding circuit diagrams.

Activity 2



Take a condensed electronic circuit board in a TV remote or old mobile phone. Look at the electrical symbols used in the circuit. Find out the meaning of the symbols known to you.

2.3.1 Some common symbols in the electrical circuit

Some of the symbols are shown in Table 1.

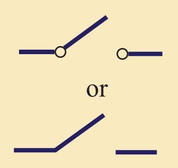
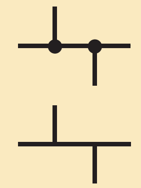
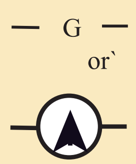
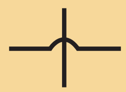
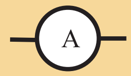
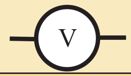
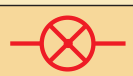
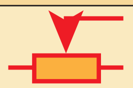
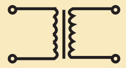
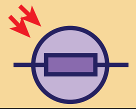
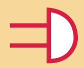
Symbol	Device	Symbol	Device	Symbol	Device
	Switch		Wires joined		galvanometer
	Cell		Wires crossed		ammeter
	Battery		Fixed resistor		Voltmeter
	D .c . power supply		variable resistor (rheostat)		Two-way switch
	A.c. power supply		fuse		Earth connector
	Light bulb		Coil of wire		capacitor
	Potentiometer		transformer		thermistor
	light-depemdent resistor (LDR)		Semiconductor diode		bell

Table 2.1 Common symbols in electrical circuits

2.3.2 Different electrical circuits

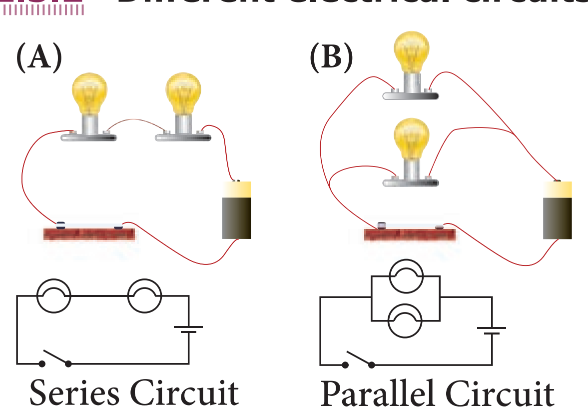


Figure 2.15 Series and parallel connections

Look at the two circuits, shown in Figure 2.15. In Figure A two bulbs are connected in series and in Figure B they are connected in parallel. Let us look at each of these separately.

Series circuits

Let us first look at the current in a series circuit. In a series circuit the components are connected one after another in a single loop. In a series circuit there is only one pathway through which the electric charge flow. From the above we can know that the current I all along the series circuit remain same. That is in a series circuit the current in each point of the circuit is same.

Now, for example, let us consider three resistors of resistances R_1, R_2 and R_3 that are connected in series. When resistors are connected in series, same current is flowing through each resistor as they are in a single loop. If the potential difference applied between the ends of the combination of resistors is V, then the potential differences across each resistor R_1, R_2 and R_3 are V_1, V_2 and V_3 respectively as shown in Figure 2.16.

The net potential difference, $V = V_1 + V_2 + V_3$

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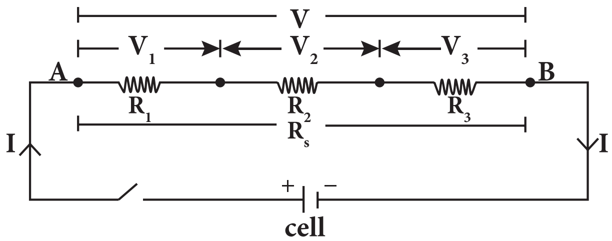


Figure 2.16 Resistors in series

By Ohm's law, $V_1 = IxR_1$; $V_2 = IxR_2$; $V_3 = IxR_3$; and $V = IxR_S$

where R_3 is the equivalent or effective resistance of the series combination.

Hence, $(IxR_s) = (IxR_1) + (IxR_2) + (IxR_3) = Ix(R_1 + R_2 + R_3)$

$$R_S = R_1 + R_2 + R_3$$

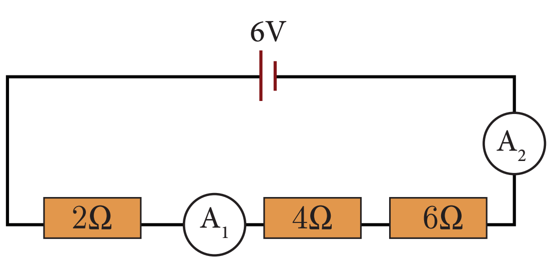
Thus, the equivalent resistance of a number of resistors in series connection is equal to the sum of the resistance of individual resistors.

Suppose, n resistors are connected in series, then the equivalent resistor is,

$$R_S = R_1 + R_2 + R_3 + \ldots\ldots + R_n$$

Exercise 2.7

Look at the series circuit below.



a. What is the effective resistance of the three resistors?

b. What is the current measured by ammeter A_1 and ammeter A_2?

c. What is the potential difference across each resister?

Solution:

a) Effective resistance $R = R_1 + R_2 + R_3$
$= 2 + 4 + 6 = 12\Omega$

b) Since, V= 6 V and effective resistance is 12Ω

$I = V/R = 6V/12\Omega = 0.5A$

As the same current flows through both the resistors, both the ammeters A_1 and A_2 will show the same current of 0.5A.

c) Let V1, V2 and V3 be the potential difference across the 2Ω, 4Ω, 6Ω resisters respectively, then

$V_1 = I \times R_1 = 0.5A \times 2\Omega = 1V$

$V_2 = I \times R_2 = 0.5A \times 4\Omega = 2\ V$

$V_3 = I \times R_3 = 0.5A \times 6\Omega = 3\ V$

Now, we can see that V = V1+V2+V3 = 6 V

Parallel circuits

In parallel circuits, the components are connected to the e.m.f source in two or more loops. In a parallel circuit there is more than one path for the electric charge to flow. In a parallel circuit the sum of the individual current in each of the parallel branches is equal to the main current flowing into or out of the parallel branches. Also, in a parallel circuit the potential difference across separate parallel branches are same.

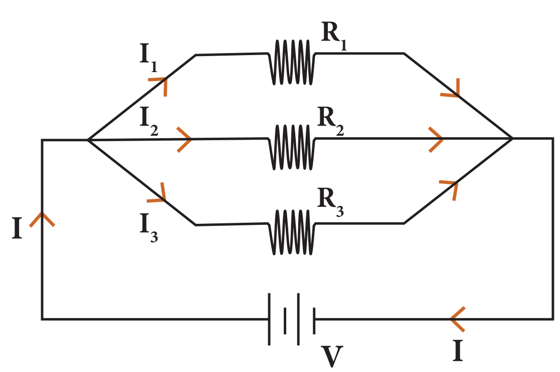


Figure 2.17 Resistors in parallel

Consider three resistors of resistances R_1, R_2 and R_3 connected in parallel. A source of e.m.f with voltage V is connected to the parallel combination of resistors. A current I entering the combination gets divided into I_1, I_2 and I_3 through R_1, R_2 and R_3 respectively as shown in Fig. 2.17.

The total current I is, $I = I_1 + I_2 + I_3$

By Ohm's law, $I_1 = V/R_1$; $I_2 = V/R_2$; $I_3 = V/R_3$; and $I = V/R_P$

where R_P is the equivalent or effective resistance of the parallel combination.

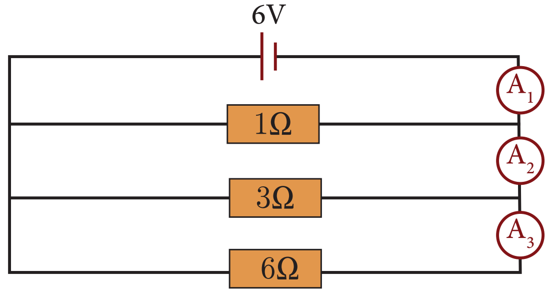
$(V/R_P) = (V/R_1) + (V/R_2) + (V/R_3) = Vx(1/R_1 + 1/R_2 + 1/R_2)$

$1/R_P = 1/R_1 + 1/R_2 + 1/R_2$

Thus, the reciprocal of the effective resistance of resisters in parallel ($1/R_P$) is equal to the sum of the reciprocal of all the individual resistance.

Exercise 2.8

Figure shows three resistors of values 1 Ω, 3 Ω, and 6 Ω connected in parallel to a 6 V dry cell.



(a) What is the effective resistance of the three resistors?

(b) What is the p.d. across each resistor?

(c) What is the current measured by ammeters A_1, A_2 and A_3?

Solution:

(a) $1/R_p = 1/R_1 + 1/R_2 + 1/R_3$

$1/R_p = 1/1 + 1/3 + 1/6$

$1/R_p = 9/6$

$\therefore R_p = 0.667\ \Omega$

(b) As the resistors are in parallel, the p.d. across each resistor is equal, ∴ p.d. = 6V

(c) (i) $I = V/R = 6\ V/6\ \Omega = 1\ A$

Current measured by ammeter A_1 is 1 A

(ii) Current through 3 Ω resistor

$= 6\ V/3\ \Omega = 2\ A$

Current measured by ammeter A_2

$= 1\ A + 2\ A = 3\ A$

(iii) Current through the 1 Ω resistor

$= 6\ V/1\ \Omega = 6\ A$

Current measured by ammeter A_3

$= 6\ A + 3\ A = 9\ A$

Alternatively, since V = 6 V and effective resistence R = 0.667 Ω, current measured by ammeter

$A_3 = 6\ V / 0.667\ \Omega = 9\ A$

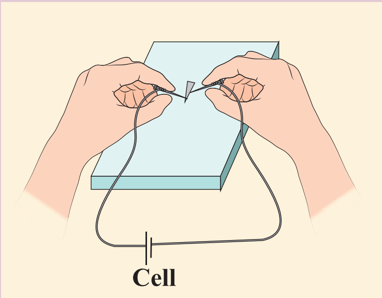
2.4 Effects of electric current

When current flows in a circuit it exhibits various effects. The main effects are heating, chemical and magnetic effects.

2.4.1 Heating effect

Activity 3

Cut an arrow shaped strip from aluminium foil. Ensure that the head is a fine point. Remove any paper backing it may have. Keep the arrow shaped foil on a wooden board. Connect a thin pin to two lengths of wire. Connect the wires to the terminals of electric cell, may be of 9V. Press one pin onto the pointed tip and other pin at a point about one or two mm away. Can you see that the tip of aluminium foil starts melting?



When the flow of current is 'resisted' generally heat is produced. This is because the electrons while moving in the wire or resistor suffer resistance. Work has to be done to overcome the resistance which is converted in to heat energy. **This conversion of electrical energy in to heating energy is called 'Joule heating'** as this effect was extensively studied by the scientist Joule. This forms the principle of all electric heating appliances like iron box, water heater, toaster etc. Even connecting wires offer a small resistance to the flow of current. That is why almost all electrical appliances including the connecting wires feel warm when used in an electric circuit.

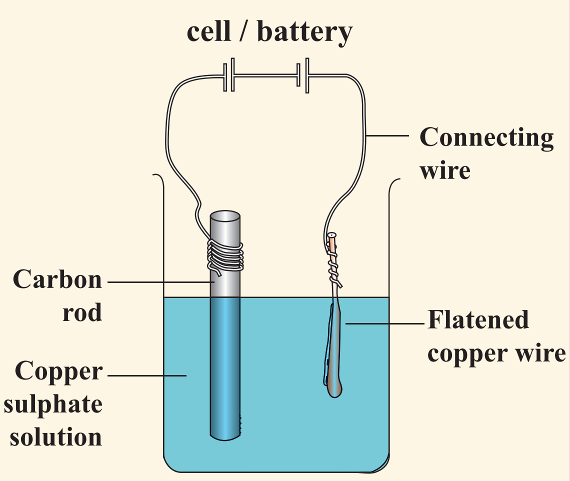
Caution:

The heating effect and the chemical effect experiments have to be performed only with a dc cell of around 9V. The 9V dc cell will not give any electrical shock.

Students at any cost **should not use** the main domestic electric supply which is a 220V ac voltage. If it is used it will give a heavy electric shock leading to a severe damage to our body.

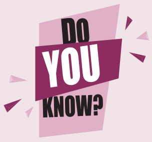
2.4.2 Chemical effect

Activity 4



Take a beaker half filled with copper sulphate solution. Take a carbon rod from a used dry cell. Wind a wire on its upper end. Take a thick copper wire, clean it well and flatten it with a hammer. Immerse both the copper wire and carbon rod in the copper sulphate solution. Connect the carbon rod to the negative terminal of an electric cell and copper wire to the positive terminal of the cell. Also ensure that the copper and the carbon rod do not touch each other, but are close enough. Wait and watch. After some time you would find fine copper deposited over the carbon rod. This is called as electroplating. This is due to the chemical effect of current.

So far we have come across the cases in which only the electrons can conduct electricity. But, here when current passes through electrolyte like copper sulphate solution, both the electron and the positive copper ion conduct electricity. **The process of conduction of electric current through solutions is called 'electrolysis'. The solution through which the electricity passes is called 'electrolyte'.** The positive terminal inserted in to the solution is called 'anode' and the negative terminal 'cathode'. In the above experiment, copper wire is anode and carbon rod is cathode.



Extremely weak electric current is produced in the human body by the movement of charged particles. These are called synaptic signals. These signals are produced by electro-chemical process. They travel between brain and the organs through nervous system.

2.4.3 Magnetic effect of electricity

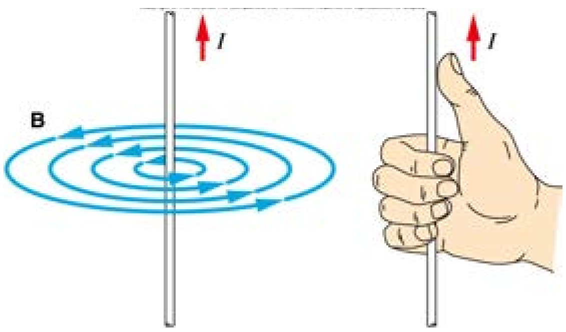


Figure 2.18 Direction of current and magnetic field

A wire or a conductor carrying current develops a magnetic field perpendicular to the direction of the flow of current. This is called magnetic effect of current. The discovery of the scientist Oersted and the 'right hand thumb rule' are detailed in the chapter on Magnetism and Electromagnetism in this book.

Direction of current is shown by the right hand thumb and the direction of magnetic field is shown by other fingers of the same right hand (Fig. 2.18).

2.5 Types of current

There are two distinct types of electric currents that we encounter in our everyday life: direct current (dc) and alternating current (ac).

2.5.1 Direct current

We know current in electrical circuits is due to the motion of positive charge from higher potential to lower potential or electron from lower to higher electrical potential. Electrons move from negative terminal of the battery to positive of the battery. Battery is used to maintain a potential difference between the two ends of the wire. Battery is one of the sources for dc current. The dc is due to the unidirectional flow of electric charges. Some other sources of dc are solar cells, thermocouples etc. The graph depicting the direct current is shown in Fig. 2.19.

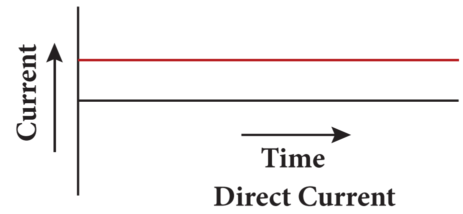


Figure 2.19 Wave form of dc

Many electronic circuits use dc. Some examples of devices which work on dc are cell phones, radio, electric keyboard, electric vehicles etc.

2.5.2 Alternating current

If the direction of the current in a resistor or in any other element changes its direction alternately, the current is called an alternating current. The alternating current varies sinusoidally with time. This variation is characterised by a term called as frequency. **Frequency is the number of complete cycle of variation, gone through by the ac in one second.** In ac, the electrons do not flow in one direction because the potential of the terminals vary between high and low alternately. Thus, the electrons move to and fro in the wire carrying alternating current. It is diagrammatically represented in Fig. 2.20.

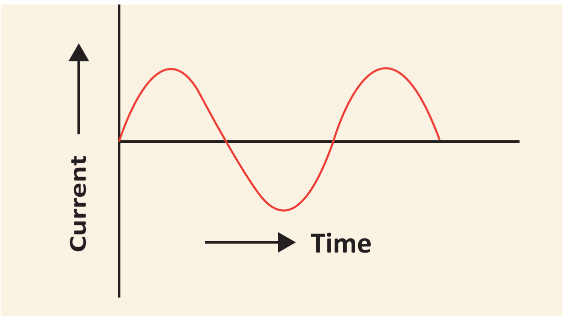


Figure 2.20 Wave form of ac

Domestic supply is in the form of ac. When we want to use an electrical device in dc, then we have to use a device to convert ac to dc. **The device used to convert ac to dc is called rectifier.** Colloquially it is called with several names like battery eliminator, dc adaptor and so on. The device used to convert dc in to ac is called inverter. The symbols used in ac and dc circuits are shown in Fig. 2.21.

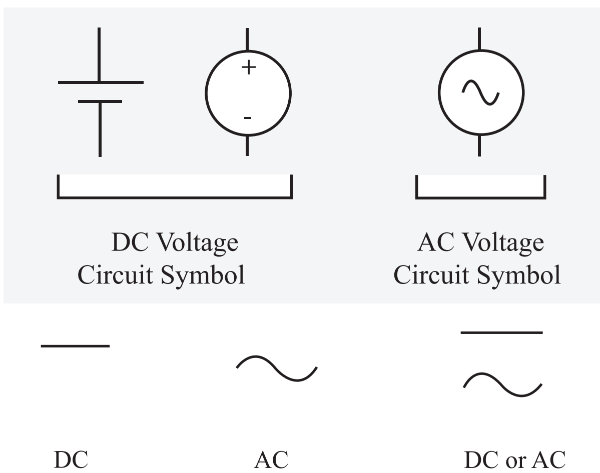


Figure 2.21 The symbol used in ac and dc circuit diagrams

Joule's heating effect of current is common to both direct and alternating current.

2.5.3 Advantages of ac over dc

The voltage of ac can be varied easily using a device called transformer. The ac can be carried over long distances using step up transformers. The loss of energy while distributing current in the form of ac is negligible. Direct current cannot be transmitted as such. The ac can be easily converted into dc. Generating ac is easier than dc. The ac can produce electromagnetic induction which is useful in several ways.

2.5.4 Advantage of dc over ac

Electroplating, Electro refining, electrotyping can be done only using dc. Electricity can be stored only in the form of dc.

In India, the voltage and frequency of ac used for domestic purpose is 220V and 50Hz respectively where as in United States of America it is 110V and 60 Hz respectively.

2.6 Safe handling of electrical energy

Electricity is to be handled with much precaution because the passage of electricity causes heavy damage to human body. As electric current produces heat, several safety aspects are to be strictly adhered while handling electric current.

2.6.1 Dangers of electricity and precautions to be taken

The following are the possible dangers as for as electric current is concerned.

i. Damaged insulation – Do not touch the bare wire, use safety glows and stand on insulating stool or rubber slippers while handling electricity.

ii. Overheating of cables – use quality ISI certified cable wires for domestic wiring

iii. Overload of power sockets – Do not connect too many electrical devices to a single electrical socket.

iv. Inappropriate use of electrical appliances – Always use the electrical appliances according to the power rating of the device like ac point, TV point, microwave oven point etc.

v. Environment with moisture and dampness – Keep the place where there is electricity out of moisture and wetness as it will lead to leakage of electric current.

vi. Beyond the reach of children – The electrical sockets are to be kept away from the reach of little children who do not know the dangers of electricity.

2.6.2 Safety features

There are many safety features to be followed while handling electricity. Some of them are given below.

Ground connection

The metal bodies of all the electrical appliances are to be connected to the ground by means of a third wire apart from the two wires used for electrical connection. Normally the ground connection wire will be green in colour while the main wire is in red and the return wire is in black. This ground connection provides an easy path for the current avoiding it from flowing through our body. All the ground wires from various electrical sockets are connected together finally to a thick copper wire that is buried deep in to the ground so that the excess current could directly pass in to the ground without passing in to our body.

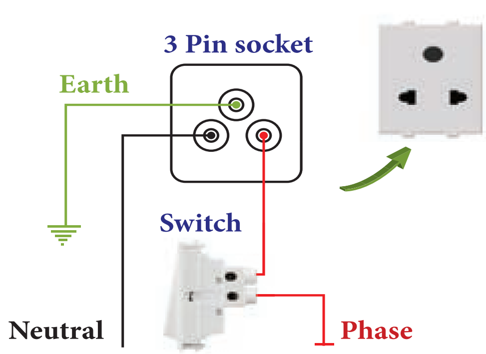


Figure 2.22 Earth and other connections given to a three pin socket

DO YOU KNOW?

Resistance of a dry human body is about 1,00,000 ohm. Because of the presence of water in our body the resistance is reduced to few hundred ohm. Thus, a normal human body is a good conductor of electricity. Hence, precautions are required while handling with electricity.

Trip switch

It is an electromechanical device which does not allow a current beyond a particular value by automatically switching off the connection. We have trip switches of various current ratings used for specific purposes. It works on relay principle. A set of the trip switches used in electrical connections is shown in Figure 2.23.

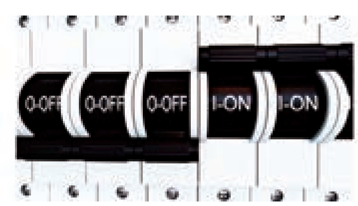


Figure 2.23 Set of trip switches

Fuse

A fuse is another safety mechanism which works on joule heating principle. Fuse is a wire made up of a Nickel and Chromium alloy which has a definite melting point. If current passes through the fuse beyond a particular desired value, the excess heat produced melts the fuse wire, thus the electrical connection is cut-off. Fuse has to be kept in tight a ceramic enclosure to avoid the melting heat from producing fire accidents.

Figure 2.24 Fuse with ceramic carrier

Points to remember

- Electric charge is a fundamental property of all matter.
- The unit of electric charge is coulomb with a symbol C.
- The charge of an electron is negative of 1.6×10-19 C (represented as e). This is the fundamental unit of charge.
- Like charges repel and unlike charges attract.
- Electric field (E) is represented by lines and arrowheads indicating the direction of the electric filed.
- Electric current flows from higher electric potential to lower electric potential.
- The movement of the positive charge is called as 'conventional current'. The flow of electrons is termed as 'electron current'.
- The standard SI unit for current is the ampere with the symbol A.
- The SI unit for both e.m.f and potential difference is the same in volt (V).
- The opposition to the flow of current is called resistance.
- Metals like copper, aluminium etc., have very much negligible resistance. Thus they are good conductors.
- The SI unit of resistance is ohm with the symbol Ω.
- The four main components of any circuit are: cell, connecting wire, switch and resistor.
- In a parallel circuit there is more than one path for the electric charge to flow.
- The main effects when current flows in a circuit are heating, chemical and magnetic effects.
- There are two distinct types of electric currents that we encounter in our everyday life: direct current (dc) and alternating current (ac).
- Dangers of electricity are: damaged insulation, overheating of cables, overload of power sockets, inappropriate use of electrical appliances and environment with moisture and dampness.
- Safety features to be followed are: Ground connection, Trip switch, Fuse

A-Z GLOSSARY

Electric charge	It is the fundamental property of matter.
Electric field	The region around a charge in which another charge experiences electric force.
Electric lines of force	The electric lines of force are straight or curved paths along which a unit positive charge tends to move in the electric field.
Electric potential	It is a measure of the work done on unit positive charge to bring it to that point against all electrical forces.
Electric current	Current is the rate at which charges flow across a conductor in a circuit.
Ammeter	An instrument used for measuring the amount of electric current.

e.m.f	It is the work done by the electrical energy source in driving a unit charge around the complete circuit.
Voltmeter	It is an instrument used to measure the potential difference.
Resistance	The measure of opposition offered by the component to the flow of electric current through it.
Resistors	Components used for providing resistance are called as resistors.
Electrolyte	The solution through which electric current flows.
Anode	The positive terminal in the electrolyte.
Cathode	The negative terminal in the electrolyte.
Alternating current	If the direction of the current in a resistor or in any other element changes its direction alternately, the current is called an alternating current.

TEXT BOOK EXERCISES

I. Choose the correct answer

1. In current electricity, a positive charge refers to,

   a) presence of electron

   b) presence of proton

   c) absence of electron

   d) absence of proton

2. Rubbing of comb with hair

   a) creates electric charge

   b) transfers electric charge

   c) either (a) or (b)

   d) neither (a) nor (b)

3. Electric field lines ________ from positive charge and ________ in negative charge.

   a) start; start   b) start; end

   c) start: end   d) end; end

4. Potential near a charge is the measure of its ________ to bring a positive charge at that point.

   a) force   b) abiility

   c) tendency   d) work

5. In an electrolyte the current is due to the flow of,

   a) electrons

   b) positive ions

   c) both (a) and (b)

   d) neither (a) nor (b)

6. Heating effect of current is called,

   a) Joule heating

   b) Coulomb heating

c) voltage heating

d) Ampere heating

7. The following is not a safety device.

a) fuse b) trip switch

c) ground connection d) wire

8. Electroplating is an example for

a) heating effect b) chemical effect

c) flowing effect d) magnetic effect

9. Resistance of a wire depends on,

a) temperature b) geometry

c) nature of material d) all the above

10. In India the frequency of alternating current is,

a) 220 Hz b) 50 Hz

c) 5 Hz d) 100 Hz

II. Match the following

1.	Electric Charge	(a) ohm
2.	Potential difference	(b) ampere
3.	Electric field	(c) coulomb
4.	Resistance	(d) newton per coulomb
5.	Electric current	(e) volt

III. True or False

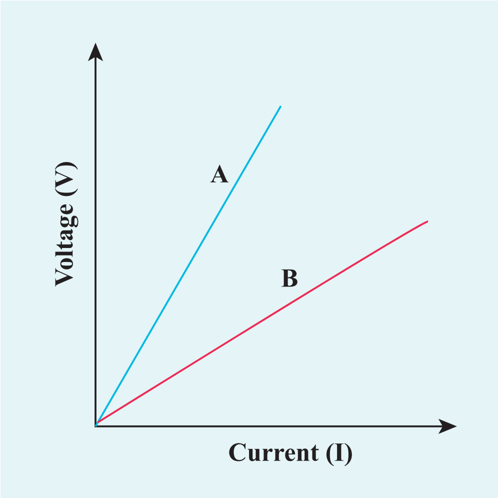
1. Electrically neutral means it is either zero or equal positive and negative charges.
2. Ammeter is connected in parallel in any electric circuit.
3. The anode in electrolyte is negative.
4. Current can produce magnetic field.
5. Electric fuse works on Joule heating principle.

IV. Fill in the blanks

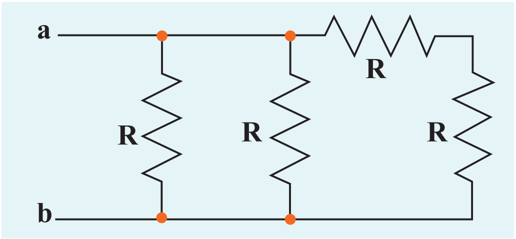
1. Electrons move from ________ potential to ________ potential.
2. The direction opposite to the movement of electron is called ________ current.
3. The e.m.f of a cell is analogues to ________ of a pipe line.
4. The domestic electricity in India is an ac with a frequency of ________ Hz.
5. Trip switch is a ________ safety device.

V. Conceptual questions

1. A bird sitting on a high power electric line is still safe. How?
2. Two resistors 12Ω and 6Ω are first connected in series and then in parallel. The current-voltage graph for the two connections will be represented by which lines in the graph?



3. Does a solar cell always maintain the potential across its terminals constant? Discuss.
4. What is the effective resistance across the terminals a and b of the arrangement of resistors?



5. Can electroplating be possible with alternating current?

VI. Answer the following

1. On what factors does the electrostatic force between two charges depend?
2. What are electric lines of force?
3. Define electric field.
4. Define electric current and give its unit.
5. State Ohm's law.
6. On what factor does the resistance of a wire depend at a particular temperature?
7. Name any two appliances which work under the principle of heating effect of current.
8. Draw a circuit with a 2Ω and 5Ω resistors in series. Connect another 3Ω resistor parallel to the above connection.
9. How are the home appliances connected in general, in series or parallel. Give reasons.
10. List the safety features while handling with electricity.

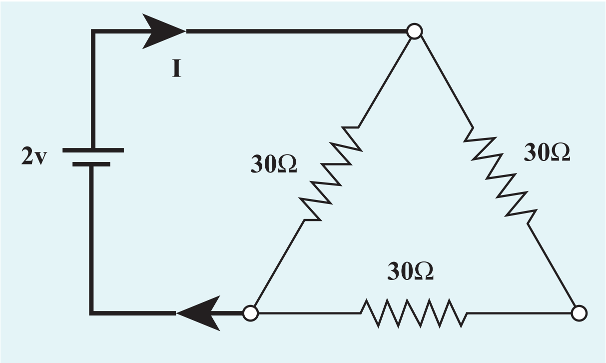
VII. Exercises

1. Rubbing a comb on hair makes the comb get – 0.4C. (a) Find which material has lost electron and which one gained it. (b) Find how many electrons are transferred in this process.
2. Calculate the amount of charge that would flow in 2 hours through an element of an electric bulb drawing a current of 2.5A.
3. The values of current I flowing through a resistor for various potential differences V across the resistor are given below. What is the value of resistor?

I (ampere)	0.5	1.0	2.0	3.0	4.0
V (volt)	1.6	3.4	6.7	10.2	13.2

[Hint: plot V-I a graph and take slope]

4. Find the value of current in the circuit.



5. A wire of resistance 10 Ω is bent in the form of a circle .Find the effective resistance between the points A and B which lies on the diameter.

REFERENCE BOOKS

Fundamentals of Physics by K.L Gomber and K. L.Gogia

Concepts of Physics by H.C Verma

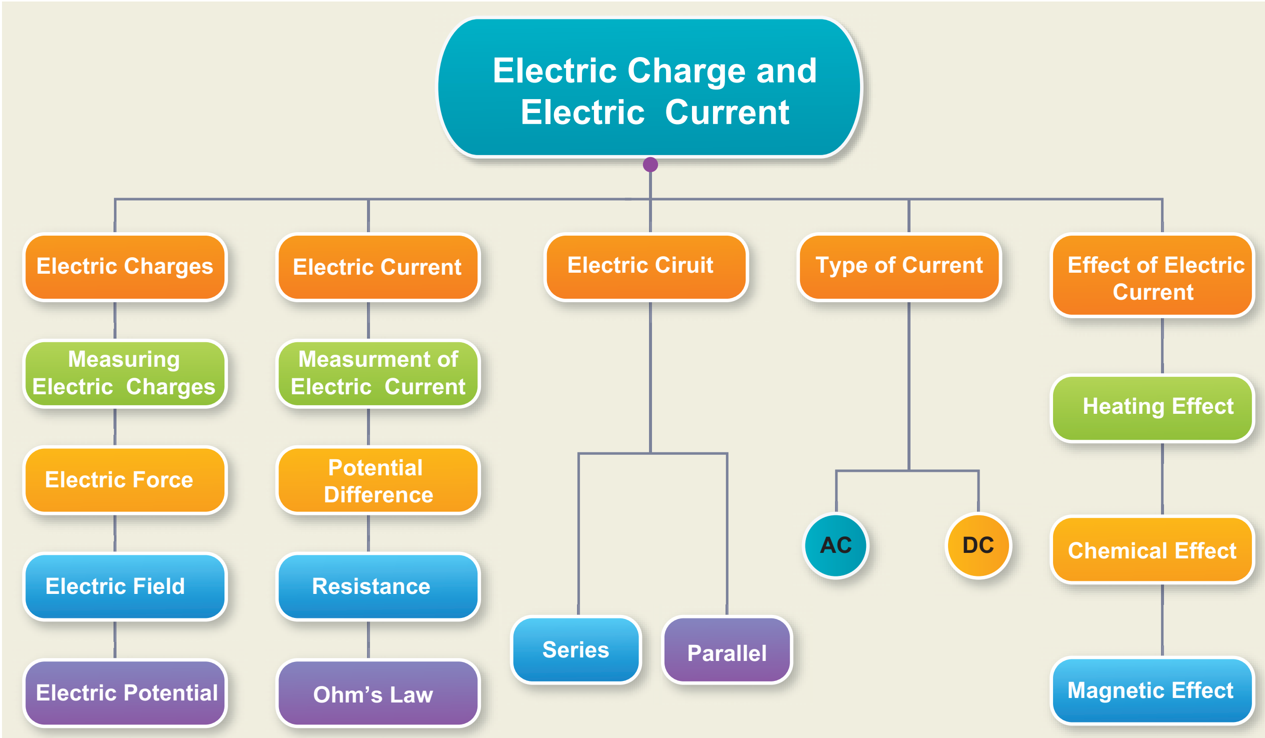
General Physics by W.L. Whiteley

INTERNET RESOURCES

http://www.qrg.northwestern.edu/projects/vss/docs/propulsion/1-what-is-an-ion.html

https://www.explainthatstuff.com/batteries.html

https://www.woodies.ie/tips-n-advice/how-the-fusebox-works-in-the-home-new



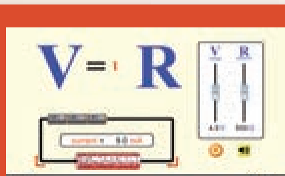
ICT CORNER

Ohm's Law Verification

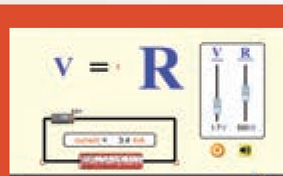
This activity enables to learn the relationship between current and potential difference.

Step 1

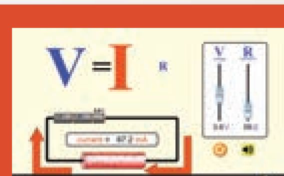
- Type the URL link given below in the browser OR scan the QR code.
- You can vary the value of **V** and **R** to know the change the **current flowing across the conductor**
- On the right you can do the changes in V and R to learn the variations.



Step1



Step2



Step3

Step4

Browse in the link:

URL: https://phet.colorado.edu/en/simulation/ohms-law

B467_SCI_9_T2_EM

*Pictures are indicative only

UNIT 3

Magnetism and Electromagnetism

BH6RTD

Learning Objectives

After studying this chapter, students will be able to

- understand the concept of magnetic field
- know the properties of magnetic field lines
- calculate the force exerted on a current carrying conductor in a magnetic field
- understand the force between two parallel current carrying conductors
- know the concept of electromagnetic induction and apply it in the case of generators.
- appreciate how voltage can be increased or decreased using transformers
- understand the applications of electromagnet and apply the knowledge in constructing devices using electromagnets

Introduction

Have you ever played with magnets? Do you wonder why it attracts iron? Magnets are always very attractive objects for the humans. In fact famous scientist Einstein mentioned that he was always attracted by magnets in his childhood. In the olden days magnets were used in the ships. Captains of the ships effectively used the magnets to identify the direction of the ship in the sea.

There are two kinds of magnets that we can see around us: Natural magnet and Artificial magnet. Natural magnets exist in the nature. These kind of magnets can be found in rocks and sandy deposits in various parts of the world. The strangest natural magnet is lodestone magnetite (Fig. 3.1)

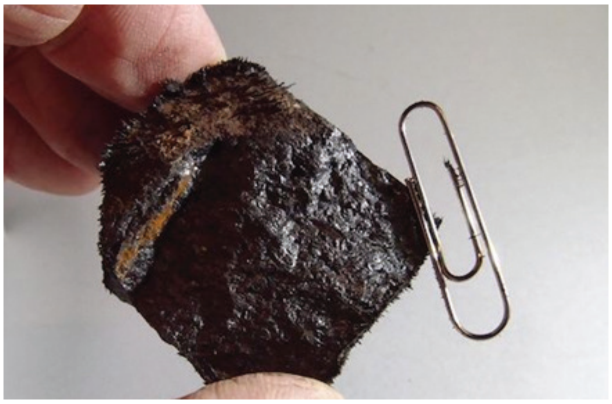


Figure 3.1 Natural magnets

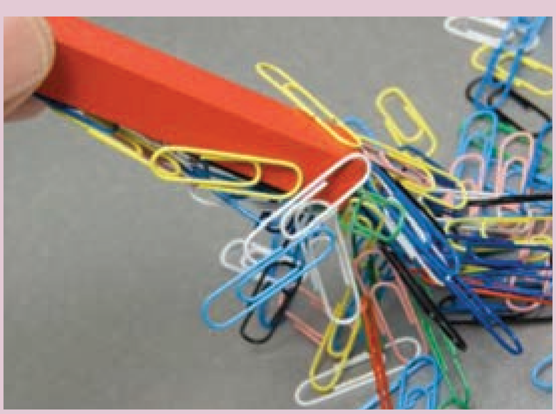
The magnetic property in the natural magnets is permanent. It never gets destroyed. The lodestone are used to make compasses in the olden days. Artificial magnets are made by us. The magnets available in the shops are basically artificial magnets (Fig. 3.2) In this lesson we shall study about magnetic properties and how it is effectively used in day to day life.

Figure 3.2 Artificial magnets

3.1 Magnetic field (B)

Activity 1

Put a magnet on a table and place some paper clips nearby. If you push the magnet slowly towards the paper clips, there will be a point at which the paper clips jump across and stick to the magnet. What do you understand from this?



The interesting question is how the magnet attracts the paper clip? From the above activity we notice that magnets have an invisible field all around them which attracts magnetic materials. In this space we can feel the force of attraction or repulsion due to the magnet. Thus, magnetic field is the region around the magnet where its magnetic influence can be felt. It is denoted by B and its unit is Tesla.

DO YOU KNOW?

The broad spectrum of magnetic-field strengths is very interesting to know:

Human Brain's magnetic field = 1 pT = 1 pico tesla

Magnetic field in a galaxy = 0.5 nT = 0.5 nano tesla

Magnetic field due to microwave oven (at 1 foot distance) = 8 μT = 8 micro tesla

Earth's magnetic field at Chennai (13^{o} latitude) = 42 μT = 42 micro tesla

Magnetic field of MRI scanner = 2 T

The direction of the magnetic field around a magnet can be found by placing a small compass in the magnetic field as shown in the Fig 3.3

Figure 3.3 Compass showing direction of magnetic field

Magnetic field can penetrate through all kinds of materials, not just air. The Earth produces its own magnetic field, which shields the earth's ozone layer from the solar wind and is important in navigation using a compass.

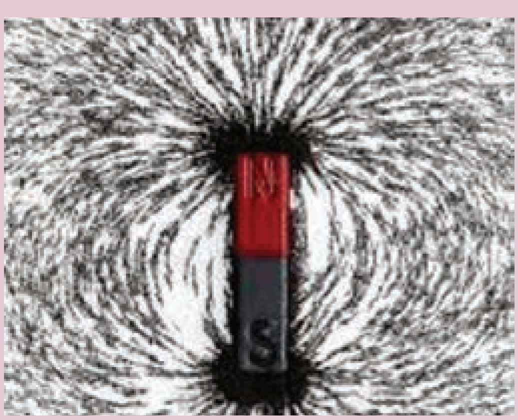
DO YOU KNOW?

Some sea turtles (loggerhead sea turtle) return to their birth beach many decades after they were born, to nest and lay eggs. In a research, it is suggested that the turtles learnt their home beach's location through what is called "geomagnetic imprinting". The turtles, it seems, can perceive variations in magnetic parameters of Earth such as magnetic field intensity and remember them. This memory is what helps them in returning to their homeland.

3.2 Magnetic Field Lines

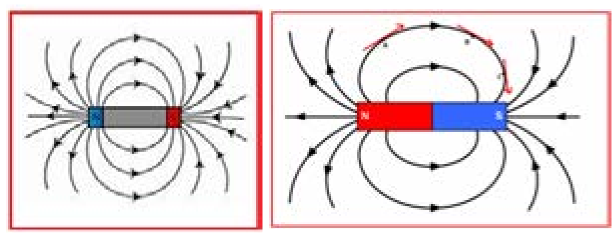
Activity 2

Place a magnet over a cardboard. Sprinkle some iron-filings on the cardboard. Tap the card board gently. We observe that the iron filings align themselves in definite pattern. These patterns are called magnetic lines of force.



Activity 2 shows that magnets have some curved lines around them and these lines are called magnetic field lines. This can also be inferred by placing a test magnet in the magnetic field of another magnet. Through the direction the test magnet moves, magnetic field lines can be identified. The magnetic field lines start at north pole and ends at south pole as shown in the Figure 3.4(a)

A magnetic field line is defined as a curve drawn in the magnetic field in such a way that the tangent to the curve at any point gives the direction of the magnetic field as shown in the Figure 3.4 (b). In the Figure 3.4 (b), the arrow mark indicates the direction of magnetic field at points A, B and C. Note carefully that the magnetic field at a point is tangential to the magnetic field lines.



a b

Figure 3.4 Magnetic field lines

We all know that earth also behaves like a magnet and the magnetic field lines of earth's is shown in the figure 3.5

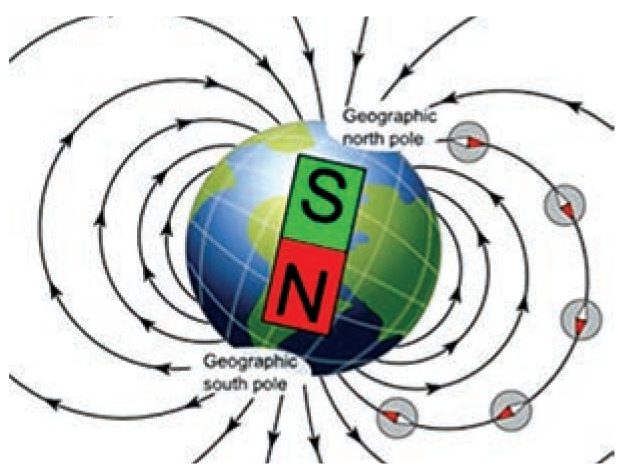


Figure 3.5 Earth's magnetic field lines

3.2.1 Magnetic flux

Magnetic flux is the number of magnetic field lines passing through a given area as shown in the figure 3.6. It is denoted by ϕ and its unit is weber (Wb).

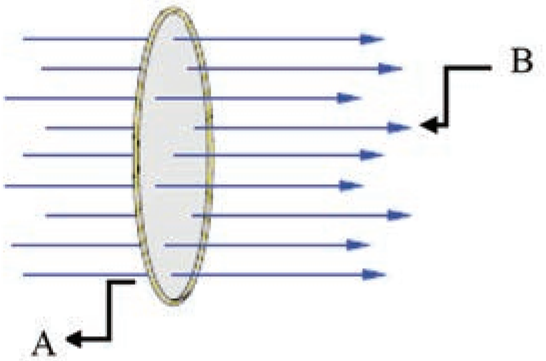


Figure 3.6 Magnetic flux

The number of magnetic field lines crossing unit area kept normal to the direction of field lines is called magnetic flux density. It is shown in the figure 3.7. Its unit is Wb/m2

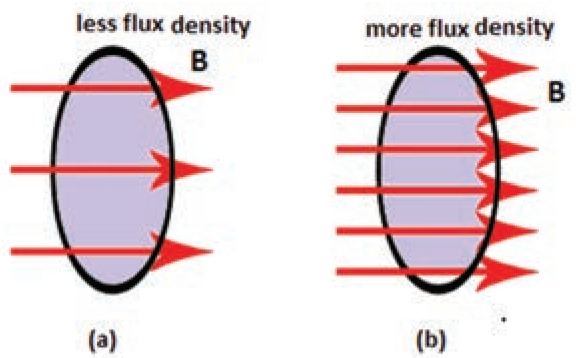


Figure 3.7 Magnetic flux density

3.2.2 Properties of magnetic lines of force

- Magnetic lines of force are closed continuous curves, extending through the body of the magnet.
- Magnetic lines of force start from the North Pole and end at the South Pole.
- Magnetic lines of force never intersect.
- They will be maximum at the poles than at the equator.
- The tangent drawn at any point on the curved line gives the direction of magnetic field.

More to Know

Magnetic Shielding

The computer hard disk stores information using magnetism. Therefore if the hard disk comes near a powerful magnet the data may get corrupted because of the strong magnetic field. Hence we may have to shield computer hard disk, MRI and other such sensitive equipments from such magnetic effects. Stopping the magnetic field from entering into a region is called magnetic shielding. It is known that soft magnetic materials like iron or nickel-iron alloy have the ability to choke up magnetic lines. Magnetic lines coming out of a magnet prefer to pass within the soft metals rather than through air.

3.2.3 Magnetic field lines between two magnets

What does happen when two magnets are placed near each other? There are four ways we can keep them. They are shown in Fig 3.8

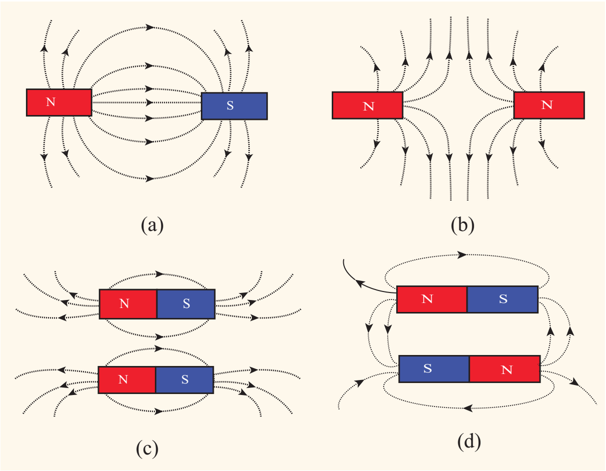


Figure 3.8 Magnets placed together in different directions

(a) two unlike poles facing each other, (b) two like poles facing each other, (c) parallel magnets with same poles facing same side and (d) parallel magnets with opposite poles facing same side. All these positions are.

3.3 Magnetic effect of current

It was on 21st April 1820, Hans Christian Oersted, a Danish Physicist was giving a lecture. He was demonstrating electrical circuits in that class. He had to often switch on and off the circuit during the lecture. Accidentally, he noticed the needle of the magnetic compass that was on the table. It deflected whenever he switched on and the current was flowing through the wire. The compass needle moved only slightly, so that the audience didn't even notice. But it was clear to Oersted that something significant was happening. Intrigued, he conducted experiments to find out a startling effect, the magnetic effect of current.

Oersted aligned a wire XY such that they were exactly along the North-South direction. He kept one magnetic compass above the wire at A and another under the wire at B. When the circuit was open and no current was flowing through it, the needle of both the compass was pointing to north. Once the circuit was closed and electric current was flowing, the needle at A pointed to east and the needle at B to the west as shown in Figure 3.9. This showed that current carrying conductor produces magnetic field around it.

The direction of the magnetic lines around a current carrying conductor can be easily understood using the right hand thumb rule. Hold the wire with four fingers of your right hand with thumbs-up position. If the direction of the current is towards the thumb then the magnetic lines curl in the same direction as your other four fingers as shown in Figure 3.10. This shows that the magnetic field is always perpendicular to the direction of current.

The strength of the magnetic field at a point due to current carrying wire depends on: (i) the current in the wire, (ii) distance of the point from the wire, (iii) the orientation of the point from the wire and (iv) the magnetic nature of the medium. The magnetic field lines are stronger near the current carrying wire and it diminishes as you go away from it. This is represented by drawing magnetic field lines closer together near the wire and farther away from the wire.

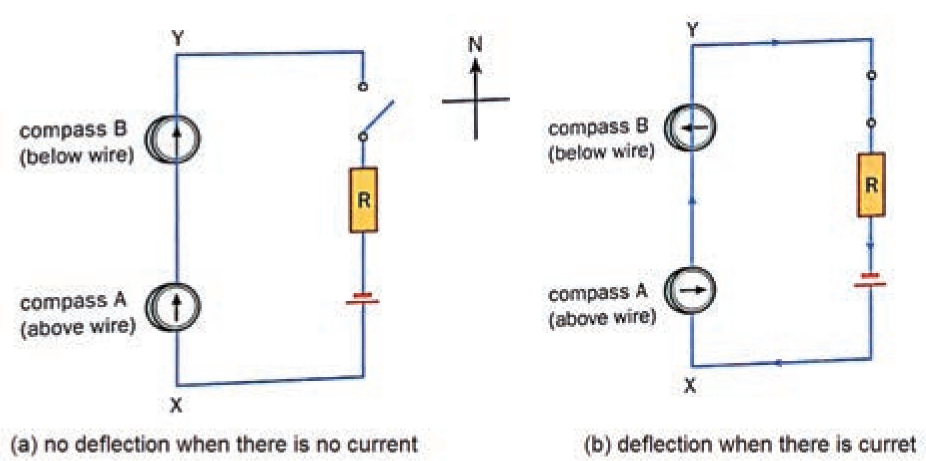


Figure 3.9 Current produces magnetic field

Know Your Scientist

Hans Christian Oersted, (14th August 1777 – 9th March 1851) was a Danish Physicist and Chemist who discovered that electric currents create magnetic fields, which was the first connection found between electricity and magnetism. In 1824, Oersted founded Selskabet for Naturlærens Udbredelse (SNU), a society to disseminate knowledge of the natural sciences.

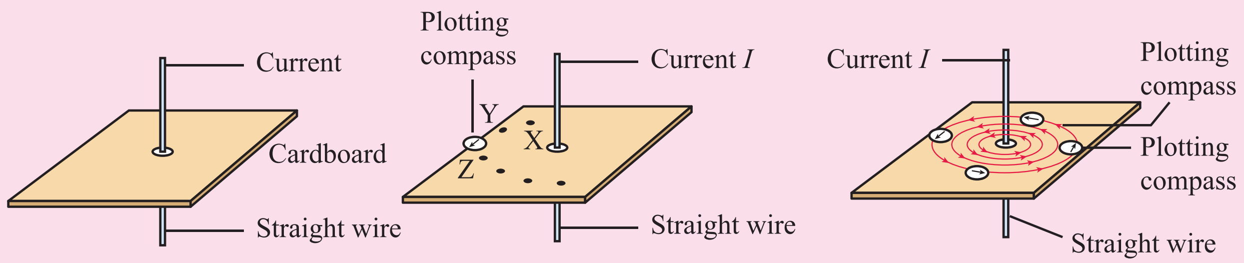
3.4 Force on a current carrying conductor in a magnetic field

H.A.Lorentz found that a charge moving in a magnetic field, in a direction other than the direction of magnetic field, experiences a force. It is called the magnetic Lorentz force. Since charge in motion constitutes a current, a conductor carrying moving charges, placed in magnetic field other than the direction of magnetic field, will also experience a force and can produce motion in the conductor.

In activity 3, we saw that a current carrying wire has a magnetic field perpendicular to the

Activity 3

Take a cardboard and thread a wire perpendicular through it. Connect the wire such that current flows up the wire. Switch on the circuit. Let the current flow. Place a magnetic compass on the cardboard. Mark S and N point of the compass as X and Y respectively on the cardboard. Move the compass such that S end touches Y. Now mark the N end as Z. In the next step move the compass such that S end touch Z. Repeat the steps. Now if you join all the points you will find that it is a circle. Start again, but now keep the compass away from the center or towards the center. If you follow the above steps, you can see that you can draw another magnetic line and the magnetic lines are concentric circles. Also you will find the magnetic lines are anti-clockwise.



Reverse the direction of the current, you will find the magnetic circles are clockwise. Note: The flow of current here means conventional current and not the direction of the flow of electrons.

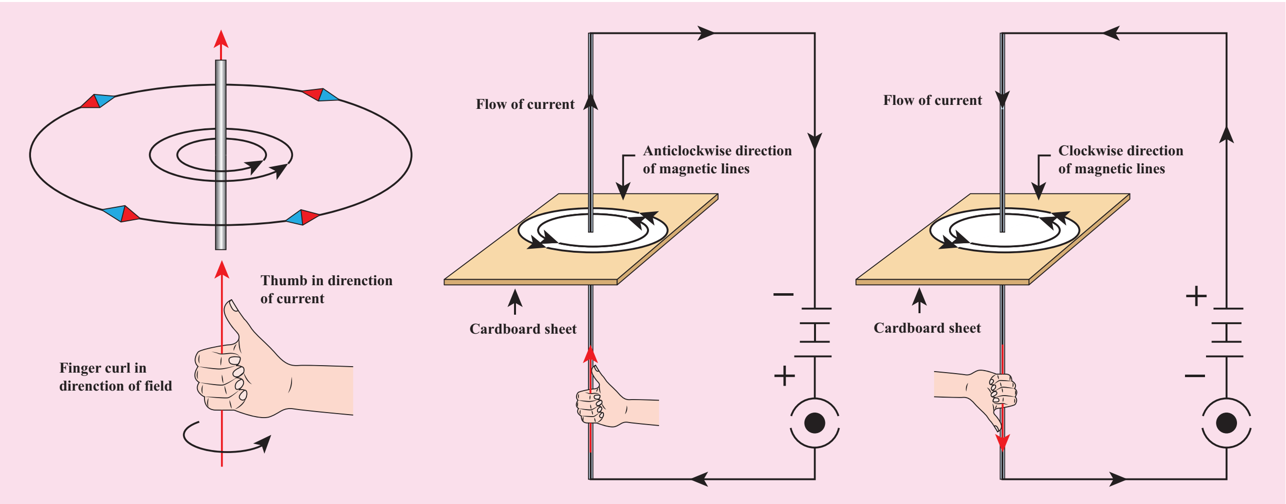


Figure 3.10 Right hand thumb rule

wire, by looking at the deflection of the compass needle in the vicinity of a current carrying conductor. The deflection of the needle implies that the current carrying conductor exerts a force on the compass needle. In 1821, Michael Faraday discovered that a current carrying conductor also gets deflected when it is placed in a magnetic field. In Figure 3.11, we can see that the magnetic field of the permanent magnet and the magnetic field produced by the current carrying conductor interact and produce a force on the conductor. The view perpendicular to the direction of current is shown in Figure 3.12.

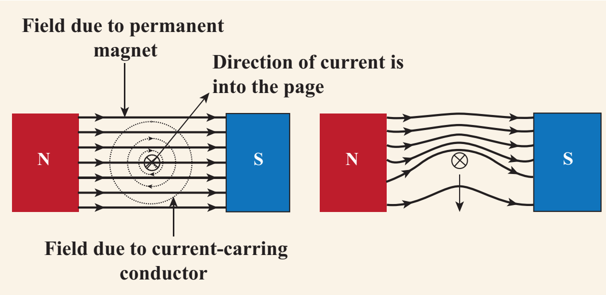


Figure 3.12 Force on current carrying conductor kept in magnetic field

If a current I is flowing through a conductor of length L kept perpendicular to the magnetic field B, then the force F experienced by it is given by the equation,

Activity 4

Stand near the TV screen (The old CRT type TV). Do you feel any sensation on your skin? Take a bar magnet and bring it near the TV Screen. What do you observe? You can observe that the picture on the screen is distorted. Move the bar magnet away from the screen. Now you will get a clear picture. Repeat this to confirm that the motion of electrons is affected by the field produced by the bar magnet. This must be due to the fact that the magnetic field exerts force on the moving charges. This force is called magnetic force.

$$F = I\,L\,B$$

The above equation indicates that the force is proportional to current through the conductor, length of the conductor and the magnetic field in which the current carrying conductor is kept.

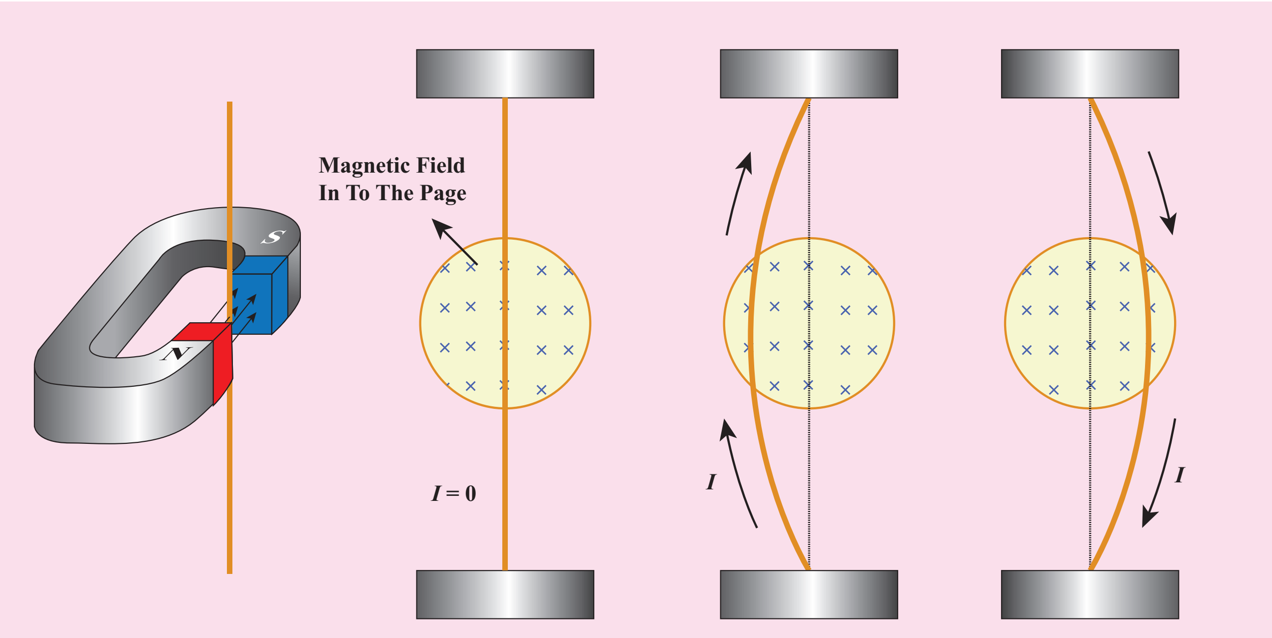


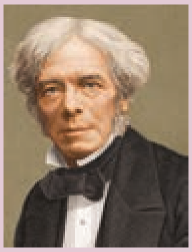
Figure 3.11 Deflection of current carrying wire in magnetic field

Note : The angle of inclination between the current and magnetic field also affects the magnetic force. When the conductor is perpendicular to the magnetic field, the force will be the maximum (=BIL). When it is parallel to the magnetic field, the force will be zero.

The force is always a vector quantity. A vector quantity has both magnitude and direction. It means we should know the direction in which the force would act. The direction is often found using what is known as Fleming's Left hand Rule (formulated by the scientist John Ambrose Fleming).

The law states that while stretching the three fingers of left hand in perpendicular manner with each other, if the direction of the current is denoted by middle finger of the left hand and the second finger is for direction of the magnetic field then the thumb of the left hand denotes the direction of the force or movement of the conductor (Fig. 3.13)

Know Your Scientist



Michael Faraday (22 September 1791 – 25 August 1867) was a British Scientist who contributed to the study of electromagnetism and electrochemistry. His main discoveries include the principles underlying electromagnetic induction, diamagnetism and electrolysis.

Although Faraday received little formal education, he was one of the most influential scientists in history. Faraday was an excellent experimentalist who conveyed his ideas in clear and simple language. The SI unit of capacitance is named in his honour: the farad. Albert Einstein kept a picture of Faraday on his study wall, alongside pictures of Isaac Newton and James Clerk Maxwell. Faraday is one of the greatest scientific discoverers of all time.

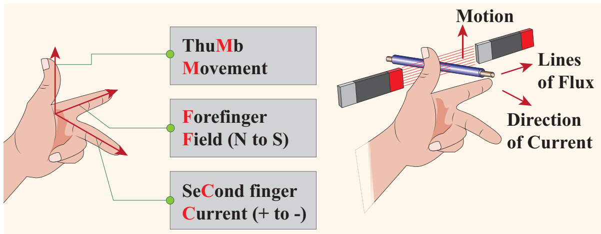


Figure 3.13 Fleming's left hand rule

Exercise 1

A conductor of length 50 cm carrying a current of 5 A is placed perpendicular to a magnetic field of induction 2×10^{-3} T. Find the force on the conductor.

Solution:

Force on the conductor = ILB

$$= 5\times50\times10^{-2}\times2\times10^{-3}$$

$$= 5\times10^{-3}\text{ N}$$

Exercise 2

A current carrying conductor of certain length, kept perpendicular to the magnetic field experiences a force F. What will be the force if the current is increased four times, length is halved and magnetic field is tripled?

Solution:

Let the current be I, length be L, and magnetic field be B. Therefore, F = I L B.

When current is increased four times, length is halved and magnetic field tripled then,

force, $F_1 = (4I) \times (L/2) \times (3B)$

$F_1 = 6F$

Therefore, the force increases six times.

3.5 Force on parallel current carrying conductors

We have seen that a current carrying conductor has a magnetic field around it. If we place another conductor carrying current parallel to the first one, the second conductor will experience a force due to the magnetic field of the first conductor. Similarly, the first conductor will experience a force due to the magnetic field of the second conductor. These two forces will be equal in magnitude and opposite in direction. This is shown in Fig. 3.14.

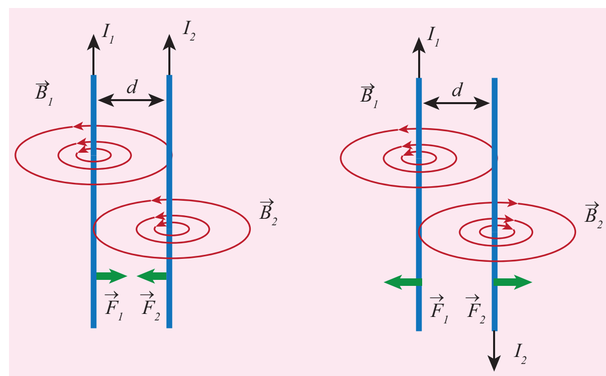


Figure 3.14 Attractive and repulsive force on current carrying wires

Using Fleming's left hand rule we can find that the direction of the force on each wire would be towards each other when the current in both of them are flowing in the same direction. That is the wires would experience an attractive force. However, if the direction of the flow of current is in opposite direction, then the force on each of the wire will also be in opposite direction. These are shown in Figure 3.14. The perpendicular view of the same is shown in Figure 3.15.

Connection between Electricity and magnetism:

Before 18th century people thought that magnetism and electricity were separate subjects of study. After Oersted experiment the electricity and magnetism were united and became a single subject called "Electromagnetism".

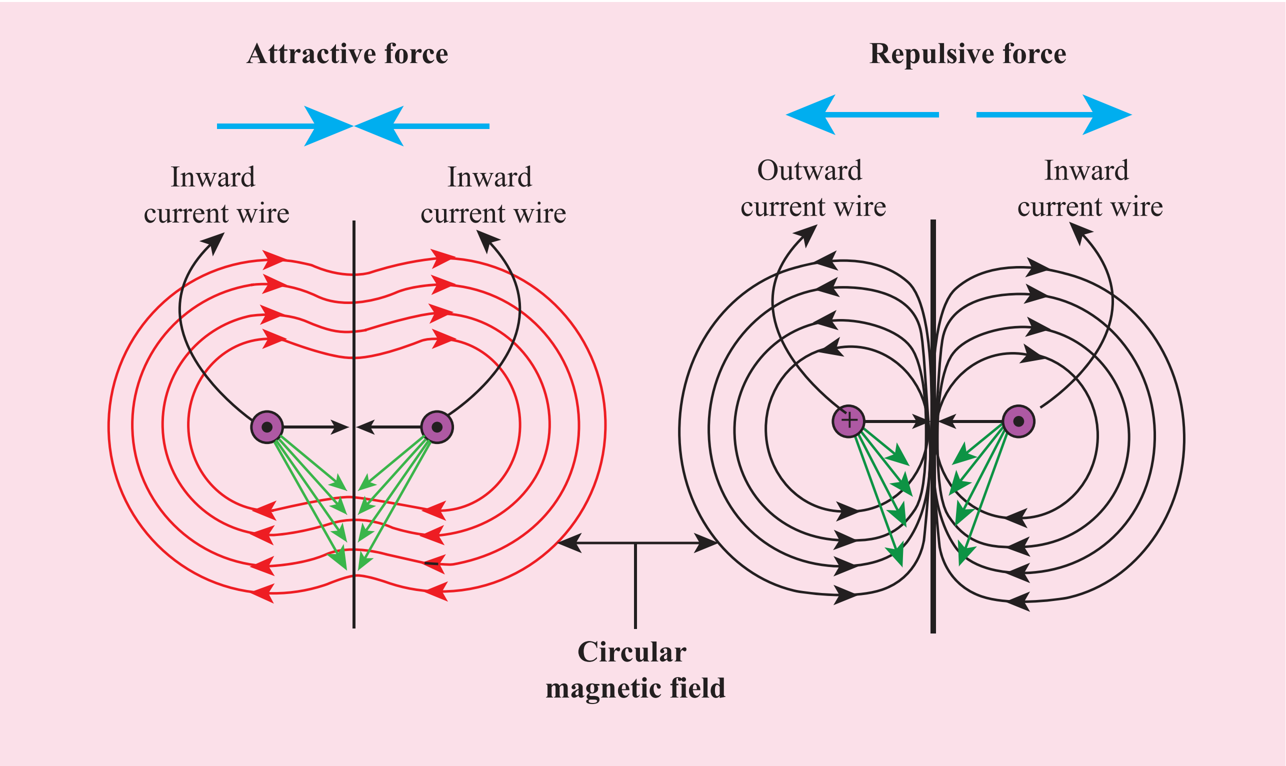


Figure 3.15 Force on current carrying conductors when viewed perpendicular to the direction of current

When there is current, the magnetic field is produced and the current carrying conductor behaves like a magnet. You may now wonder how was it possible for a lodestone to behave like a magnet when there was no current passing through it. In the twentieth century only we understood that the magnetic property arises due to the motion of electrons in the lodestone. In the circuit the electrons flow from negative of the battery to positive of the battery and constitutes current. As a result it produces magnetic field. In natural magnets and artificial magnets we buy in shops, the electrons move around the nucleus constitutes current which leads to magnetic property. Here, every orbiting electron in its orbit is like a current carrying loop. Even though in all materials the electron orbits around the nucleus, only for certain special type of material called magnetic material the motion of electrons around the nucleus gets added up and as a result we have permanent magnetic field.

3.6 Electric motor

BHFMV1

An electric motor is a device which converts electrical energy into mechanical energy. Electric motors are crucial in modern life. They are used in water pump, fan, washing machine, juicer, mixer, grinder etc. We have already seen that when electric current is passed through a conductor placed normally in a magnetic field, a force is acting on the conductor and this force makes the conductor to move. This is harnessed to construct an electric motor.

To understand how a motor works, we need to understand how a current carrying coil experiences a turning effect when placed inside a permanent magnetic field and it is shown in Figure 3.16.

In Fig. 3.16, a simple coil is placed inside two poles of a magnet. Now look at the current carrying conductor segment AB. The direction of the current is towards B, whereas in the conductor segment CD the direction is opposite. As the current is flowing in opposite directions in the segments AB and CD, the direction of the motion of the segments would be in opposite directions according to Fleming's left hand rule. When two ends of the coil experience force in opposite direction, they rotate.

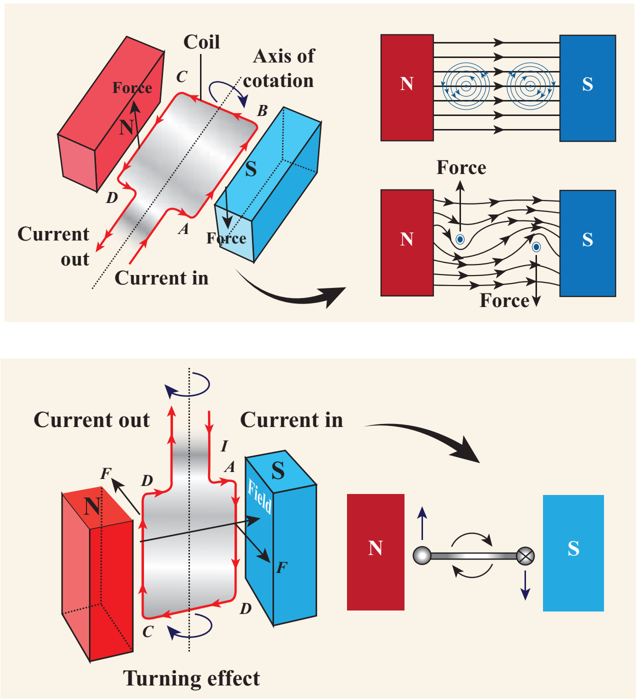


Figure 3.16 Turning effect in a coil

If the current flow is along the line ABCD, then the coil will rotate in clockwise direction first and then in anticlockwise direction. If we want to make the coil rotate in any one

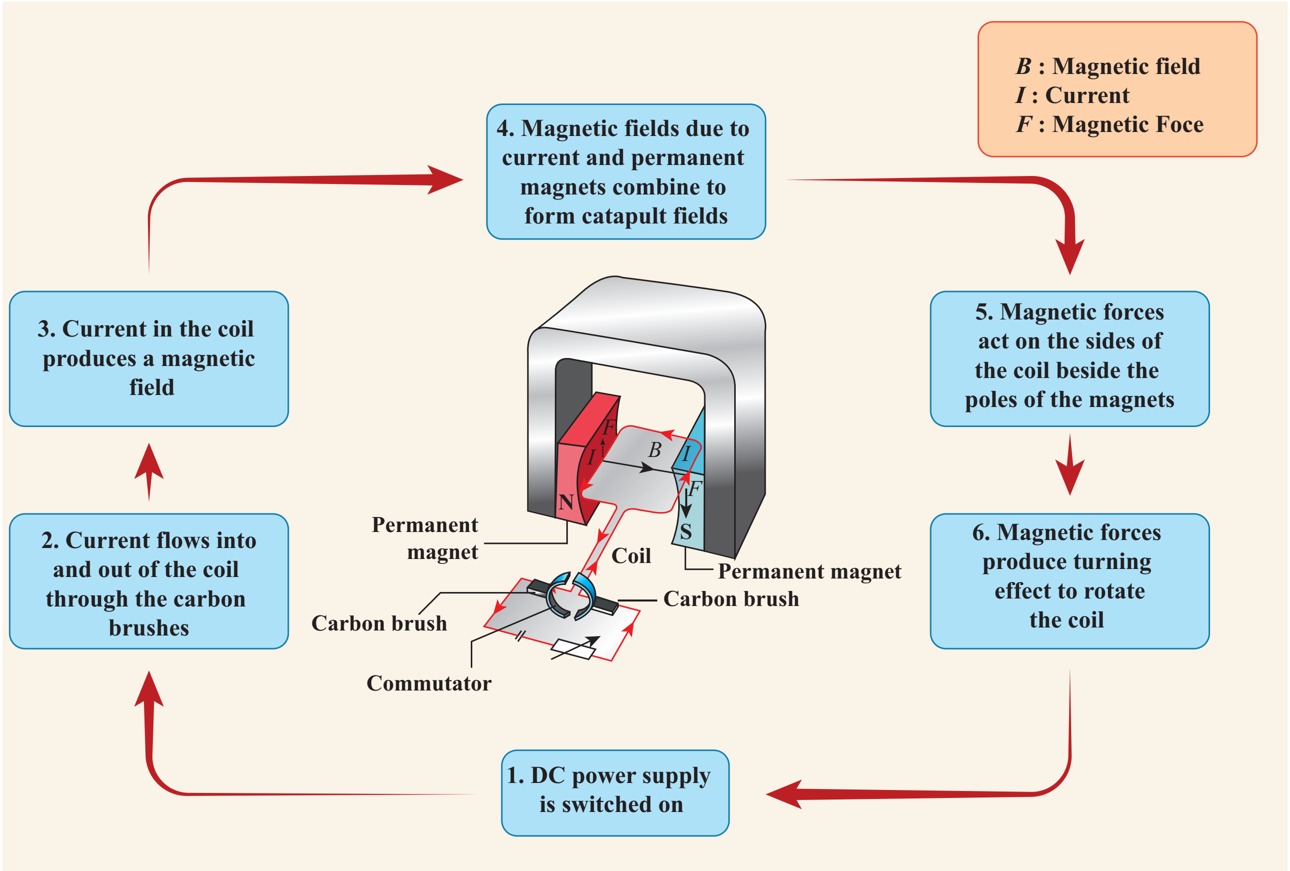


Figure 3.17 Principle of electric motor

direction, say clockwise, then the direction of the current should be along ABCD in the first half of the rotation and along DCBA in the second half of the rotation. To change the direction of the current, a small device called split ring commutator is used (Fig. 3.18).

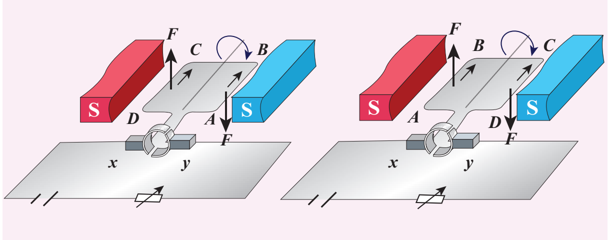


Figure 3.18 Split ring as commutator to produce rotation in same direction.

When the gap in the split ring commutator is aligned with terminals X and Y there is no flow of current in the coil. But, as the coil is moving, it continues to move forward bringing one of the split ring commutator in contact with the carbon brushes X and Y. The reversing of the current is repeated at each half rotation, giving rise to a continuous rotation of the coil.

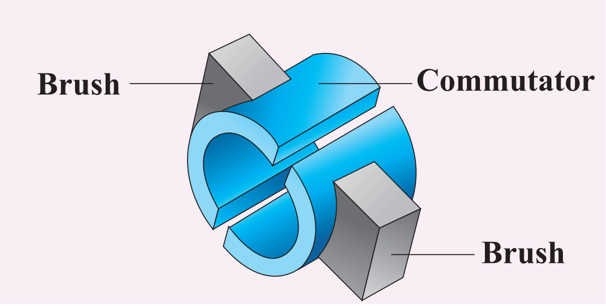


Figure 3.19 Close view of split ring and carbon brushes

The speed of rotation of coil can be increased by:

i. increasing the strength of current in the coil.

ii. increasing the number of turns in the coil.

iii. increasing the area of the coil and

iv. increasing the strength of the magnetic field.

3.7 Electromagnetic Induction

When it was shown by Oersted that magnetic field is produced around a conductor carrying current, the reverse effect was also attempted. In 1831, Michael Faraday explained the possibility of producing an e.m.f across the conductor when the magnetic flux linked with the conductor is changed. In order to demonstrate this Faraday conducted the following experiments.

3.7.1 Faraday's experiments

Experiment 1

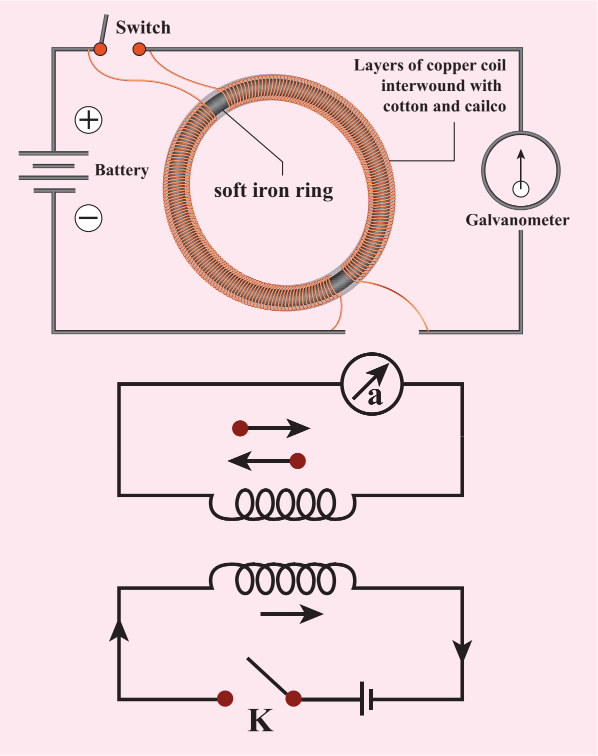


Figure 3.20 Faraday's experiment

In this experiment, two coils were wound on a soft iron ring (separated from each other). The coil on the left is connected to a battery and a switch K. A galvanometer is attached to the coil on the right. When the switch is put 'on', at that instant, there is a deflection in the galvanometer. Likewise, when the switch is put 'off', again there is a deflection – but in the opposite direction. This proves the generation of current.

Experiment 2

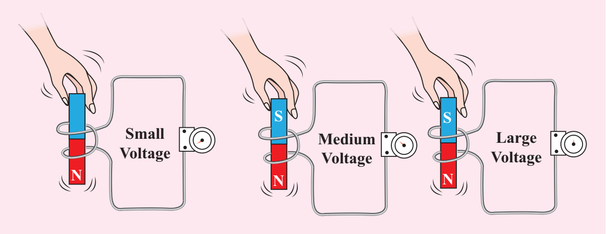


Figure 3.21 Electromagnetic induction by moving the magnet

In this experiment, current (or voltage) is generated by the movement of the magnet in and out of the coil. The greater the number of turns, the higher is the voltage generated.

Experiment 3

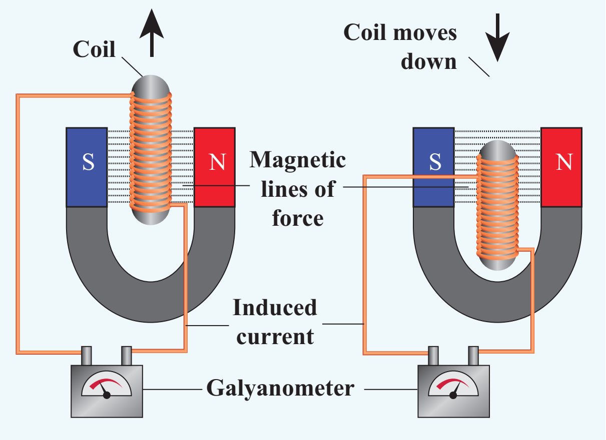


Figure 3.22 Electromagnetic induction by moving the coil

In this experiment, the magnet is stationary, but the coil is moved in and out of the magnetic field (indicated by the magnetic lines of force). Here also, current is induced.

All these observations made Faraday to conclude that whenever there is a change in the magnetic flux linked with a closed circuit an emf is produced and the amount of emf induced varies directly as the rate at which the flux changes. This emf is known as induced emf and the phenomenon of producing an induced emf due to change in the magnetic flux linked with a closed circuit is known as electromagnetic induction.

Note:

The direction of the induced current was given by Lenz's law, which states that the induced current in the coil flows in such a direction as to oppose the change that causes it. The direction of induced current can also be given by another rule called Fleming's Right Hand Rule.

Activity 5

Create your own electromagnet

You are given with a long iron nail, insulation coated copper wire and a battery. Can you make your own electromagnet?

3.7.2 Fleming's Right Hand Rule

Fleming formulated Right Hand Rule to find the direction of flow of current when a conductor is placed in a changing magnetic field as he formulated Left Hand Rule to find the direction of the force in a current carrying conductor placed in a magnetic field.

Stretch the thumb, fore finger and middle finger of your right hand mutually perpendicular to each other. If the fore finger indicates the direction of magnetic field and the thumb indicates the direction of motion of the conductor, then the middle finger will indicate the direction of induced current. Fleming's Right hand rule is also called "generator rule".

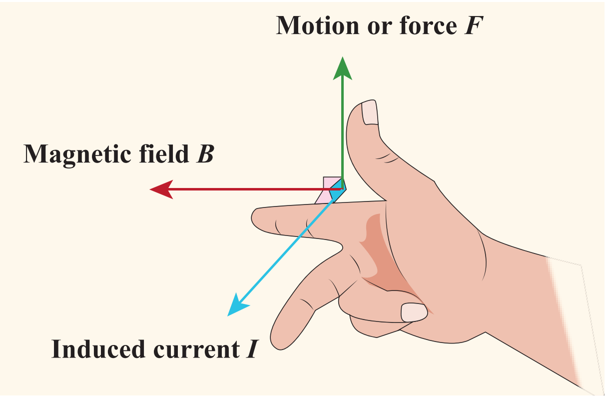


Figure 3.23 Fleming's right hand rule

3.8 Electric generator

An alternating current (AC) generator, as shown in Figure 3.24, consists of a rotating rectangular coil ABCD called armature placed between the two poles of a permanent magnet. The two ends of this coil are connected to the two slip rings S_1 and S_2. The inner sides of these rings are insulated. Two conducting stationary brushes B_1 and B_2 are kept separately on the rings S_1 and S_2 respectively. The two rings S_1 and S_2 are internally attached to an axle. The axle may be mechanically rotated from outside to rotate the coil inside the magnetic field. Outer ends of the two brushes are connected to the external circuit.

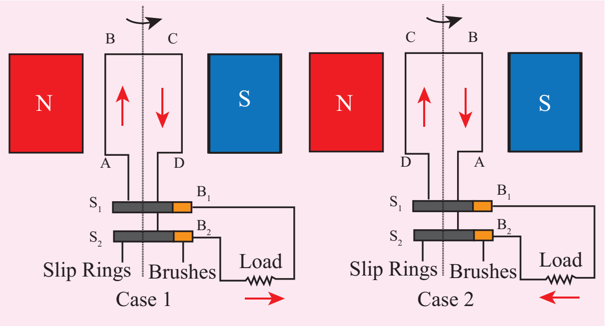


Figure 3.24 AC generator

When the coil is rotated, the magnetic flux linked with the coil changes. This change in magnetic flux will lead to generation of induced current. The direction of the induced current, as given by Fleming's Right Hand Rule, is along ABCD in the coil and in the outer circuit it flows from B_2 to B_1. During the second half of rotation, the direction of current is along DCBA in the coil and in the outer circuit it flows from B1 to B2. As the rotation of the coil continues, the induced current in the external circuit is changing its direction for every half a rotation of the coil.

To get a direct current (DC), a split ring type commutator must be used. With this arrangement, one brush is at all times in contact with the arm moving up in the field while the other is in contact with the arm moving down. Thus a unidirectional current is produced. The generator is thus called a DC generator (Figure 3.25).

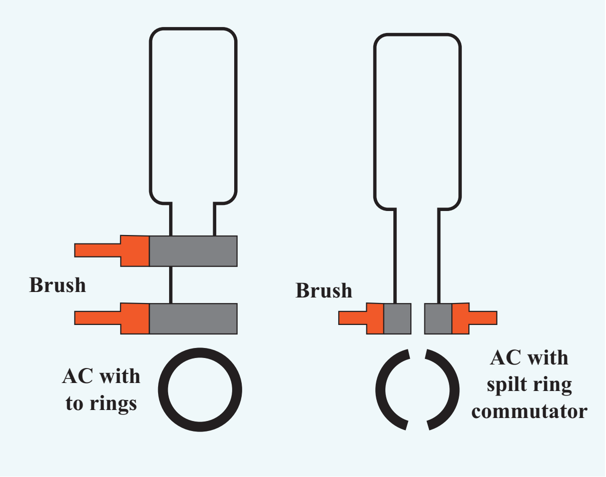


Figure 3.25 Comparison of AC and DC generators

3.9 Transformer

Transformer is a device used for converting low voltage into high voltage and high voltage into low voltage. It works on the principle of electromagnetic induction. It consists of primary and secondary coil insulated from each other. In Figure 3.26, the alternating current flowing through the primary coil induces magnetic field in the iron ring. The magnetic field of the iron ring induces a varying emf in the secondary coil.

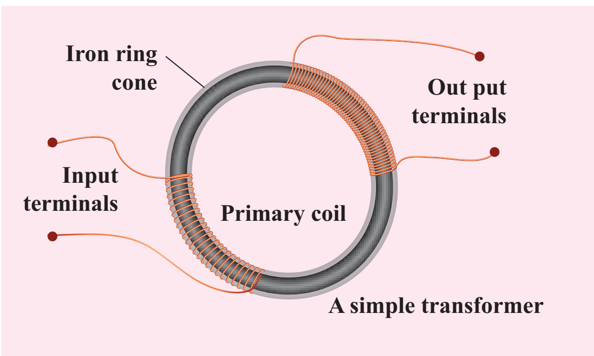


Figure 3.26 Principle of transformer

Depending upon the number of turns in the primary and secondary coils, we can step-up or step-down the voltage in the secondary coil as shown in Figure 3.27.

Step up transformer: The transformer used to change a low alternative voltage to a high alternating voltage is called a step up transformer. ie (Vs > Vp) . In a step up transformer, the number of turns in the secondary coil is more than the number of turns in the primary coil (Ns > Np).

Step down transformer: The transformer used to change a high alternating voltage to a low alternating voltage is called a step down transformer (Vs < Vp). In a step down transformer, the number of turns in the secondary coils are less than the number of turns in the primary coil (Ns < Np).

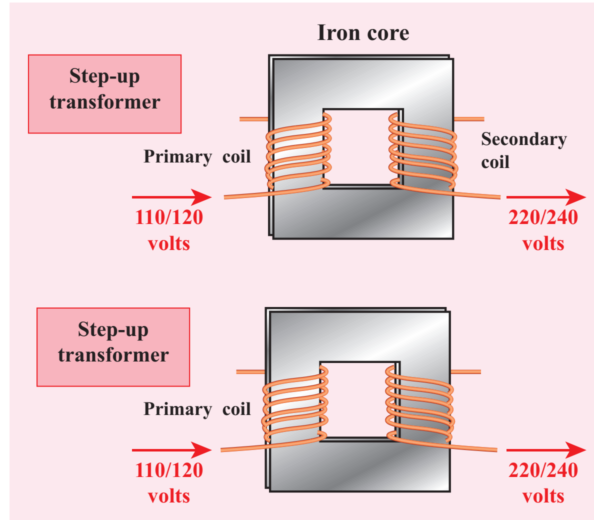


Figure 3.27 Step up and Step down transformers

DO YOU KNOW?

A step up transformer increases the voltage but it decreases the current and vice versa. Basically there will be loss of energy in a transformer in the form of heat, sound etc.

The formulae pertaining to the transformers are given in the following equations.

$$\frac{\text{The number of primary turns } N_p}{\text{The number of secondary turns } N_s} = \frac{\text{The primary voltage } V_p}{\text{The secondary voltage } V_s}$$

$$\frac{\text{The number of secondary turns } N_s}{\text{The number of primary turns } N_p} = \frac{\text{The primary current } I_p}{\text{The secondary current } I_s}$$

A transformer cannot be used with the direct current (DC) source because of current in primary coil is constant (ie. DC). Then there will be no change in the number of magnetic field lines linked with the secondary coil and hence no emf will be induced in the secondary coil.

Exercise 3

The primary coil of a transformer has 800 turns and the secondary coil has 8 turns. It is connected to a 220 V ac supply. What will be the output voltage?

Solution:

In a transformer, $E_s / E_p = N_s / N_p$

$E_s = N_s / N_p \times E_p$

$= 8/800 \times 220$

$= 220/100$

$E_s = 2.2$ volt

Exercise 4

A transformer is designed to give a supply of 8 V to ring a house bell from 240 V ac mains. The primary coil has 4800 turns. How many turns will be in the secondary coil.

Solution:

In a transformer, $E_s / E_p = N_s / N_p$

$N_s = E_s / E_p \times N_p$

$= 8/240 \times 4800$

$N_s = 4800/30 = 160$ turns

3.10 Applications of Electromagnets

Electromagnetism has created a great revolution in the field of engineering applications. In addition, this has caused a great impact on various fields such as medicine, industries, space etc.

3.10.1 Speaker

Inside the speaker, the electromagnet is placed in front of a permanent magnet. The permanent magnet is fixed firmly in position whereas the electromagnet is mobile. As pulses of electricity pass through the coil of the electromagnet, the direction of its magnetic field is rapidly changed. This means that it is in turn attracted to and repelled from the permanent magnet vibrating back and forth. The electromagnet is attached to a cone made of a flexible material such as paper or plastic which amplifies these vibrations, pumping sound waves into the surrounding air towards our ears.

DO YOU KNOW?

An electric bell contains an electromagnet, consisting of coils of insulated wire wound around iron rods. When an electric current flows though the coils, the rods become magnetic and attract a piece of iron attached to a clapper. The clapper hits the bell and makes it ring.

3.10.2 Magnetic Levitation Trains

Magnetic levitation (Maglev) is a method by which an object is suspended with no support other than magnetic fields. In maglev trains two sets of magnets are used, one set to repel and push the train up off the track, then another set to move the floating train ahead at great speed without friction. In this technology, there is no moving part. The train travels along a guideway of magnets which controls the train’s stability and speed using the basic principles of magnets.

3.10.3 Medical System

Nowadays electromagnetic fields play a key role in advanced medical equipments such as hyperthermia treatments for cancer, implants and magnetic resonance imaging (MRI). In a, sophisticated equipments working based on the electromagnetism can scan minute details of the human body.


MRI Scanner

Many of the medical equipments such as scanners, x-ray equipments and other equipments also use principle of electromagnetism for their functioning.

Points to Remember:

- When current passes through a wire a magnetic field is set up around the wire. This effect of current is called magnetic effect of current.
- The space surrounding a bar magnet in which its influence in the form of magnetic force can be detected, is called magnetic field.
- The path along which a free magnetic north pole will move in a magnetic field is called magnetic field lines.
- Magnetic field lines do not intersect.
- The magnetic field set up by a current carrying conductor is always at right angles to the direction of flow of current.
- Two parallel wires carrying current in the same directions attract each other.
- Two parallel wires carrying current in the opposite directions repel each other.
- Direction of the force in a current carrying conductor is determined by Fleming's Left Hand Rule.
- Electric motor is a device which converts electrical energy into mechanical energy.
- The phenomenon of producing induced current in a closed circuit due to the change in magnetic field in the circuit is known as electromagnetic induction.
- Direction of induced current in a conductor is determined by Fleming's Right Hand Rule.
- Electric generator is a device used to convert mechanical energy into electrical energy.
- Electric generator works on the principle of electromagnetic induction.
- Transformer is a device which converts low alternating current to high alternating current and vice versa.
- Transformer transfers electric power from one circuit to another.

A-Z GLOSSARY

Magnetic field	The region surrounding a magnet in which the force of the magnet can be detected.
Magnetic line of force	The path followed by a magnetic needle in a magnetic field.
Dynamo	Device which converts mechanical energy into electrical energy.
Motor	Device which converts electrical energy into mechanical energy.
Electromagnetic induction	The phenomenon of producing an induced emf due to the changes in the magnetic lines of forces associated with a conductor.
Transformer	Device which converts low alternating current to high alternating current and vice versa.
MRI	Magnetic Resonance Imaging which is used to obtain images of the internal parts of our body.

TEXT BOOK EXERCISES

I. Choose the correct answer.

1. Which of the following converts electrical energy into mechanical energy.
   a) motor b) battery
   c) generator d) switch

2. An electric generator converts
   a) electrical energy into mechanical energy
   b) mechanical energy into heat energy
   c) electrical energy into electrical energy
   d) mechanical energy into electrical energy.

3. The part of the AC generator that passes the current from the armature coil to the external circuit is
   a) field magnet b) split rings
   c) slip rings d) brushes

4. Transformer works on
   a) AC only
   b) DC only
   c) both AC and DC
   d) Ac nor effectively than DC

5. The unit of magnetic flux density is
   a) Weber b) weber/metre
   c) weber/meter^2 d) weber . meter^2

II. Fill in the blanks.

1. The SI Unit of magnetic field induction is ________.

2. No force acts in a current carrying conductor when it is ________ to the magnetic field.

3. Devices which is used to convert high alternating current to low alternating current ________.
4. An electric motor converts ________.
5. A device for producing electric current is ________.

III. Match the following.

1. Magnetic material	(a) Oersted
2. Non-magnetic material	(b) iron
3. Current and magnetism	(c) induction
4. Electromagnetic induction	(d) wood
5. Electric generator	(e) Faraday

IV. True or False:

1. A generator converts mechanical energy into electrical energy.
2. Magnetic field lines always repels each other and do not intersect.
3. Fleming's Left hand rule is also known as Dynamo rule.
4. The speed of rotation of an electric motor can be increased by decreasing the area of the coil.
5. A transformer can step up direct current.
6. In a step down transformer the number turns in primary coil is greater than that of the number of turns in the secondary coil.

V. Answer in brief.

1. State Fleming's Left Hand Rule.
2. Define magnetic flux density.
3. List the main parts of an electric motor.
4. Draw and label the diagram of an AC generator.
5. State an important advantage of ac over dc.
6. Differentiate step up and step down transformer.
7. A portable radio has a built in transformer so that if can work from the mains instead of batteries. Is this a step up or step down transformer?
8. Two coils A and B of insulated wire are kept close to each other. Coil A is connected to a galvanometer. While coil B is connected to a battery through a key. What would happen if
   (i) a current is passed through coil B by plugging the key?
   (ii) the current is stopped by removing the plug from the key?
9. State Faraday's laws of electromagnetic induction.

VI. Answer in detail.

1. Explain the principle, construction and working of a dc motor.
2. Explain two types of transformer.
3. Draw a neat diagram of an AC generator.

REFERENCE BOOKS

Advanced Physics by Keith Gibbs – Cambridge University Press.

Principles of physics (Extended) – Halliday Resnick and Walker. Wiley publication, New Delhi.

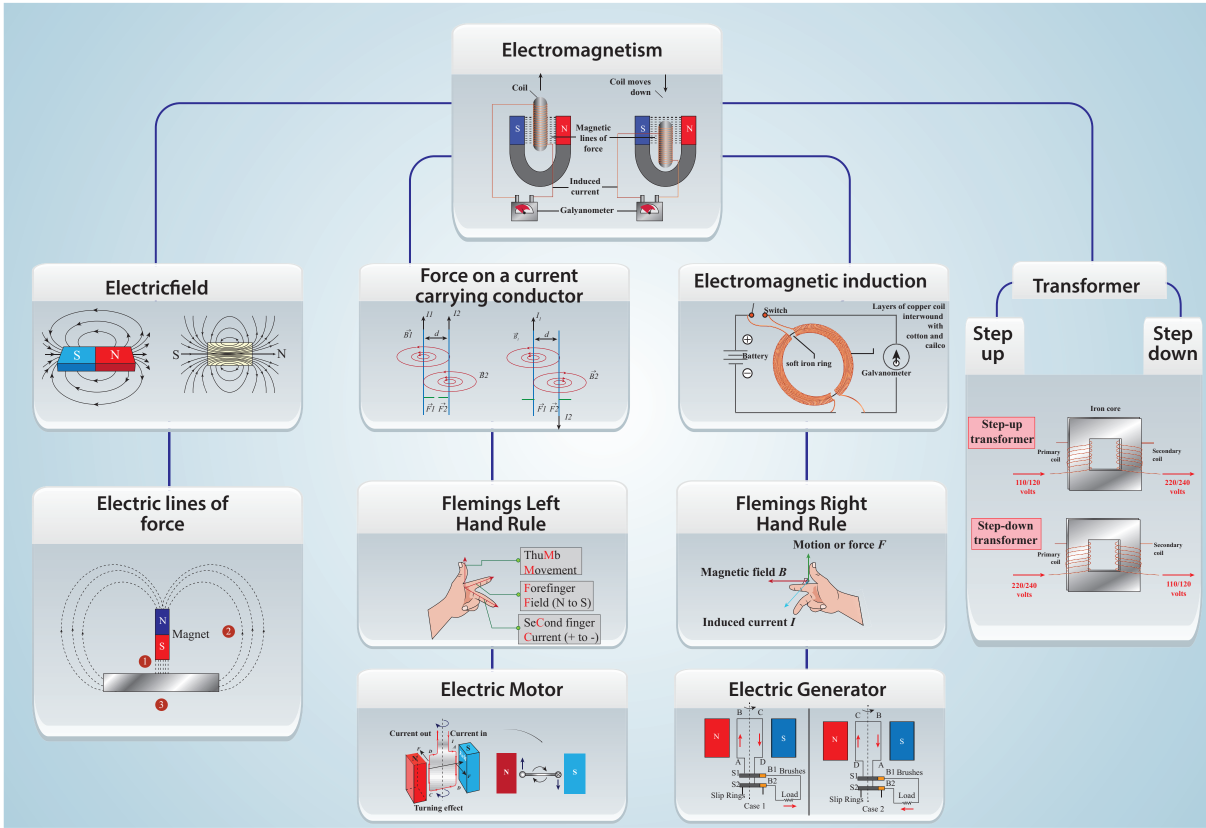
Fundamental University Physics – M. Alonso, E. J. Finn Addimon Wesley (1967)

INTERNET RESOURCES

www.physicsabout.com

https://science.howstuffworks.com

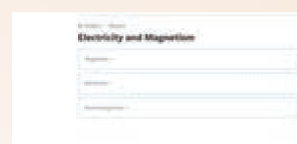
http://arvindguptatoys.com/films.html



ICT CORNER

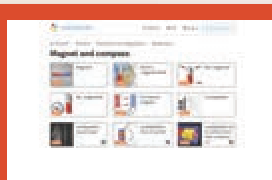
Magnetism and Electromagnetism

Explore this activity to know about the various properties in magnetism

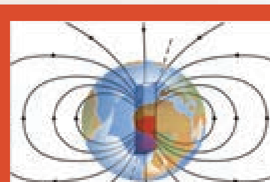


Steps

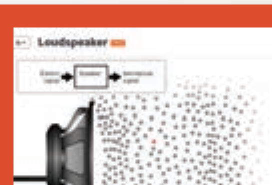
- Copy and paste the link given below or type the URL in the browser. Click the option **Magnet and Compass**.
- You can find six activities and three videos related to magnets and loudspeaker.
- Click any one of the six activities to simulate and understand the process.
- Click any one of the three videos to understand the concepts related to loudspeaker and magnets. Try all the other activities and videos as well.



Step1



Step2



Step3

Step4

Browse in the link:

URL: http://www.edumedia-sciences.com/en/node/75-magnetism

*Pictures are indicative only

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UNIT 4

Periodic classification of elements

BN8AZY

Learning Objectives

After studying this chapter, students will be able to

- know the concept of classification of elements in early days.
- understand the postulates, advantages and limitations of modern periodic table.
- understand the classification of elements based on the electronic configuration.
- learn about the position of hydrogen in periodic table.
- study about the position of Rare Gases (Noble gases) in the periodic table.
- distinguish between metals and non-metals.
- know about the metalloids and alloys.

Introduction

Think of a morning prayer in your school. Students stand in rows which are horizontal as well as vertical. Each class stands in a single line, height wise. Generally, height of students of class I is the shortest and that of class 12 is the tallest.

The vendor in a medical store could locate the medicines we seek in a flash of time with the use of a pattern they are arranged. We can easily identify the books in the library as quickly as possible.

There is a pattern in all these cases and this pattern makes the selection easy. (Pattern: regular arrangement)

We live in the world of substances with great diversity. The substances are formed by the combination of various elements. All the elements are unique in their nature and property. To categorize these elements according to their properties, scientists started to look for a way. In 1800, there were only 31 known elements. By 1865, their number became 63. Now 118 elements have been discovered. As different elements were being discovered, scientists gathered more and more information about the properties of these elements. They found it difficult to organize all that was known about the elements. They started looking for some pattern in their properties, on the basis of which they could study such a large number of elements with ease. Let us discuss the concepts of classification of elements proposed by various scientists from early to modern period.

4.1. Early Concepts Of Classification Of Elements

4.1.1. DOBEREINER'S TRIADS

In 1817, Johann Wolfgang Dobereiner, a German chemist, suggested a method of grouping of elements based on their relative atomic masses. He arranged the elements into groups containing three elements each. He called these groups as 'triads' (tri – three).

Dobereiner showed that when the three elements in a triad are arranged in the ascending order of their atomic masses the atomic mass of the middle element is nearly the same as average of atomic masses of other two elements. This statement is called the Dobereiner's law of triads. Table 4.1 shows the law of triads proposed by Dobereiner:

Example: In the triad group (1), arithmetic mean of atomic masses of 1st and 3rd elements, (6.9 + 39.1)/2 = 23. So the atomic mass of Na (middle element) is 23.

DO YOU KNOW?

Johann Wolfgang Dobereiner was a German chemist who is best known for his periodic law of triads of chemical elements. Dobereiner discovered furfural, used platinum as a catalyst and discovered a lighter, known as Dobereiner's lamp.

Limitations:

- Dobereiner could identify only three triads from the elements known at that time and all elements could not be classified in the form of triads.
- The law was not applicable to elements having very low atomic mass and very high atomic mass.

Table 4.1 Dobereiner`s law of triads

Triad Group (1)		Triad Group (2)		Triad Group (3)	
Element	Atomic Mass	Element	Atomic Mass	Element	Atomic Mass
Li	6.9	Cl	35.5	Ca	40.1
Na	23	Br	79.9	Sr	87.6
K	39.1	I	126.9	Ba	137.3

4.1.2 NEWLANDS' LAW OF OCTAVES

In 1866, John Newlands arranged 56 known elements in the increasing order of their atomic mass. He observed that every eighth element had properties similar to those of the first element like the eighth note in an octave of music is similar to the first and this arrangement was known as "law of octaves".

The octave of Indian music system is sa, re, ga, ma, pa, da, ni, sa. The first and last notes of this octave are same i.e. sa. Likewise, in the Newlands' table of octaves, the element 'F' is eighth from the element 'H' thus they have similar properties.

Activity 1

Find the pair of elements having similar properties by applying Newlands' law of Octaves (Example: Mg & Ca):

Set I : F, Mg, C, O, B

Set II: Al, Si, S, Cl, Ca

Limitations:

- There are instances of two elements being fitted into the same slot, e.g. cobalt and nickel.
- Some elements, totally dissimilar in their properties, were fitted into the same group. (Arrangement of Co, Ni, Pd, Pt and Ir in the row of halogens)
- The law of octaves was not valid for elements that had atomic masses higher than that of calcium.

DO YOU KNOW?

John Newlands (1837-1898) was a Scottish analytical chemist. He continued Dobereiner's work with triads and published his 'Law of Octaves' in 1865, which stated that 'any given element will exhibit analogous behaviour to the eighth element following it in the table.' Newlands arranged all the known elements, starting with hydrogen and ending with thorium, into seven groups of eight, which he linked to octaves of music. In Newlands' table, the elements were ordered by the atomic weights that were known at the time and were numbered sequentially to show their order. After Dmitri Mendeleev and Lothar Meyer, he received the prestigious Davy Medal in 1887.

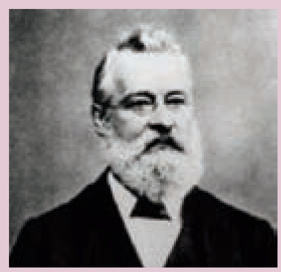


Table 4.2 Newland's table of octaves (oct- eight)

NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
H1	F8	Cl 15	Co&Ni 22	Br 29	Pd 36	I 42	Pt & Ir 50
Li 2	Na 9	K 16	Cu 23	Rb 30	Ag 37	Cs 44	Os 51
G 3	Mg 10	Ca 17	Zn 24	Sr 31	Cd 38	Ba & V45	Hg 52
BO 4	Al 11	Cr 19	Y 25	Ce & La33	U40	Ta 46	Ti 53
C 5	Si 12	Ti 18	In 26	Zr 32	Sn 39	W 47	Pb 54
N 6	P 13	Mn 20	As 27	Di&Mo 34	Sb 41	Nb 48	Bi 55
O7	S 14	Fe 21	Se 28	Ro&Ru 35	To 43	Au 49	Th 56

- ❖ Newlands' table was restricted to only 56 elements and did not leave any room for new elements.
- ❖ Discovery of inert gases (Neon. Argon….) at later stage made the 9th element similar to the first one. Eg: Neon between Fluorine and Sodium.

4.1.3 MENDELEEV'S PERIODIC TABLE

In 1869, Russian chemist, Dmitri Mendeleev observed that the elements of similar properties repeat at regular intervals when the elements are arranged in the order of their atomic masses. Based on this, he proposed the law of periodicity which states that "the physical and chemical properties of elements are the periodic functions of their atomic masses". He arranged 56 elements known at that time according to his law of periodicity. This was best known as the short form of periodic table.

Features of Mendeleev's Periodic Table:

- ❖ It has eight vertical columns called 'groups' and seven horizontal rows called 'period'.
- ❖ Each group has two subgroups 'A' and 'B'. All the elements appearing in a group were found to have similar properties.
- ❖ For the first time, elements were comprehensively classified in such a way that elements of similar properties were placed in the same group.
- ❖ It was noticed that certain elements could not be placed in their proper groups in this manner. The reason for this was wrongly determined atomic masses, and consequently those wrong atomic masses were corrected. Eg: The atomic mass of beryllium was known to be 14. Mendeleev reassessed it as 9 and assigned beryllium a proper place.
- ❖ Columns were left vacant for elements which were not known at that time and their properties also were predicted. This gave motivation to experiment in Chemistry. Eg: Mendeleev gave names Eka Aluminium

Table 4.3 Mendeleev's Periodic Table

Group	I	II	III	IV	V	VI	VII	VIII
Oxide: Hydride:	R_2O RH	RO RH_4	R_2O_3 RH_4	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods	A B	A B	A B	A B	A B	A B	A B	Transition series
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.988	
3	Na 22.99	Mg 22.99	Al 24.31	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First Series Second series	K 39.102 Cu 63.54	Ca 40.08 Zn 65.54	Sc 44.96 Ga 69.72	Ti 47.90 Ge 72.59	V 50.94 As 74.92	Cr 50.20 Se 78.96	Mn 54.94 Br 79.909	Fe Co Ni 55.85 58.93 58.71
5 First Series Second series	Rb 85.47 Ag 107.87	Sr 87.62 Cd 112.40	Y 88.91 In 114.82	Zr 91.22 Sn 118.69	Nb 92.91 Sb 121.60	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru Rh Pd 101.07 102.91 106.4
6 First Series Second series	Cs 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Tl 204.37	Hf 178.40 Pb 207.19	Ta 180.95 Bi 208.98	W 183.85		Os Ir Pt 190.2 192.2 195.05
7	Rn 222	Fr 223	Ra 226	Ac 227	Th 232	Pa 231	U 238	

and Eka Silicon to those elements which were to be placed below Aluminium and Silicon respectively in the periodic table and predicted their properties. The discovery of Germanium later on, during his life time, proved him correct.

Table 4.4 Properties of Germanium

Property	Mendeleev's prediction (1871)	Actual property (1886)
Atomic Mass	About 72	72.59
Specific Gravity	5.5	5.47
Colour	Dark grey	Dark grey
Formula of Oxide	EsO_2	GeO_2
Nature of Chloride	$EsCl_4$	$GeCl_4$

Limitations:

- Elements with large difference in properties were included in the same group. Eg: Hard metals like copper (Cu) and silver (Ag) were included along with soft metals like sodium (Na) and potassium (K).
- No proper position could be given to the element hydrogen. Non-metallic hydrogen was placed along with metals like lithium (Li), sodium (Na) and potassium (K).
- The increasing order of atomic mass was not strictly followed throughout. Eg. Co & Ni, Te & I
- No place for isotopes in the periodic table

Activity 2

Name the class rooms in your school from the first element of the periodic table Hydrogen, Helium …. instead of numbering them. (*Example: Room no: 1- Hydrogen, Room no:2- Helium and so on*)

Dmitri Ivanovich Mendeleev (1834-1907) was a Russian chemist and inventor. He formulated the Periodic Law, and used it to correct the properties of some already discovered elements and also to predict the properties of eight elements yet to be discovered. Mendeleev also investigated the composition of petroleum and helped to establish the first oil refinery in Russia. He recognized the importance of petroleum as a source for petrochemicals. He is called as 'Father of Modern Periodic Table'.

4.2 MODERN PERIODIC TABLE

In 1913, the English Physicist Henry Moseley, through his X-ray diffraction experiments, proved that the properties of elements depend on the atomic number and not on the atomic mass. Consequently, the modern periodic table was prepared by arranging elements in the increasing order of their atomic number.

This modern periodic table is the extension of the original Mendeleev's periodic table and known as the long form of periodic table.

4.2.1 Modern Periodic Law

Atomic number of an element (Z) not only indicates the number of protons (positive charge) but also the number of electrons (negative charge). The physical and chemical properties of elements depend not only on the number of protons but also on the number of

PERIODIC TABLE OF THE ELEMENTS

RELATIVE ATOMIC MASS (1)
GROUP IUPAC: 1 — GROUP CAS: IA
ATOMIC NUMBER: 1 — 1.008
SYMBOL: H
ELEMENT NAME: HYDROGEN

Metal | Semimetal | Nonmetal
Alkali metal | Alkaline earth metal | Transition metals | Lanthanide | Actinide
Chalcogens element | Halogens element | Noble gas

STANDARD STATE (25 °C; 101 kPa)
Ne - gas | Fe - solid
Hg - liquid | Tc - synthetic

PERIOD \ GROUP	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.008 HYDROGEN																	2 He 4.0026 HELIUM
2	3 Li 6.94 LITHIUM	4 Be 9.0122 BERYLLIUM											5 B 10.81 BORON	6 C 12.011 CARBON	7 N 14.007 NITROGEN	8 O 15.999 OXYGEN	9 F 18.998 FLUORINE	10 Ne 20.180 NEON
3	11 Na 22.990 SODIUM	12 Mg 24.305 MAGNESIUM											13 Al 26.982 ALUMINIUM	14 Si 28.085 SILICON	15 P 30.974 PHOSPHORUS	16 S 32.06 SULPHUR	17 Cl 35.45 CHLORINE	18 Ar 39.948 ARGON
4	19 K 39.098 POTASSIUM	20 Ca 40.078 CALCIUM	21 Sc 44.956 SCANDIUM	22 Ti 47.867 TITANIUM	23 V 50.942 VANADIUM	24 Cr 51.996 CHROMIUM	25 Mn 54.938 MANGANESE	26 Fe 55.845 IRON	27 Co 58.933 COBALT	28 Ni 58.693 NICKEL	29 Cu 63.546 COPPER	30 Zn 65.38 ZINC	31 Ga 69.723 GALLIUM	32 Ge 72.64 GERMANIUM	33 As 74.922 ARSENIC	34 Se 78.971 SELENIUM	35 Br 79.904 BROMINE	36 Kr 83.798 KRYPTON
5	37 Rb 85.468 RUBIDIUM	38 Sr 87.62 STRONTIUM	39 Y 88.906 YTTRIUM	40 Zr 91.224 ZIRCONIUM	41 Nb 92.906 NIOBIUM	42 Mo 95.95 MOLYBDENUM	43 Tc (98) TECHNETIUM	44 Ru 101.07 RUTHENIUM	45 Rh 102.91 RHODIUM	46 Pd 106.42 PALLADIUM	47 Ag 107.87 SILVER	48 Cd 112.41 CADMIUM	49 In 114.82 INDIUM	50 Sn 118.71 TIN	51 Sb 121.76 ANTIMONY	52 Te 127.60 TELLURIUM	53 I 126.90 IODINE	54 Xe 131.29 XENON
6	55 Cs 132.91 CAESIUM	56 Ba 137.33 BARIUM	57-71 La-Lu Lanthanide	72 Hf 178.49 HAFNIUM	73 Ta 180.95 TANTALUM	74 W 183.84 TUNGSTEN	75 Re 186.21 RHENIUM	76 Os 190.23 OSMIUM	77 Ir 192.22 IRIDIUM	78 Pt 195.08 PLATINUM	79 Au 196.97 GOLD	80 Hg 200.59 MERCURY	81 Tl 204.38 THALLIUM	82 Pb 207.2 LEAD	83 Bi 208.98 BISMUTH	84 Po (209) POLONIUM	85 At (210) ASTATINE	86 Rn (222) RADON
7	87 Fr (223) FRANCIUM	88 Ra (226) RADIUM	89-103 Ac-Lr Actinide	104 Rf (267) RUTHERFORDIUM	105 Db (268) DUBNIUM	106 Sg (271) SEABORGIUM	107 Bh (272) BOHRIUM	108 Hs (277) HASSIUM	109 Mt (276) MEITNERIUM	110 Ds (281) DARMSTADTIUM	111 Rg (280) ROENTGENIUM	112 Cn (285) COPERNICIUM	113 Nh (285) NIHONIUM	114 Fl (287) FLEROVIUM	115 Mc (289) MOSCOVIUM	116 Lv (291) LIVERMORIUM	117 Ts (294) TENNESSINE	118 Og (294) OGANESSON

LANTHANIDE

57 La 138.91 LANTHANUM	58 Ce 140.12 CERIUM	59 Pr 140.91 PRASEODYMIUM	60 Nd 144.24 NEODYMIUM	61 Pm (145) PROMETHIUM	62 Sm 150.36 SAMARIUM	63 Eu 151.96 EUROPIUM	64 Gd 157.25 GADOLINIUM	65 Tb 158.93 TERBIUM	66 Dy 162.50 DYSPROSIUM	67 Ho 164.93 HOLMIUM	68 Er 167.26 ERBIUM	69 Tm 168.93 THULIUM	70 Yb 173.05 YTTERBIUM	71 Lu 174.97 LUTETIUM

ACTINIDE

89 Ac (227) ACTINIUM	90 Th 232.04 THORIUM	91 Pa 231.04 PROTACTINIUM	92 U 238.03 URANIUM	93 Np (237) NEPTUNIUM	94 Pu (244) PLUTONIUM	95 Am (243) AMERICIUM	96 Cm (247) CURIUM	97 Bk (247) BERKELIUM	98 Cf (251) CALIFORNIUM	99 Es (252) EINSTEINIUM	100 Fm (257) FERMIUM	101 Md (258) MENDELEVIUM	102 No (259) NOBELIUM	103 Lr (262) LAWRENCIUM

electrons and their arrangements (electronic configuration) in atoms. Hence, the modern periodic law can be stated as follows: "The Chemical and Physical properties of elements are periodic functions of their atomic numbers". Based on the modern periodic law, the modern periodic table is derived.

DO YOU KNOW?

Henry Gwyn Jeffreys Moseley (1887-1915) was an English physicist. He developed the chemical concept of atomic number. This concept was developed from his study of X-ray spectra.

Moseley's law advanced atomic physics, nuclear physics and quantum physics by providing the first experimental evidence in favour of Niels Bohr's theory, aside from the hydrogen atom spectrum which the Bohr theory was designed to reproduce. That theory refined Ernest Rutherford's and Antonius van den Broek's model, which proposed that the atom contains in its nucleus a number of positive nuclear charges that is equal to its atomic number in the periodic table. This remains the accepted model today. Moseley redefined the idea of atomic numbers from its previous status to help sorting the elements into an exact sequence of ascending atomic numbers that made the Periodic Table exact. This was later to be the basis of the Aufbau principle in atomic studies.

4.2.2 Features of Modern Periodic Table

- All the elements are arranged in the increasing order of their atomic number
- The horizontal rows are called periods. There are seven periods in the periodic table.
- The elements are placed in periods based on the number of shells in their atoms
- Vertical columns in the periodic table starting from top to bottom are called groups. There are 18 groups in the periodic table
- Based on the physical and chemical properties of elements, they are grouped into various families.

Table 4.5 Groups in modern periodic table

Group	Families
1	Alkali metals
2	Alkaline earth metals
3 to 12	Transition metals
13	Boron Family
14	Carbon Family
15	Nitrogen Family
16	Oxygen Family (or) Chalcogen family
17	Halogens
18	Noble gases

DO YOU KNOW?

The International Union of Pure and Applied Chemistry (IUPAC) is an international federation of Organizations that represents chemists from various countries. IUPAC is registered in Zürich, Switzerland, and the "IUPAC Secretariat", is in United States.

IUPAC
INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

Activity 3

List the elements (any five) which are used in our daily life by seeing the Modern Periodic table.

	Element	Use
1.	Flourine	toothpaste
2.	________	________
3.	________	________
4.	________	________
5.	________	________
6.	________	________

DO YOU KNOW?

New elements named by IUPAC

The elements having atomic number 113 to 118 have been named by IUPAC as follows:

Nihonium (Nh) for Element 113. (Earlier it was Uut)

Moscovium (Mc) for Element 115. (Earlier it was Uup)

Tennessine (Ts) for Element 117. (Earlier it was Uus)

Oganesson (Og) for Element 118. (Earlier it was Uuo)

4.2.3 Classification of elements into blocks in Modern Periodic Table

We know that the electrons in an atom are accommodated in shells around the nucleus. Each shell consists of one or more subshells in which the electrons are distributed in certain manner. These subshells are designated as s, p, d, and f. The maximum number of electrons that can be accommodated in s, p, d, and f are 2, 6, 10 and 14 respectively.

Based on the arrangement of electrons in subshells, the elements of periodic table are classified into four blocks as shown in Table 4.6

(1) s-Block Elements

While arranging the electrons of elements of group 1 and 2, the last electron is added to s subshell. These elements are called s-block elements. The elements of group 1 (except hydrogen) are metals. They react with water to form solutions that change the colour of a vegetable dye from red to blue. These solutions are said to be highly alkaline or basic. Hence they are called alkali metals.

The elements of group 2 are also metals. They combine with oxygen to form oxides, formerly called "earths," and these oxides produce alkaline solutions when they are

Table 4.6 Number of electrons in subshell

Shell number (Symbol)	1 (K)	2 (L)		3 (M)			4 (N)			
Sub shell	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f
The maximum number of electrons in each sub shell	2	2	6	2	6	10	2	6	10	14
The maximum number of electrons in each shell	2	8		18			32			

dissolved in water. Hence, these elements are called alkaline earth metals.

(2) p-Block Elements

The last electron in these elements is filled in p subshells and hence these elements are called p block elements. These elements are in group 13 to 18 in the periodic table. They include boron, carbon, nitrogen, oxygen, fluorine families in addition to noble gases (Except helium). The p-block is home to the biggest variety of elements and is the only block that contains all three types of elements: metals, nonmetals, and metalloids.

(3) d-Block Elements

The elements of group 3 to 12 have their valence electrons in their outermost d subshells. These elements are called d block elements. They are found in the centre of the periodic table. Their properties are intermediate to that of s block and p block elements and so they are called transition elements.

(4) f – Block Elements

Part of the group 3 elements have their valence electrons in inner f subshell. They are known as f block elements or inner transition elements. They are placed at the bottom of the periodic table. There are two series in f block elements. The elements that follow Lanthanum are called "Lanthanides" and that follow Actinium are called "Actinides".

Activity 4

Note down the atomic numbers of Li, Sc, Mg, Be, Al, B, C, Cl, N, O, F and Ne and find out the period that the elements are present.

Element	Atomic Number	Period Number
Li	3 (2,1)	2
Sc	21 (2,8, 8,3)	4

More to Know

- Most of the coloured salts are compounds of d block elements (transition elements).
- Most of the elements in d block accounts for variable oxidation states.
- Transition elements also show catalytic property.
- All the above properties of d block elements are due to the presence of transition ions.

4.2.4 Advantages of the Modern Periodic Table

- The table is based on a more fundamental property i.e., atomic number.
- It correlates the position of the element with its electronic configuration more clearly.
- The completion of each period is more logical. In a period, as the atomic number increases, the energy shells are gradually filled up until an inert gas configuration is reached.
- It is easy to remember and reproduce.
- Each group is an independent group and the idea of subgroups has been discarded.
- One position for all isotopes of an element is justified, since the isotopes have the same atomic number.
- The position of the eighth group (in Mendeleev's table) is also justified in this table. All transition elements have been brought in the middle as the properties of transition elements are intermediate between left portion and right portion elements of the periodic table.

- The table completely separates metals from nonmetals. The nonmetals are present in upper right corners of the periodic table.
- The positions of certain elements which were earlier misfit (interchanged) in the Mendeleev's periodic table are now justified because it is based on atomic number of the elements.
- Justification has been offered for placing lanthanides and actinides at the bottom of the periodic table.

4.2.5 Position of hydrogen in the periodic table:

Hydrogen is the lightest, smallest and first element of the periodic table. Its electronic configuration ($1s^1$) is the simplest of all the elements. It occupies a unique position in the periodic table. It behaves like alkali metals as well as halogens in its properties.

In the periodic table, it is placed at the top of the alkali metals.

(i) Hydrogen can lose its only electron to form a hydrogen ion (H^+) like alkali metals.

(ii) It can also gain one electron to form the hydride ion (H^-) like halogens.

(iii) Alkali metals are solids while hydrogen is a gas.

Hence the position of hydrogen in the modern periodic table is still under debate as the properties of hydrogen are unique.

4.2.6. Position of Rare Gases

The elements Helium, Neon, Argon, Krypton, Xenon and Radon of group 18 in the periodic table are called as Noble gases or

More to Know

Hydrogen is the most abundant element in the universe, and makes up four-fifths of all ordinary matter. It is believed to be the fuel of the future, but it remains difficult to produce, transport and store. At extreme temperatures and pressures, like those at the core of a gas-giant planet, hydrogen can become metallic. (A gas giant is a large planet composed mostly of gases, such as hydrogen and helium, with a relatively small rocky core. The gas giants of our solar system are Jupiter, Saturn, Uranus and Neptune.)

Rare gases. They are monoatomic gases and do not react with other substances easily, due to completely filled subshells. Hence they are called as inert gases. They are found in very small quantities and hence they are called as rare gases.

These gases are chemically inert or non-reactive in nature because they have stable electronic structures which are very difficult to change.

Though they are found rare, they have many uses.

1. Helium is used for filling weather balloon, as it has very low density.
2. Neon gas is used in discharge lamps for the orange column.
3. Argon gas is filled in electrical bulbs to prevent evaporation of the filament.
4. Radon is a radioactive gas.

Table 4.7 Electronic structure of Rare gases.

Element	Symbol	Atomic Number	Electronic Structure
Helium	He	2	2
Neon	Ne	10	2, 8
Argon	Ar	18	2, 8, 8
Krypton	Kr	36	2, 8, 18, 8
Xenon	Xe	54	2, 8, 18, 18, 8
Radon	Rn	86	2, 8, 8, 32, 18, 8

4.3 METALS, NON-METALS AND METALLOIDS

4.3.1 Metals

Metals are typically hard, shiny, malleable (can be made as sheet), fusible and ductile (can be drawn into wire) with good electrical and thermal conductivity. Except mercury, most of the metals are solids at room temperature. Metals occupy larger area in the periodic table and are categorized as:

(i) Alkali metals e.g. Sodium and Potassium

(ii) Alkaline earth metals e.g: Calcium and Magnesium

(iii) Transition Metals e.g: Iron and Nickel

(iv) Other Metals e.g: Aluminium and Tin

4.3.2. Non-metals

A non-metal is an element that does not have the characters of hard, shiny, malleable, suitable and ductile. In other words, a non-metal is an element that does not have the properties of metal. E.g. Oxygen, Nitrogen

4.3.3 Metalloids

Elements which have the properties of both metals and non-metals are called as metalloids. (eg) Boron, Arsenic.

4.4 Alloys

During 3500 BC(BCE), people used an alloy named 'bronze'. The idea of making an alloy was quite old. The majority of the metallic substances used today are alloys. Alloys are mixtures of two or more metals and are formed by mixing molten metals thoroughly. Rarely nonmetals are also mixed with metals to produce alloys.

It is generally found that alloying produces a metallic substance that has more useful properties than the original pure metals from which it is made. For example, the alloy brass is made from copper and zinc.

BNH72L

4.4.1 Advantages of alloys

- Alloys do not get corroded or get corroded to very less extent.
- They are harder and stronger than pure metals (example: gold is mixed with copper and it is harder than pure gold)
- They have less conductance than pure metals (example: copper is good conductor of heat and electricity whereas brass and bronze are not good conductors)
- Some alloys have lower melting point than pure metals (example: solder is an alloy of lead and tin which has lower melting point than each of the metals)
- When metal is alloyed with mercury, it is called amalgam

Table 4.8 **Comparison of the physical properties of metals and non-metals**

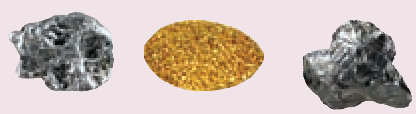
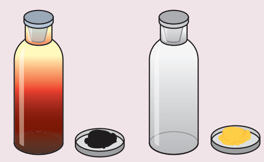
S. No	Properties	Metals	Non-metals
1.	Appearance	Have a lustre, known as metallic lustre. The surface is polishable.  Platinum Gold Silver	Have no lustre and I.k dull. Surface cannot be polished. (Exceptions: Graphite and iodine are lustrous).  Yellow - Sulphur,White - Phosphorous. Red - Bromine, Black-Carbon
2.	Physical state	In genral, they are hard crystaline solids.(Exception: Mercury is a liquid)	They exist as soft solids or gases. (Expections: Diamond is a hard solid and bromine is a liquid)
3.	Density	They have a high density. (Exceptions: Sodium and Potassium).	They have a low density.
4.	Melting and boiling points	Usually they have high melting and boling points. (Exceptions: Sodium and Potassium).	They have low melting and boiling points (Exceptions: diamond and graphite)
5.	Malleability and ductility	They are malleable and ductile.	Solid non-metals are brittle.
6.	Heat conductivity	They are good conductors.	They are bad conductors. (Exceptions: diamond)
7.	Electrical conductivity	They are good conductors	They are bad conductors. (Exception: Graphite)
8.	Sonority (phenornenon of producing a characteristic sound when a material is struck)	They are sonorous	They are non-sonorous. (Exception: Iodine crystals produce a soft metallic clink when they are shaken in a bottle)
9.	Alloy formation	Metals form alloys with each other and also with some non-metals	Non-metals usually do not form alloys. (Exception: B, C, Si and P from alloys with metals)

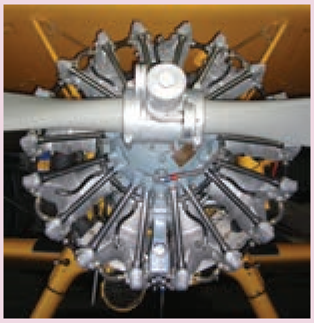
Table 4.9 **Comparison of the chemical properties of metals and non-metals**

S. No.	Chemical Property	Metals	Nonmetals
1.	Electro Positive / Electro Negative	Electro Positive. Metals lose electrons and form cation eg.) $Na \rightarrow Na^+ + e^-$ $Al \rightarrow Al^{3+} + 3e^-$	Electro Negative. Nonmetals gain electrons and form anion $Cl + e^- \rightarrow Cl^-$ $O + 2e^- \rightarrow O^{2-}$
2.	Reaction with Oxygen	Metals burn with Oxygen to form metal oxides. Generally, these metal oxides are basic.	Nonmetals when heated with oxygen produce covalent oxides. Most of the non-metal oxides are acidic in nature.
3.	Reaction with water a) Cold Water	a) Metals like Sodium and Potassium react with cold water to liberate hydrogen gas.	a) Carbon reacts with water to form carbon monoxide and hydrogen
	b) Steam	b) Metals like Magnesium and Iron react with steam to form their respective oxides and hydrogen ii) Aluminium reacts slowly with steam to form aluminium hydroxide and hydrogen. Note : Copper, Nickel, Silver and Gold do not react with water.	Nonmetals are less reactive with steam
4.	Reaction with Acids	Metals such as Sodium, Magnesium, Aluminium react with dilute hydrochloric acid to give their respective salts.	Generally, nonmetals do not react with acids, but when heated with con. HNO_3 or con H_2SO_4, the respective oxides or oxy acids are formed.
5	Reaction with Halogens	Metals react with halogen to form ionic halides	Nonmetals react with halogens to form covalent halides
6	Oxidation/ Reduction	Metals get oxidized (lose electron) on reaction with nonmetals	Nonmetals get reduced (gain electron) on reaction with metals

Table 4.10 Composition and uses of alloys

S. No	Alloy	Composition	Uses
1	Brass	Cu & Zn (Copper and Zinc)	Decorative articles, taps etc.
2	Bronze	Cu & Sn (Copper and Tin)	Statues and medals
3	Solder	Pb & Sn (Lead and Tin)	Soldering electronic circuits
4	Stainless Steel	Fe, C, Cr and Ni (Iron, carbon , Chromium and Nickel)	Utensils, Surgical instruments
5	German Silver	Cu, Ni, Zn (Copper, Nickel and Zinc)	Artificial jewellery
6	Gun metal	Cu , Sn & Zn (Copper,Tin & Zinc)	Guns and frames of spectacles
7	Duralumin	Al, Mg, Cu & Mn (Aluminium, Magnesium, Copper & Manganese)	Bodies of aircraft
8	Magnalium	Al & Mg (Aluminium & Magnesium)	Kitchen wares
9	Steel	Fe & C (Iron and Carbon)	Ship construction etc

More to Know



Monel is an alloy of nickel (67%) and copper with small amounts of iron, manganese, carbon, and silicon. It is stronger than pure nickel and it is extremely resistant to corrosion even that caused by sea water. It is used in aircraft construction and skins of experimental rocket planes

Points to remember

- Dobereiner grouped the elements based on their relative atomic masses in a group of three (triads).
- John Newlands arranged 56 known elements in the increasing order of their atomic mass.
- Dmitri Mendeleev proposed the law of periodicity.
- Mendeleev's Periodic Table has eight vertical column called 'groups' and seven horizontal rows called 'period'.
- The physical and chemical properties of elements depend not on the number of protons but on the number of electrons and their arrangements (electronic configuration) in atoms.
- In the modern periodic table all the elements are arranged in the increasing order of their atomic number.
- There are seven periods and 18 groups in the periodic table.

- The elements are placed in periods based on the number of shells in their atoms.
- Based on the common characteristics of elements in each group, they are grouped as various families.
- The maximum number of electrons that can be accommodated in s, p, d and f sub shells are 2, 6, 10 and 14 respectively.
- Lanthanides and actinides are kept at the bottom of the periodic table.
- Based on the arrangement of electrons in subshells, the elements of periodic table are classified into four blocks as s, p d and f.
- Hydrogen is the lightest, smallest and first element of the periodic table. Its electronic configuration ($1s^1$) is the simplest of all the elements. It occupies a unique position in the periodic table. It behaves like alkali metals as well as halogens in its properties.
- Rare gases are chemically inactive because they have stable electronic structures which are very difficult to change.

A-Z GLOSSARY

Dobereiner's Law of Triads	The atomic mass of the middle element is nearly the same as average of atomic masses of other two elements.
Newlands' Law of Octaves	Every eighth element had properties similar to those of the first element like the eighth note in an octave of music is similar to the first.
Mendeleev's Law of Periodicity	The physical and chemical properties of elements are the periodic functions of their atomic masses.
Modern Periodic Law	The chemical and physical properties of elements are periodic functions of their atomic numbers.
Periods	Horizontal rows in the modern periodic table.
Columns	Vertical columns in the modern periodic table
S block elements	Elements whose valence electron is added to s subshell.
p block elements	Elements whose valence electron is filled in p subshells.
d block elements	Elements having their valence electrons in the d subshells.
Noble gases	The elements in group 18 of the periodic table are called as Noble gases or Rare gases.
Metals	Metals are hard, shiny, malleable (can be made as sheet), fusible and ductile (can be drawn into wire) with good electrical and thermal conductivity.

Non metals	A nonmetal is an element that does not have the characters of hardness, shiny, malleable, suitable and ductile.
Metalloids	Elements which have the properties of both metals and nonmetals are called as metalloids. (eg) Boron, Arsenic.
Alloys	Alloys are mixtures of two or more metals and are formed by mixing molten metals thoroughly.

BNR349

TEXT BOOK EXERCISES

I. Choose the correct answer

1. If Dobereiner is related with 'law of triads', then Newlands is related with
   a) Modern periodic law
   b) Hund's rule
   c) law of octaves
   d) Pauli's Exclusion principle

2. Modern periodic law states that the physical and chemical properties of elements are the periodic functions of their ________
   a) atomic numbers b) atomic masses
   c) similarities d) anomalies

3. Elements in the modern periodic table are arranged in _____ groups and _____ periods.
   a) 7, 18 b) 18,7 c) 17,8 d) 8, 17

4. The increasing order of the energy of subshells is
   a) $s>p>d>f$ b) $s<p<d<f$
   c) $s<p<f<d$ d) $p<s<d<f$

5. If the electronic configuration of an element is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$, then it will occupy ________ block of the periodic table
   a) s b) p c) d d) f

II. Fill in the blanks

1. In Dobereiner's triads, the atomic weight of the middle element is the ________ of the atomic masses of 1st and 3rd elements.
2. Noble gases belong to ________ group of the periodic table.
3. The basis of the classifications proposed by Dobereiner, Newlands and Mendeleev was ________.
4. B, Si, Ge and As are the examples of ________.
5. Example for liquid metal is ________.

III. Match the following

1.	Triads	Newlands
2.	Alkali metal	Calcium
3.	Law of octaves	Henry Moseley
4.	Alkaline earth metal	Sodium
5.	Modern Periodic Law	Dobereiner

IV. State whether True or False

1) Newlands' periodic table is based on atomic masses of elements and modern periodic table is based on atomic number of elements

2) Metals can gain electrons

3) Alloys bear the characteristics of both metals and nonmetals

4) Lanthanides and actinides are kept at the bottom of the periodic table because they resemble each other but they do not resemble with any other group elements

5) Group 17 elements are named as Halogens

V. Assertion and Reason

Statement: Elements in a group generally possess similar properties but elements along a period have different properties.

Reason: The difference in electronic configuration makes the element differ in their chemical properties along a period.

a) Statement is true and reason explains the statement.

b) Statement is false but the reason is correct.

VI. Answer the following

1. State modern periodic law.
2. What are groups and periods in the modern periodic table?
3. What are the limitations of Mendeleev's periodic table?
4. State any five features of modern periodic table.

VII. Complete the following table

Element	Number of electrons	Sub shell electronic configuration
N	7	$1s^2\ 2s^2\ 2p^3$
F	9	1s 2s p
Na		
Cl		
Ar		

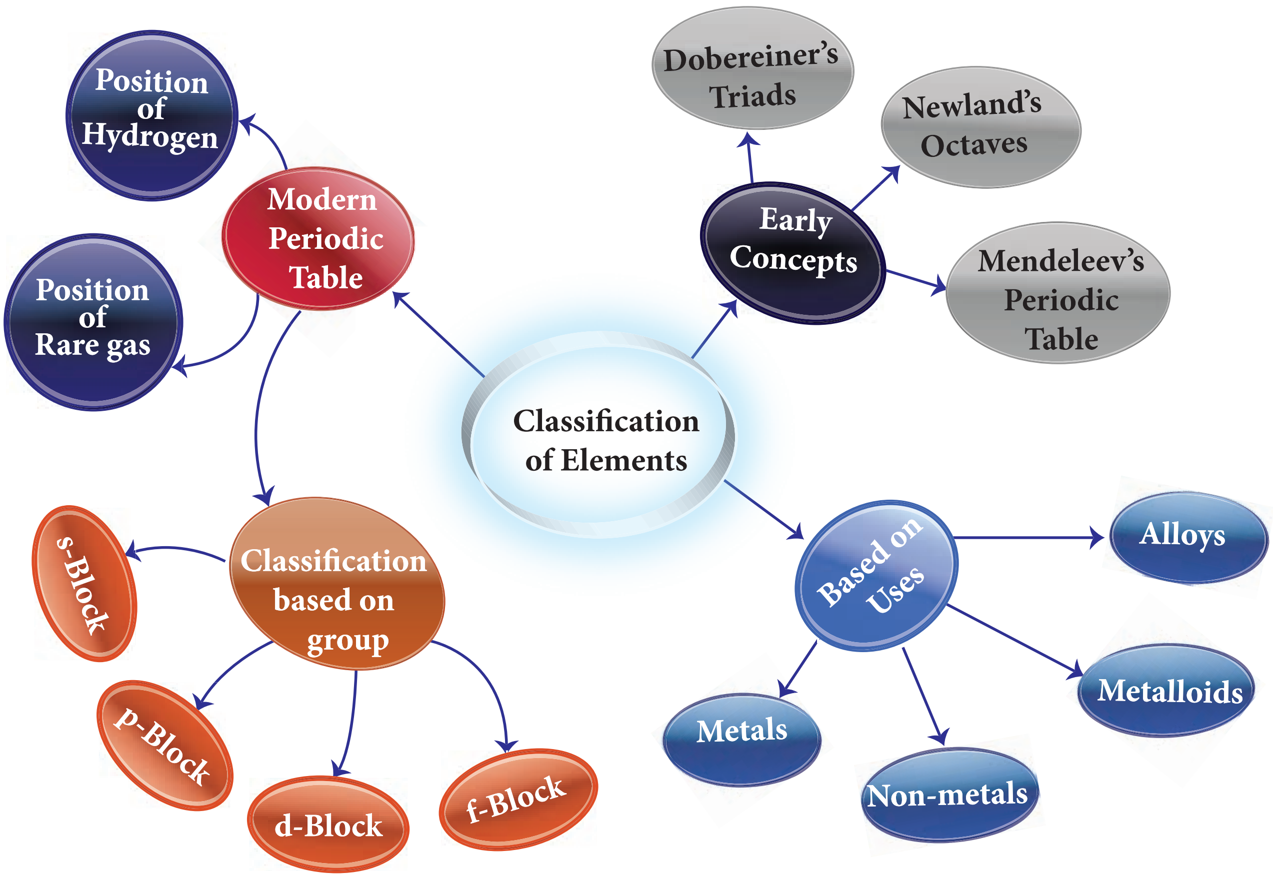
VIII. Arrange the jumbled letters to answer the following

1. We are a family of five and lies in 17th group of periodic table (7 letters)
2. I am being stored in kerosene and be cut by knife (6 letters)
3. I am the most corrosion resistant silvery white metal and lies in group 9 (7 letters)
4. I am being used as refrigerant in liquid form with atomic number 7 (8 letters)
5. I am in your blood as hemoglobin and without me no buildings are possible (4 letters)
6. I am the highly radioactive and newly designated element in the modern periodic table with atomic number 113 (8 letters)
7. I am used as a disinfectant for drinking water. (8 letters)
8. I am mixed with salt and used for thyroid health (6 letters)
9. I am the key part of biological molecules and have the valency of four. (5 letters)
10. I am the first in the noble gas group and used to fill balloons (6 letters)

S.No	Jumbled letters	Answer
1	L A O H S E N G	
2	S D I M U O	
3	R I D M U I I	
4	T I R N G O N E	
5	N R O I	
6	I H N M U I N O	
7	H C L E I R N O	
8	E N I D O I	
9	B A R C O N	
10	E L I H U M	

IX) Complete the following table referring the modern periodic table:

Period number	Total no of elements	Elements		Total no of elements in			
		From	To	s-block	p-block	d-block	f-block
1							
2							
3							
4							
5							
6							
7							



REFERENCE BOOKS

1. CONCISE Inorganic chemistry : 5th Edition by J.D. Lee
2. Inorganic Chemistry by P.L.Soni
3. The Periodic table: Its story and its significance: Eric R. Scerri

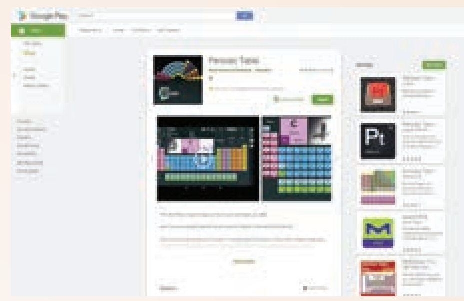
INTERNET RESOURCES

1. https://www.ptable.com/
2. https://iupac.org/what-we-do/periodic-table-of-elements/
3. www.rsc.org/periodic-table
4. https://sciencestruck.com/periodic-table-facts
5. https://ww.teachbeside.com/memorize-periodictable

ICT CORNER

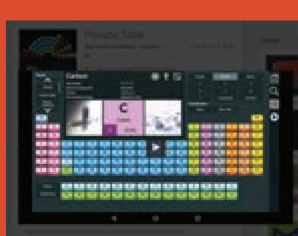
Periodic Classification

This activity enables to explore the properties of elements.

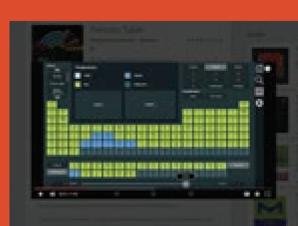


Steps

- Type the URL link given below in the browser OR scan the QR code. You can also download the "**Royal society of chemistry**" mobile app from the given app URL.
- Click the element from the table and explore the properties of the element you want to learn.
- On the right top corner click option as shown to learn the uses and properties.
- For every element we can understand the uses and the properties of elements.



Step1



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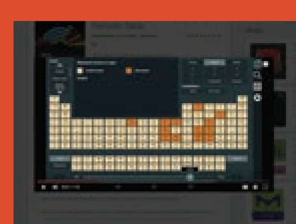
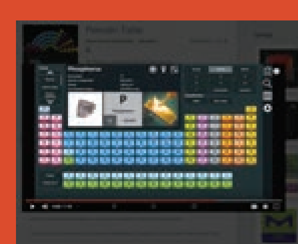


Step3



Step4

Browse in the link:

URL: https://play.google.com/store/apps/details?id=org.rsc.periodictable or Scan the QR Code.

*Pictures are indicative only

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UNIT 5

Chemical bonding

Learning Objectives

After studying the unit, the student will be able to:

- Understand how molecules are formed and what is a chemical bond
- Explain Octet rule
- Draw Lewis dot structure of atoms
- Understand different types of bonds
- Differentiate the characteristics of ionic bond, covalent bond and coordinate bond
- Understand redox reactions
- Find out the oxidation number of different elements

Introduction

We already know that atoms are the building blocks of matter. Under normal conditions no atom exists as an independent (single) entity in nature, except Noble gases. However, a group of atoms is found to exist together as one species. Such a group of atoms is called molecule. Obviously there should be a force to keep the constituent atoms together as the thread holds the flowers together in a garland. This attractive force which holds the atoms together is called a bond.

Figure. 5.1 Flowers held together by thread

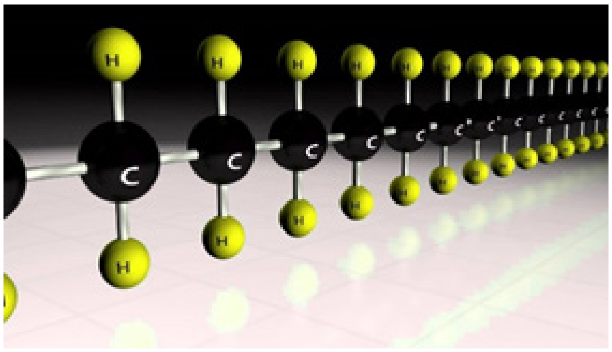


Figure. 5.2 Atoms held together by bond

A Chemical bond may be defined as the force of attraction between the two atoms that binds them together as a unit called molecule.

5.1 Kossel – Lewis approach to chemical bonds

5.1.1 Octet rule

Atoms of various elements combine together in different ways to form chemical compounds. This phenomenon raised many questions.

- Why do atoms combine?
- How do atoms combine?
- Why do certain atoms combine while others do not?

To answer such questions different theories have been put forth from time to time and one of such theory which explained the formation of molecules is Kossel-Lewis theory.

Kossel and Lewis gave successful explanation based upon the concept of electronic configuration of noble gases about why atoms combine to form molecules. Atoms of noble gases have little or no tendency to combine with each other or with atoms of other elements. This means that these atoms must be having stable electronic configurations. The electronic configurations of noble gases are given in Table 5.1.

Table 5.1 The electronic configurations of noble gases

Name of the element	Atomic number	Shell electronic configuration
Helium (He)	2	2
Neon (Ne)	10	2,8
Argon (Ar)	18	2,8,8
Krypton (Kr)	36	2,8,18,8
Xenon (Xe)	54	2,8,18,18,8

Except Helium, all other noble gases have eight electrons in their valence shells. Even helium has its valence shell completely filled and hence no more electrons can be added. Thus by having stable valence electronic configuration, the noble gas atoms neither have any tendency to gain nor lose electrons and their valency is zero. They are so inert that they even do not form diatomic molecules and exist as monoatomic gaseous atoms.

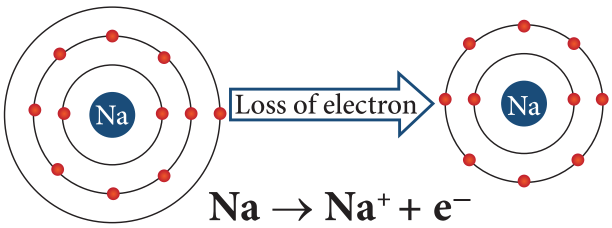
More to Know

The number of electrons lost from a metal atom is the valency of the metal and the number of electrons gained by a non-metal is the valency of the non-metal

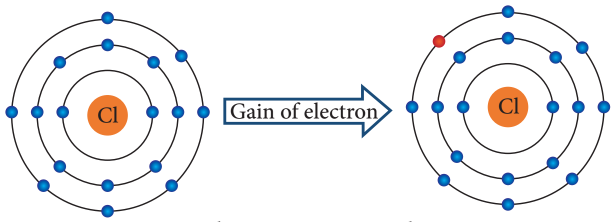
Based on the noble gas electronic configuration, Kossel and Lewis proposed a theory in 1916 to explain chemical combination between atoms and this theory is known as 'Electronic theory of valence' or Octet rule. According to this, atoms of all elements, other than inert gases, combine to form molecules because they have incomplete valence shell and tend to attain a stable electronic configuration similar to noble gases. Atoms can combine either by transfer of valence electrons from one atom to another or by sharing of valence electrons in order to achieve the stable outer shell of eight electrons.

The tendency of atoms to have eight electrons in the valence shell is known as the 'Octet rule' or the 'Rule of eight'

For example, Sodium with atomic number 11 will readily loose one electron to attain Neon's stable electronic configuration. Similarly, chlorine has electronic configuration 2,8,7. To get the nearest noble gas (i.e. argon) configuration, it need one more electron. So chlorine readily gains one electron from other atom and obtains stable electronic configuration. Thus elements tend to have stable valence shell (eight electrons) either by losing or gaining electrons.



$$Na \rightarrow Na^{+} + e^{-}$$



$$Cl + e^- \rightarrow Cl^-$$

Which atoms tend to lose electrons?
Which are tend to gain electrons?

Atoms that have 1,2,3 electrons in their valence shell tend to lose whereas atoms having 5,6,7 valence electrons tend to gain.

Table 5.2 Unstable electronic configuration

Element	Atomic number	Electron distribution	Valence electrons
Boron	5	2, 3	3
Nitrogen	7	2, 5	5
Oxygen	8	2,6	6
Sodium	11	2, 8, 1	1

Activity 1

Write the electronic distribution of the following elements and find out whether they have stable electronic configuration.

Element	Atomic number	Electron distribution	Valence electrons	Stable	Unstable
Hydrogen	1	1	1		✓
Fluorine	9				
Krypton	36				
Xenon	54				

Walther Kossel
(1888-1956)

Gilbert N Lewis
(1875-1946)

5.2 Lewis dot structure

When atoms combine to form compounds, their valence electrons involve in bonding. Therefore, it is helpful to have a method to depict the valence electrons in the atoms. This can be done using Lewis dot symbol method. The Lewis dot structure or electron dot symbol for an atom consists of the symbol of the element surrounded by dots representing the electrons of the valence shell of the atom. The unpaired electron in the valence shell is represented by a single dot whereas the paired electrons are represented by a pair of dots.

Symbols other than dots, like crosses or circles may be used to differentiate the electrons of the different atoms in the molecule.

Table 5.3 Lewis dot structure

Element	Atomic number	Electron distribution	Valence electrons	Lewis dot structure
Hydrogen	1	1	1	H•
Helium	2	2	2	•He•
Beryllium	4	2, 2	2	•Be•
Carbon	6	2, 4	4	$\cdot\dot{\underset{\cdot}{C}}\cdot$
Nitrogen	7	2, 5	5	$\cdot\ddot{\underset{\cdot}{N}}\cdot$
Oxygen	8	2,6	6	$\cdot\ddot{O}\colon$

Activity 2

Write the electronic dot symbol for the following elements.

Element	Atomic number	Electron distribution	Valence electrons	Stable	Lewis dot structure
Boron					
Argon					
Chlorine					
Sodium					
Fluorine					

More to Know

Note that dots are placed one to each side of the letter symbol until all four sides are occupied. Then the dots are written two to a side until all valence electrons are accounted for. The exact placement of the single dots is immaterial.

5.3 Types of chemical bond

All the elements differ with each other in their valence shell electronic configuration. So the way in which they combine to form compounds also differs. Hence, there are different types of chemical bonding possible between atoms which make the molecules. Depending on the type of bond they show different characteristics or properties. Such types of bonding that are considered to exist in molecules are categorized as shown below. Among these, let us learn about the Ionic bond, Covalent bond and Coordinate bond in this chapter and other types of bond in the higher classes.

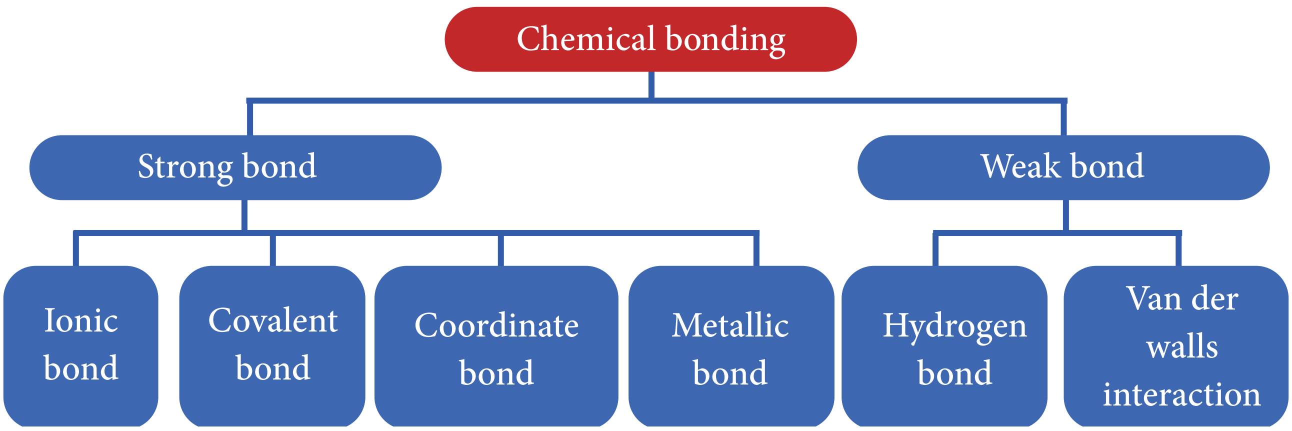
5.3.1 Ionic (or) Electrovalent bond

An ionic bond is a chemical bond formed by the electrostatic attraction between positive and negative ions. The bond is formed between two atoms when one or more electrons are transferred from the valence shell of one atom to the valence shell of the other atom. The atom that loses electrons will form a cation (positive ion) and the atom that gains electrons will form an anion (negative ion). These oppositely charged ions come closer to each other due to electrostatic force of attraction and thus form an ionic bond. As the bond is between the ions, it is called ***Ionic bond*** and the attractive forces being electrostatic, the bond is also called ***Electrostatic bond***. Since the valence concept has been explained in terms of electrons, it is also called as ***Electrovalent bond***.

Formation of ionic bond

Let us consider two atoms A and B. Let atom A has one electron in excess and atom B has one electron lesser than the stable octet electronic configuration. If atom A transfer one electron to atom B, then both the atoms will acquire stable octet electronic configuration. As the result of this electron transfer, atom A will become positive ion (cation) and atom B will become negative ion (anion). These oppositely charged ions are held together by electrostatic force of attraction which is called ***Ionic bond*** or ***Electrovalent bond***.

In general, ionic bond is formed between a metal and non-metal. The compounds



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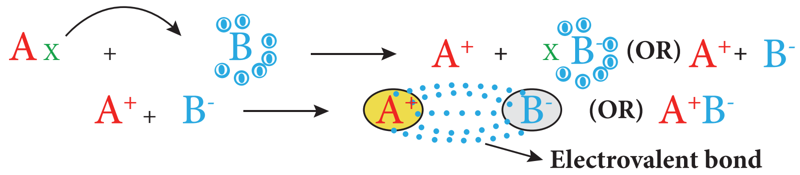


containing ionic bonds are called ionic compounds. Elements of Group 1 and 2 in periodic table, i.e. alkali and alkaline earth metals form ionic compounds when they react with non-metals.

More to Know

The number of electrons that an atom of an element loses or gains to form an electrovalent bond is called its **Electrovalency**.

Illustration 1 – Formation of Sodium Chloride (NaCl)

The atomic number of Sodium is 11 and its electronic configuration is 2, 8, 1. It has one electron excess to the nearest stable electronic configuration of a noble gas - Neon. So sodium has a tendency to lose one electron from its outermost shell and acquire a stable electronic configuration forming sodium cation (Na^+).

The atomic number of chlorine is 17 and its electronic configuration is 2, 8, 7. It has one electron less to the nearest stable electronic configuration of a noble gas - Argon. So chlorine has a tendency to gain one electron to acquire a stable electronic configuration forming chloride anion (Cl^-).

When an atom of sodium combines with an atom of chlorine, an electron is transferred from sodium atom to chlorine atom forming sodium chloride molecule thus both the atoms achieve stable octet electronic configuration.

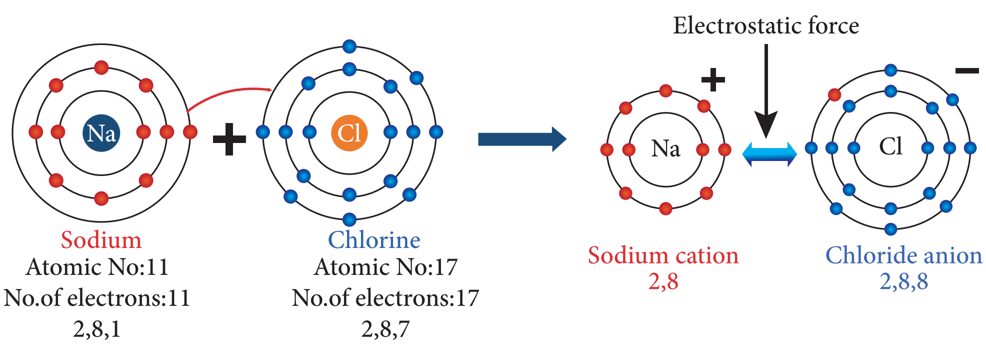
DO YOU KNOW?

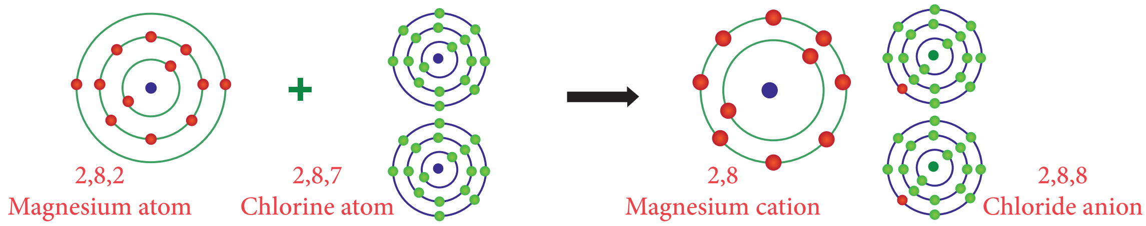
What is the most important food additive you have in your kitchen?

Definitely it is common salt. It is formed by the combination of a highly reactive metal called sodium and a poisonous gas called chlorine. The chemical bonding between sodium and chlorine alters the properties and makes it edible.

Illustration 2 – Formation of Magnesium Chloride ($MgCl_2$)

The atomic number of Magnesium is 12 and the electronic configuration is 2, 8, 2. It has two electron excess to the nearest stable electronic configuration of a noble gas - Neon. So magnesium has a tendency to lose two electrons from its outermost shell and acquire a stable electronic configuration forming magnesium cation (Mg^{2+}).





As explained earlier two chlorine atoms will gain two electrons lost by the magnesium atom forming magnesium chloride molecule ($MgCl_2$)

Activity 3

Try to draw the electron distribution diagram as above for the formation of Calcium Chloride ($CaCl_2$) molecule with the help of given data.

Element	Atomic number	Electron distribution	Valence electrons	Number of electrons lost	Number of electrons gained	Formed Cation / Anion
Calcium	20					
Chlorine	17					

Practice:

Draw the diagram to represent the bonding in the following ionic compounds.

1. Magnesium fluoride (MgF_2)
2. Calcium oxide (CaO)
3. Lithium chloride (LiCl)

Characteristics of Ionic compounds

The nature of bonding between the atoms of a molecule is the primary factor that determine the properties of compounds. By this way, in ionic compounds the atoms are held together by a strong electrostatic force that makes the compounds to have its characteristic features as follows:

a. Physical state – These compounds are formed because of the strong electrostatic force between cations and anions which are arranged in a well-defined geometrical pattern. Thus Ionic compounds are crystalline solids at room temperature.

b. Electrical conductivity – Ionic compounds are crystalline solids and so their ions are tightly held together. The ions, therefore, cannot move freely, so they do not conduct electricity in solid state. However, in molten state and their aqueous solutions conduct electricity.

c. Melting point–the strong electrostatic force between the cations and anions hold the ions tightly together, so very high energy is required to separate them. Hence ionic compounds have high melting and boiling points.

d. Solubility – Ionic compounds are soluble in polar solvents like water. They are insoluble in non-polar solvents like benzene (C_6H_6), carbon tetra chloride (CCl_4).

e. Density, hardness and brittleness–Ionic compounds have high density and they are quite hard because of the strong electrostatic force between the ions. But they are highly brittle.

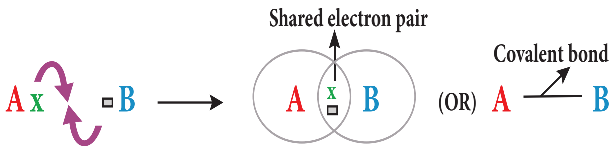
f. Reactions – Ionic compounds undergo ionic reactions which are practically rapid and instantaneous.

5.3.2 Covalent bond

Atoms can combine with each other by sharing the unpaired electrons in their outermost shell. Each of the two combining atoms contributes one electron to the electron pair which is needed for the bond formation and has equal claim on the shared electron pair. According to Lewis concept when two atoms form a covalent bond between them, each of the atoms attains the stable electronic configuration of the nearest noble gas. Since the covalent bond is formed because of the sharing of electrons which become common to both the atoms, it is also called as ***Atomic bond***.

Formation of Covalent bond

Let us consider two atoms A and B. Let atom A has one valence electron and atom B has seven valence electrons. As these atoms approach nearer to each other, each atom contributes one electron and the resulting electron pair fills the outer shell of both the atoms. Thus both the atoms acquire a completely filled valence shell electronic configuration which leads to stability.



More to Know

Covalent bonds are of three types:

1. Single covalent bond represented by a line (—) between the two atoms. Eg. H—H
2. Double covalent bond represented by a double line (=) between the two atoms. Eg. O=O
3. Triple covalent bond represented by a triple line (≡) between the two atoms. Eg. N ≡ N

Illustration 1 – Formation of hydrogen molecule (H_2)

Hydrogen molecule is formed by two hydrogen atoms. Each having one valence electron ($1s^1$), it is contributed to the shared pair and both atoms acquire stable completely filled electronic configuration.

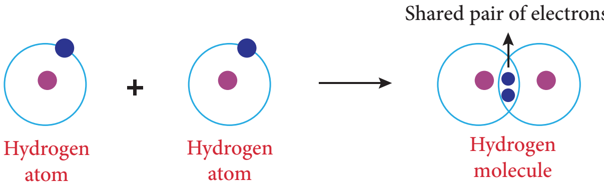
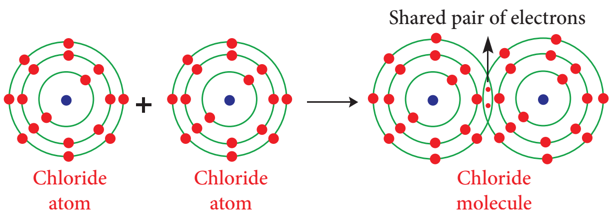


Illustration 2 – Formation of chlorine molecule (Cl_2)

Chlorine molecule is formed by two chlorine atoms. Each chlorine atom has seven valence electrons (2,8,7). These two atoms achieve a stable completely filled electronic configuration (octet) by sharing a pair of electrons.



Activity 4

Try to draw the electron distribution diagram as above for the formation of Fluorine (F_2) molecule with the help of given data.

Element	Atomic number	Electron distribution
Fluorine	9	2, 7

Fluorine atom + Fluorine atom → Fluorine molecule

Illustration 3 – Formation of methane molecule (CH_4)

Methane molecule is formed by the combination of one carbon and four hydrogen atoms. The carbon atom has four valence electrons (2, 4). These four electrons are shared with four atoms of hydrogen to achieve a stable electronic configuration (octet) by sharing a pair of electrons.

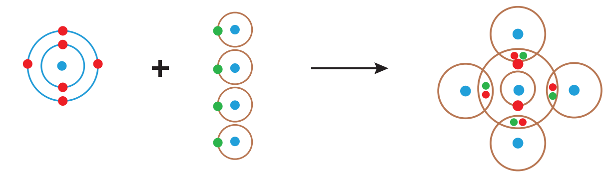
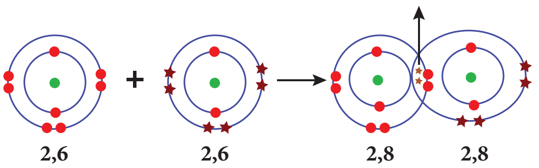


Illustration 4 – Formation of oxygen molecule (O_2)

Oxygen molecule is formed by two oxygen atoms. Each oxygen atom has six valence electrons (2, 6). These two atoms achieve a stable electronic configuration (octet) by sharing two pair of electrons. Hence a double bond is formed in between the two atoms.



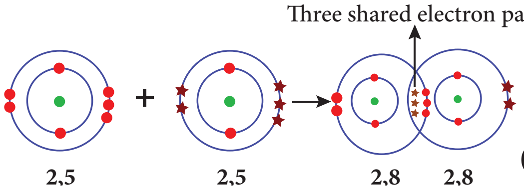
Practice:

Draw the diagram to represent the bonding in the following covalent compounds.

1. Carbon tetrachloride (CCl_4)
2. Carbon di oxide (CO_2)
3. Water (H_2O)
4. Ammonia (NH_3)

Illustration 5 – Formation of nitrogen molecule (N_2)

Nitrogen molecule is formed by two nitrogen atoms. Each nitrogen atom has five valence electrons (2, 5). These two atoms achieve a stable completely filled electronic configuration (octet) by sharing three pair of electrons. Hence a triple bond is formed in between the two atoms.



Characteristics of Covalent compounds

As said earlier, the properties of compounds depend on the nature of bonding between their constituent atoms. So the compounds containing covalent bonds possess different characteristics when compared to ionic compounds.

a. Physical state – Depending on force of attraction between covalent molecule the bond may be weaker or stronger. Thus covalent compounds exists in gaseous, liquid and solid form. Eg. Oxygen-gas; Water-liquid: Diamond-solid.

b. Electrical conductivity – Covalent compounds do not contain charged particles (ions), so they are bad conductors of electricity.

c. Melting point – Except few covalent compounds (Diamond, Silicon carbide), they have relatively low melting points compared to Ionic compounds.

d. Solubility – Covalent compounds are readily soluble in non-polar solvents like benzene (C_6H_6), carbon tetra chloride (CCl_4). They are insoluble in polar solvents like water.

e. Hardness and brittleness – Covalent compounds are neither hard nor brittle. But they are soft and waxy.

f. Reactions – Covalent compounds undergo molecular reactions in solutions and these reactions are slow.

Activity 5

Take a glass of water and add a spoon of sugar. Take another glass of coconut oil and add a spoon of sugar. Observe the difference in solubility in these two and try to find out the reason with the help of your teacher.

More to Know

Polar solvents contain bonds between atoms with very different electronegativities, such as oxygen and hydrogen. Ionic compounds are soluble in polar solvents. Ex: water, ethanol, acetic acid, ammonia

Non polar solvents contain bonds between atoms with similar electronegativities, such as carbon and hydrogen. Covalent compounds are soluble in non-polar solvents. Ex: acetone, benzene, toluene, turpentine

Fajan's Rule:

As we know, a metal combine with a non-metal through ionic bond. The compounds so formed are called ionic compounds. A compound is said to be ionic when the charge of the cation and anion are completely separated. But in 1923, Kazimierz Fajans found, through his X-Ray Crystallographic studies, that some of the ionic compounds show covalent character. Based on this, he formulated a set rules to predict whether a chemical bond is ionic or covalent. Fajan's rules are formulated by considering the charge of the cation and the relative size of the cation and anion.

- When the size of the cation is small and that of anion is large, the bond is of more covalent character
- Greater the charge of the cation, greater will be the covalent character

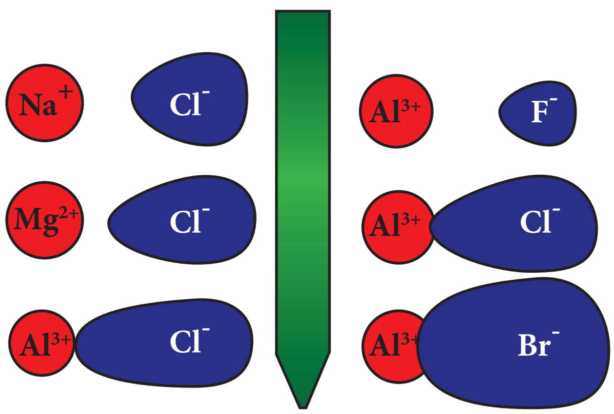
This can be summarized as follows:

Ionic	Covalent
Low positive charge	High positive charge
Large cation	Small cation
Small anion	Large anion

Table 5.4 Difference between Ionic and Covalent compounds

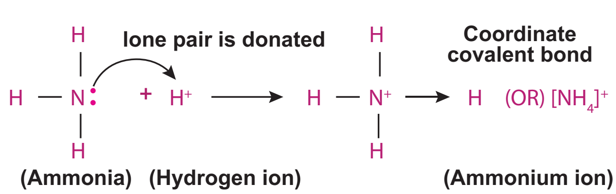
Ionic Compounds	Covalent Compounds
Formed by the transfer of electrons from a metal to a non-metal atom	Formed by sharing of electrons between non-metal atoms
Strong electrostatic force of attraction between cations and anions	Mutual sharing of electrons and so weak force of attraction between atoms
Solids at room temperature	Gases, liquids and soft solids
Conducts electricity in molten state or in solutions	Non-conductors of electricity
Have high melting and boiling points	Have low melting and boiling points
Soluble in polar solvents	Soluble in non-polar solvents
Hard and brittle	Soft and waxy
Undergo ionic reaction which are fast and instantaneous	Undergo molecular reactions which are slow

For example, in sodium chloride, low positive charge (+1), a fairly large cation and relatively small anion make the charges to separate completely. So it is ionic. In aluminium triiodide, higher is the positive charge (+3), larger is the anion and thus no complete charge separation. So is covalent. The following picture depicts the relative charge separation of ionic compounds:



5.3.3 Coordinate covalent bond

In the formation of normal covalent bond each of the two bonded atoms contribute one electron to form the bond. However, in some compounds the formation of a covalent bond between two atoms takes place by the sharing of two electrons, both of which comes from only one of the combining atoms. This bond is called

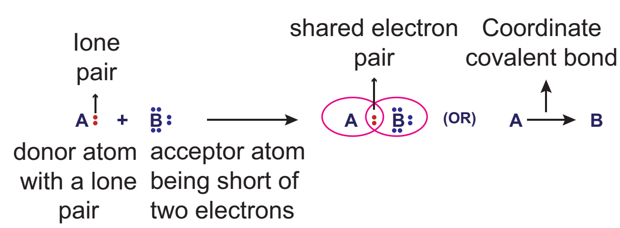


Coordinate covalent bond or Dative bond.

Mostly the lone pair of electrons from an atom in a molecule may be involved in the dative bonding. The atom which provides the electron pair is called **donor atom** while the other atom which accepts the electron pair is called **acceptor atom**. The Coordinate covalent bond is represented by an arrow (→) which points from the donor to the acceptor atom.

Formation of Coordinate covalent bond

Let us consider two atoms A and B. Let atom A has an unshared lone pair of electrons and atom B is in short of two electrons than the octet in its valence shell. Now atom A donates its lone pair while atom B accepts it. Thus the lone pair of electrons originally belonged to atom A are now shared by both the atoms and the bond formed by this mutual sharing is called Coordinate covalent bond. (A→B)



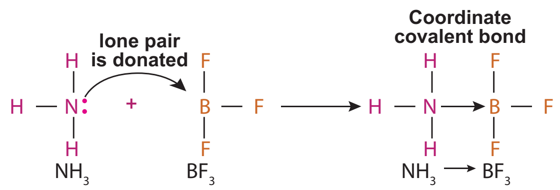
Examples (NH^{4+}, $NH_3 \rightarrow BF_3$)

Illustration 1 – Formation of coordinate covalent bond in ammonium ion ($NH4^+$)

Ammonium ion is formed by one ammonia (NH_3) molecule and one hydrogen (H^+) ion. In ammonia molecule the central nitrogen atom has five valence electrons (2,5) among which three electrons are shared with three hydrogen atoms and still it has an unshared lone pair of electrons. This lone pair electrons are donated to a Hydrogen ion and thus a N→H coordinate covalent bond is formed in ammonium ion molecule (NH_4^+)

Illustration 2 – Formation of coordinate covalent bond between $NH_3 \rightarrow BF_3$ molecules

In some cases, the donated pair of electrons comes from a molecule as a whole which is already formed to another acceptor molecule. Here the molecule ammonia (NH_3) gives a lone pair of electrons to Boron tri fluoride (BF_3) molecule which is electron deficient. Thus a Coordinate covalent bond is formed between NH_3 (donor molecule) and BF3 (acceptor molecule) and is represented by $NH_3 \rightarrow BF_3$.



Characteristics of coordinate covalent compounds

The compounds containing coordinate covalent bonds are called coordinate compounds.

a. Physical state – These compounds exist as gases, liquids or solids.

b. Electrical conductivity – Like covalent compounds, coordinate compounds also do not contain charged particles (ions), so they are bad conductors of electricity.

c. Melting point – These compounds have melting and boiling points higher than those of purely covalent compounds but lower than those of purely Ionic compounds.

d. Solubility – Insoluble in polar solvents like water but are soluble in non-polar solvents like benzene, CCl_4, and toluene.

e. Reactions – Coordinate covalent compounds undergo molecular reactions which are slow.

5.4 Oxidation, Reduction and Redox reactions

Look at the following pictures. When an apple is cut and left for sometimes, its surface turns brown. Similarly, iron bolts and nuts in metallic structures get rusted. Do you know why are these happening? It is because of a reaction called oxidation.

Oxidation: A chemical reaction which involves addition of oxygen or removal of hydrogen or loss of electrons is called oxidation.

$2\ Mg + O_2 \rightarrow 2\ MgO$ (addition of oxygen)

$CaH_2 \rightarrow Ca + H_2$ (removal of hydrogen)

$Fe^{2+} \rightarrow Fe^{3+} + e^-$ (loss of electron)

Reduction: A chemical reaction which involves addition of hydrogen or removal of oxygen or gain of electrons is called reduction.

$2\ Na + H_2 \rightarrow 2\ NaH$ (addition of hydrogen)

$CuO + H_2 \rightarrow Cu + H_2O$ (removal of oxygen)

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ (gain of electron)

Redox reactions: Generally, the oxidation and reduction occurs in the same reaction (simultaneously). If one reactant gets oxidised, the other gets reduced. Such reactions are called oxidation-reduction reactions or Redox reactions.

Ex. 1 : $2\ PbO + C \rightarrow 2\ Pb + CO_2$

Ex. 2 : $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$

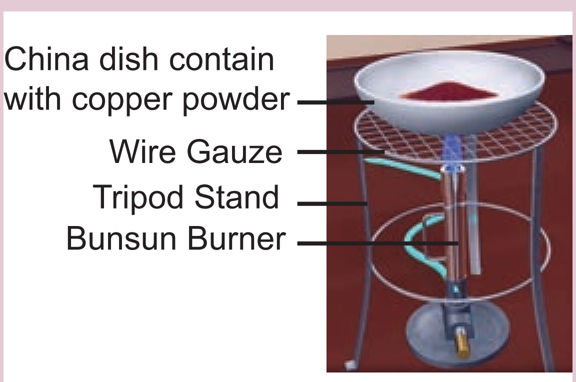
Oxidation (LEO)	addition of Oxygen
	removal of Hydrogen
	loss of electron
Reduction (GER)	removal of Oxygen
	addition of Hydrogen
	gain of electron

Activity 6

Take about one gram of copper powder in a china dish. Place the dish on a tripod stand with wire gauze and heat the copper powder using a Bunsen burner. Is there any change in colour?

Yes, the brown copper turns into black. This is because of the formation of copper oxide. Copper when heated reacts with atmosphere oxygen forming black Copper oxide.

$Cu + O_2 \rightarrow 2\ CuO$ (oxidation reaction)



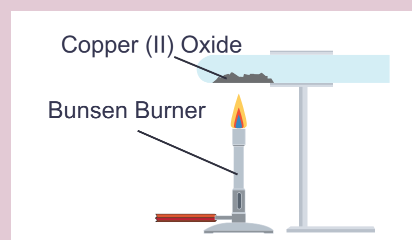
Activity 7

Take the copper oxide obtained from the above activity and pass hydrogen gas over the hot CuO and observe the change in colour. Is there any change in colour?

Yes, the black colour slowly turns into brown. This is because copper oxide loses oxygen to form copper.

$CuO + H_2 \rightarrow Cu + H_2O$ (reduction)

You can also watch the YouTube videos in the below link to know about this reaction.
https://www.youtube.com/watch?v=tEwp2fi1mpI
https://youtu.be/gJWZ8nHn59Y



Oxidising agents and Reducing agents

Substances which have the ability to oxidise other substances are called Oxidising agents. These are also called as electron acceptors because they remove electrons from other substances.

Example: H_2O_2, MnO_4^-, CrO_3, $Cr_2O_7^{2-}$

Substances which have the ability to reduce other substances are called Reducing agents. These are also called as electron donors because they donate electrons to other substances.

Example: $NaBH_4$, $LiAlH_4$ and metals like Palladium, Platinum.

Oxidation reactions in daily life:

In nature the oxygen present in atmospheric air oxidises many things, starting from metals to living tissues.

- The shining surface of metals tarnishes due to the formation of respective metal oxides on their surfaces. This is called corrosion.
- The freshly cut surfaces of vegetables and fruits turns brown after some time because of the oxidation of organic compounds present in them.
- The oxidation reaction in food materials that were left open for a long period is responsible for spoiling of food. This is called Rancidity.

Oxidation number

Oxidation number of an element is defined as the formal charge which an atom of that element appears to have when electrons are counted.

More to Know

Painting, oiling, greasing, galvanising and alloying are some of the methods to prevent corrosion.

- The spoilage of food can be prevented by adding preservatives like Vitamin C and Vitamin E.
- Keeping food in air tight containers helps to slow down the oxidation process. Also filling the pouch with Nitrogen gas will remove oxygen like in potato chips bags.

Oxidation number also called Oxidation state, the total number of electrons that an atom either gains or losses in order to form a chemical bond with another atom.The sum of oxidation numbers of all the atoms in the formula for a neutral compound is ZERO. The sum of oxidation numbers of an ion is the same as the charge on that ion. Negative oxidation number in compounds of two unlike atoms is assigned to the more electronegative atom.

More to Know

Electronegativity is the tendency of an atom in a molecule to attract towards itself the shared pair of electrons.

For example,

- Oxidation number of K and Br in KBr molecule is +1 and -1 respectively.
- Oxidation number of N in NH_3 molecule is -3
- Oxidation number of H is +1 (except hydrides)
- Oxidation number of oxygen in most cases is -2

(Oxidation Number = ON)

More to Know

One of the most valuable metals Gold has high resistance to corrosion.

Problems on determination of Oxidation Number

ON of neutral molecule is always zero

Illustration 1 – Oxidation Number of H and O in H_2O

Let us take ON of H = +1 and ON of O = -2

2 X (+1) + 1 X (-2) = 0

(+2) + (-2) = 0 thus, ON of H is +1 and ON of O is -2

Illustration 2 – Oxidation Number of Na and Cl in NaCl

ON of Na = +1 and ON of Cl = -1

(+1) + (-1) = 0 thus, ON of Na is +1 and ON of Cl is -1

Illustration 3 – Oxidation Number of S in H_2SO_4

Let ON of S be (x) and we know ON of H = +1 and O = -2

2 X (+1) + (x) + 4 X (-2) = 0

(+2) + (x) + (-8) = 0

(x) = +6 therefore, ON of S is +6

Illustration 4 – Oxidation Number of Cr in $K_2Cr_2O_7$

Let ON of Cr be x and we know ON of K = +1 and O = -2

2 X (+1) + 2 X (x) + 7 X (-2) = 0

(+2) + (2x) + (-14) = 0

2x = +12

x = +6 therefore, ON of Cr in $K_2Cr_2O_7$ is +6

Illustration 5 – Oxidation Number of Fe in FeSO4

Let ON of Fe be x and we know ON of S = +6 and O = -2

(x) + 1 X (+6) + 4 X (-2) = 0

(x) + (+6) + (-8) = 0

x = +2 therefore, ON of Fe in $FeSO_4$ is +2

Problems:

1. Find the oxidation number of Mn in $KMnO_4$
2. Find the oxidation number of Cr in $Na_2Cr_2O_7$
3. Find the oxidation number of Cu in $CuSO_4$
4. Find the oxidation number of Fe in FeO

Points to remember

- Kossel and Lewis gave explanation based upon the concept of electronic configuration of noble gases about why atoms combine to form molecules.
- Having stable valence electronic configuration, the noble gas atoms neither have any tendency to gain nor lose electrons.
- Kossel and Lewis proposed a theory in 1916 to explain chemical combination between atoms and this theory is known as 'Electronic theory of valence' or Octet rule.
- The Lewis dot structure or electron dot symbol for an atom consists of the symbol of the element surrounded by dots representing the electrons of the valence shell of the atom.
- There are different types of chemical bonding possible between atoms which make the molecules. Depending on the type of bond they show different characteristics or properties.
- An ionic bond is formed by the electrostatic attraction between positive and negative ions. It is also called as Electrovalent bond.
- The covalent bond is formed because of the sharing of electrons which become common to both the atoms. It is also called as Atomic bond.
- In some compounds the formation of a covalent bond between two atoms takes place by the sharing of two electrons, both of which comes from only one of the combining atoms. This bond is called Coordinate covalent bond or Dative bond.
- Substances which have the ability to oxidise other substances are called Oxidising agents. These are also called as electron acceptors because they remove electrons form other substances.
- Substances which have the ability to reduce other substances are called Reducing agents. These are also called as electron donors because they donate electrons to other substances.
- Oxidation number also called Oxidation State.

A-Z GLOSSARY

Chemical bond	the force of attraction between the two atoms that binds them together as a unit called molecule.
Octet rule or Rule of eight	The tendency of atoms to have eight electrons in the valence shell
Strong bonds	Ionic bond, Covalent bond, Coordinate covalent bond, Metallic bond
Weak bonds	Hydrogen bond, Van der Walls interactions
Ionic / Electrovalent bond	Bond formed between cation and anion because of the transfer of electrons from one atom to other atom
Covalent bond	Bond formed between atoms by the mutual sharing of electrons
Coordinate covalent bond	Bond formed between atoms by mutual sharing of electrons which are supplied by one atom
Oxidation	chemical reaction which involves in the addition of oxygen or removal of hydrogen or loss of electrons

Reduction	chemical reaction which involves in the addition of hydrogen or removal of oxygen or gain of electrons
Redox reaction	oxidation and reduction occurs in the same reaction simultaneously
Oxidising agents	Substances which have the ability to oxidise other substances
Reducing agents	Substances which have the ability to reduce other substances
Oxidation number	the formal charge which an atom has when electrons are counted

TEXT BOOK EXERCISES

I. Choose the correct answer:

1. Number of valence electrons in carbon is

   a) 2 b) 4 c) 3 d) 5

2. Sodium having atomic number 11, ready to ____________________ electron/ electrons to attain the nearest Noble gas electronic configuration.

   a) gain one b) gain two
   c) lose one d) lose two

3. Atoms having 1,2 or 3 electrons in its valence shell will readily form ________

   a) cation b) anion

4. The element that would form anion by gaining electrons in a chemical reaction is ________________

   a) Potassium b) Calcium
   c) Fluorine d) Iron

5. Bond formed between a metal and non metal atom is usually ___________

   a) ionic bond b) covalent bond
   c) coordinate bond

6. _______________ compounds have high melting and boiling points.

   a) Covalent b) Coordinate c) Ionic

7. Covalent bond is formed by ___________

   a) transfer of electrons
   b) sharing of electrons
   c) sharing a pair of electrons

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8. Oxidising agents are also called as ____________ because they remove electrons form other substances.

   a) electron donors b) electron acceptors

9. Elements with stable electronic configurations have eight electrons in their valence shell. They are ___

   a) Halogens b) Metals
   c) Noble gases d) non metals

II. Answer in brief

1. How do atoms attain Noble gas electronic configuration.
2. CCl_4 is insoluble in water but NaCl is soluble in water. Give reason.
3. Explain Octet rule with an example.
4. Write a note on different types on bonds?
5. Find the odd one out.

   a. H_2, Cl_2, NaCl, O_2, N_2

   b. H_2O_2, MnO_4^-, $LiAlH_4$, $Cr_2O_7^{2-}$

6. Correct the wrong statements.

   a. Ionic compounds dissolve in non polar solvents

b. Covalent compounds conduct electricity in molten or solution state.

7. Complete the table give below.

Element	Atomic number	Electron distribution	Valence electrons	Lewis dot structure
Lithium	3			
Boron	5			
Oxygen	8			

8. Draw the electron distribution diagram for the formation of Carbon di oxide (CO_2) molecule.

9. Fill in the following table according to the type of bonds formed in the given molecule.

$CaCl_2$, H_2O, CaO, CO, KBr, HCl, CCl_4, HF, CO_2, Al_2Cl_6

Ionic bond	Covalent bond	Coordinate covalent bond

10. Choose the correct answer form the choices given below.

The property which is characteristics of an Ionic compound is that

a. it often exists as gas at room temperature

b. it is hard and brittle

c. it undergoes molecular reactions

d. it has low melting point

11. Identify the following reactions as oxidation or reduction

a. $Na \rightarrow Na^{+} + e^{-}$

b. $Fe^{3+} + 2e^{-} \rightarrow Fe^{+}$

12. Identify the compounds as Ionic/ Covalent/Coordinate based on the given characteristics.

a. Soluble in non polar solvents -

b. undergoes faster/instantaneous reactions -

c. Non conductors of electricity -

d. Solids at room temperature -

13. An atom X with atomic number 20 combines with atom Y with atomic number 8. Draw the dot structure for the formation of the molecule XY.

14. Considering $MgCl_2$ as ionic compound and CH_4 as covalent compound give any two differences between these two compounds.

15. Why are Noble gases inert in nature?

III. Answer in detail

1. List down the differences between Ionic and Covalent compounds.

2. Give an example for each of the following statements.

a. a compound in which two Covalent bonds are formed

b. a compound in which one ionic bond is formed

c. a compound in which two Covalent and one Coordinate bonds are formed

d. a compound in which three covalent bonds are formed

e. a compound in which Coordinate bond is formed

3. Identify the incorrect statement and correct them.

a. Like covalent compounds, Coordinate compounds also contain charged particles (ions), so they are good conductors of electricity.

b. Ionic bond is a weak bond when compared to Hydrogen bond.

c. Ionic or electrovalent bonds are formed by mutual sharing of electrons between atoms.

d. Loss of electrons is called Oxidation and Gain of electron is called Reduction.

e. The electrons which are not involved in bonding are called valence electrons.

4. Discuss in brief about the properties of Coordinate covalent compounds.

5. Find the oxidation number of the elements in the following compounds.

a. C in CO_2

b. Mn in $MnSO_4$

c. N in HNO_3

IV. LIFE SKILLS - Debate

Divide the class into groups. Debate on the following statement.

“Sharing and caring improves human harmony like Chemical bond”

- ionic bond
- covalent bond
- coordinate bond

V. Complete the crossword using the clues.

Left to right:

1) pair of electrons which do not take part in bond formation

2) reaction in which both oxidation and reduction takes place

3) rule which says about eight electrons in outermost shell

Top to bottom:

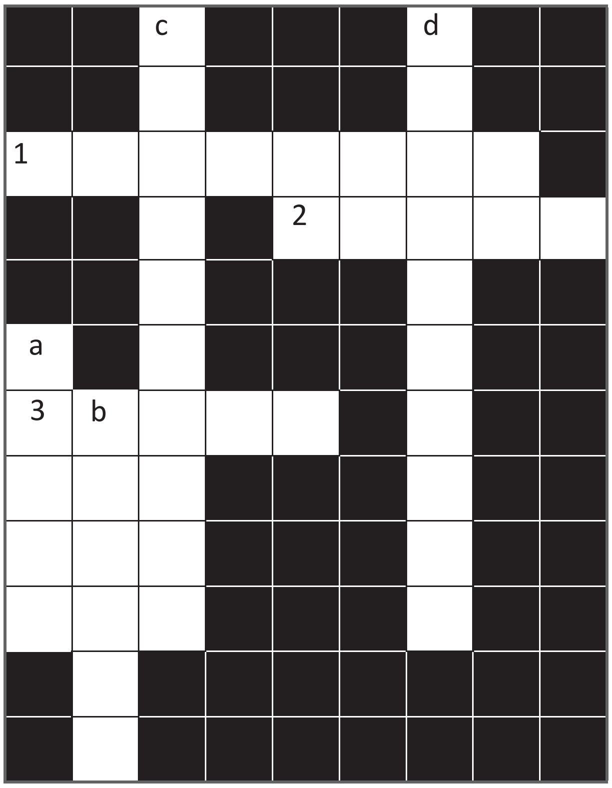
a) bond formed by transfer of electrons from one atom to another

b) ion with positive charge

c) energy required to remove the most loosely bound electron from an isolated gaseous atom of an element

d) loss of electron

(lonepair, redox, octet, ionic, cation, ionisation, oxidation)

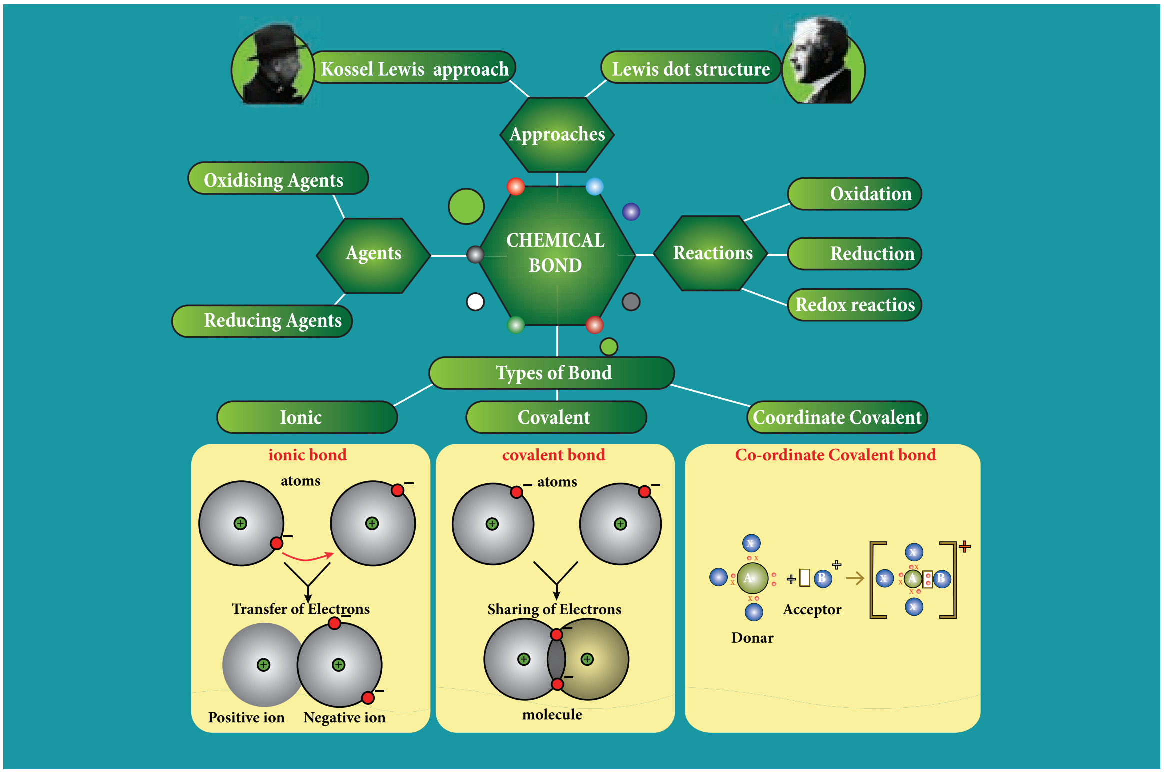


REFERENCE BOOKS

1. Modern Inorganic Chemistry – by R.D.Madan
2. Textbook of Inorganic Chemistry – by Soni, P.L. and Mohan Katyal.

INTERNET RESOURCES

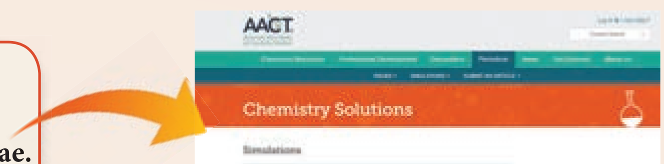
1. https://youtu.be/G08rZ6xiIuA
2. https://youtu.be/LkAykOv1foc
3. https://youtu.be/DEdRcfyYnSQ



ICT CORNER

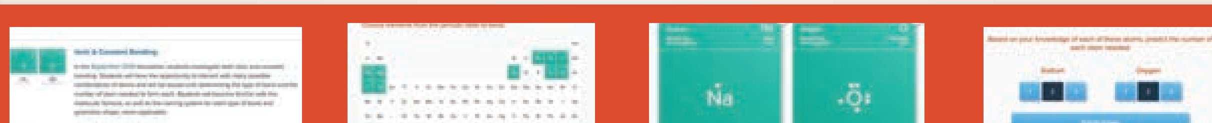
Chemical Bonding

Explore this activity to know about the various types of Chemical bonding in compounds and to learn chemical formulae.



Steps

- Copy and paste the link given below or type the URL in the browser.
- In the Simulations section, scroll down and select Ionic & Covalent Bonding option.
- Select any two elements which are highlighted in the periodic table.
- Once selected, two options called Ionic Bond or Covalent Bond will appear. In it, click any one of the options to find number of atoms option. Select the numbers and submit the answers to verify.



Step1 Step2 Step3 Step4

Browse in the link:

URL: https://teachchemistry.org/periodical/simulations or Scan the QR Code.

*Pictures are indicative only

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UNIT 6

Acids, Bases and Salts

BPNYLX

Learning Objectives

After completing this lesson, students will be able to

- know about formation, properties and uses of acids, bases and salts
- know about how they play a vital role in our daily life
- understand how to identify the nature of a solution by using indicators and pH paper
- know how strong are acid or base solutions using pH scale
- define pH scale and explain the significance of pH in everyday life
- know aquaregia and its properties

Introduction

We know that the physical world around us is made of large number of chemicals. Soil, air, water, all the life forms and the materials that they use are all consist of chemicals. Out of such chemicals, acids, bases and salts are mostly used in everyday life, let it be a fruit juice or a detergent or a medicine. They play a key role in our day-to-day activities. Our body metabolism is carried out by means of hydrochloric acid secreted in our stomach. An acid is the compound which are capable of forming hydrogen ions (H^+) in aqueous solution whereas a base is the compound that forms hydroxyl ions (OH^-) in solution. When an acid and a base react with each other, a neutral product is formed which is called salt. In this lesson let us discuss about these in detail.

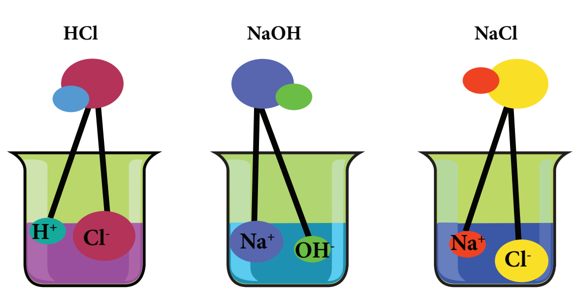


Figure 6.1 Acid, base and salt

6.1 What are Acids?

Look at the pictures of some of the materials used in our daily life given below:

Figure 6.2 Acid, base and salt in food

All these edible items taste similar i.e. sour. What cause them to taste sour? A certain type of chemical compounds present in them gives sour taste. These are called acids. The word 'acid' is derived from the Latin name "acidus" which means sour taste. Substances with sour taste are called acids.

Table 6.1 Acid and its source

SOURCE	ACID PRESENT
Apple	Malic acid
Lemon	Citric acid
Grape	Tartaric acid
Tomato	Oxalic acid
Vinegar	Acetic acid
Curd	Lactic acid
Orange	Ascorbic acid
Tea	Tannic acid
Stomach juice	Hydrochloric acid
Ant, Bee	Formic acid

In 1884, a Swedish chemist Svante Arrhenius proposed a theory on acids and bases. According to Arrhenius theory, an acid is a substance which furnishes H^+ ions or H_3O^+ ions in aqueous solution. They contain one or more replaceable hydrogen atoms. For example, when hydrogen chloride is dissolved in water, it gives H^+ and Cl^- ions in water.

$$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

What happens to an acid or a base in water? Do acids produce ions only in aqueous solution?

Hydrogen ions in HCl are produced in the presence of water. The separation of H^+ ion from HCl molecules cannot occur in the absence of water.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

Hydrogen ions cannot exist alone, but they exist in combined state with water molecules. Thus, hydrogen ions must always be H^+ (or) Hydronium (H_3O^+)

$$H^+ + H_2O \rightarrow H_3O^+$$

The following table enlists various acids and the ions formed by them in water.

Table 6.2 Ions formed by acids

Acid	Molecular Formula	Ions formed		No. of replaceable hydrogen
Acetic Acid	CH_3COOH	H^+	CH_3COO^-	1
Formic Acid	$HCOOH$	H^+	$HCOO^-$	1
Nitric Acid	HNO_3	H^+	NO_3^-	1
Sulphuric Acid	H_2SO_4	H^+	SO_4^{2-}	2
Phosphoric Acid	H_3PO_4	H^+	PO_4^{3-}	3

DO YOU KNOW?

All acids essentially contain one or more hydrogens. But all the hydrogen containing substances are not acids. For example, methane (CH_4) and ammonia (NH_3) also contain hydrogen. But they do not produce H^+ ions in aqueous solution.

6.1.1 Classification of Acids

Acids are classified in different ways as follows:

Based on their sources:

(i) Organic acids

(ii) Inorganic acids

Organic Acids:

Acids present in plants and animals (living things) are organic acids.

Example: $HCOOH$, CH_3COOH

Inorganic Acids:

Acids prepared from rocks and minerals are inorganic acids or mineral acids.

Example: HCl, HNO_3, H_2SO_4

Based on their Basicity

Monobasic Acid:

Acid that contain only one replaceable hydrogen atom per molecule is called monobasic acid. It gives one hydrogen ion per molecule of the acid in solution.

Example: HCl, HNO_3

Dibasic Acid:

An acid which gives two hydrogen ions per molecule of the acid in solution.

Example: H_2SO_4, H_2CO_3

Tribasic Acid:

An acid which gives three hydrogen ions per molecule of the acid in solution.

Example: H_3PO_4

DO YOU KNOW?

For acids, we use the term basicity that refers to the number of replaceable hydrogen atoms present in one molecule of an acid. For example, acetic acid (CH_3COOH) has four hydrogen atoms but only one can be replaced. Hence it is monobasic.

Based on Ionisation

Acids get ionised in water (produce H^+ ions) completely or partially. Based on the extent of ionisation acids are classified as follows:

Strong Acids:

These are acids that ionise completely in water. Example: HCl

Weak Acids:

These are acids that ionise partially in water. Example: CH_3COOH.

DO YOU KNOW?

Ionisation is the condition of being dissociated into ions by heat or radiation or chemical reactions or electrical discharge.

Based on Concentration

Concentrated Acid:

It has relatively large amount of acid dissolved in a solvent.

Dilute Acid:

It has relatively smaller amount of acid dissolved in solvent.

Caution:

Care must be taken while mixing any concentrated inorganic acid with water. The acid must be added slowly and carefully with constant stirring to water since it generates large amount of heat. If water is added to acid, the mixture splashes out of the container and it may cause burns.

6.1.2 Properties of Acids

a) They have sour taste

b) Their aqueous solutions conduct electricity since they contain ions

c) Acids turns blue litmus red

d) Acids react with active metals to give hydrogen gas.

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2 \uparrow$$

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2 \uparrow$$

DO YOU KNOW?

Few metals do not react with acid and liberate hydrogen gas. For example: Ag, Cu.

e) Acids react with metal carbonate and metal hydrogen carbonate to give carbon dioxide.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2 \uparrow$$

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2 \uparrow$$

f) Acids react with metallic oxides to give salt and water.

$$CaO + H_2SO_4 \rightarrow CaSO_4 + H_2O$$

g) Acids react with bases to give salt and water.

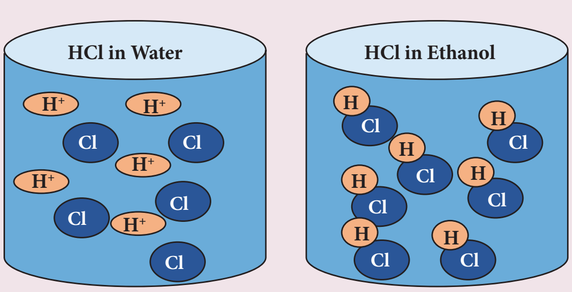
$$HCl + NaOH \rightarrow NaCl + H_2O$$

DO YOU KNOW?

Role of water in acid solution

Acids show their properties only when dissolved in water. In water, they ionise to form H+ ions which determine the properties of acids. They do not ionise in organic solvents.

For example, when HCl is dissolved in water it produces H^+ ions and Cl- ions whereas in organic solvent like ethanol they do not ionise and remain as molecule.



Activity 1

- Take about 10 ml of dilute hydrochloric acid in a test tube and add a few pieces of zinc granules into it. What do you observe? Why are bubbles formed in the solution?
- Take a burning candle near a bubble containing hydrogen gas, the flame goes off with a 'Popping' sound. This confirms that metal displaces hydrogen gas from the dilute acid.

6.1.3 Uses of Acids

- Sulphuric acid is called King of Chemicals because it is used in the preparation of many other compounds. It is used in car batteries also.
- Hydrochloric acid is used as a cleansing agent in toilets.
- Citric acid is used in the preparation of effervescent salts and as a food preservative.
- Nitric acid is used in the manufacture of fertilizers, dyes, paints and drugs.
- Oxalic acid is used to clean iron and manganese deposits from quartz crystals. It is also used as bleach for wood and removing black stains.
- Carbonic acid is used in aerated drinks.
- Tartaric acid is a constituent of baking powder.

6.1.4 Aquaregia

We know that metals like gold and silver are not reactive with either HCl or HNO_3. But the mixture of these two acids can dissolve gold. This mixture is called Aquaregia. It is a mixture of hydrochloric acid and nitric acid prepared optimally in a molar ratio of 3:1. It is a yellow-orange fuming liquid. It is a highly corrosive liquid, able to attack gold and other resistant substances.

Chemical formula	:	$3\ HCl + HNO_3$
Solubility in Water	:	Miscible in water
Melting point	:	- 42°C (- 44°F, 231K)
Boiling point	:	108°C (226°F, 381K)

The term aquaregia is a Latin phrase meaning "King's Water". The name reflects the ability of aquaregia to dissolve the noble metals such as gold, platinum and palladium.

Uses of Aquaregia:

1. It is used chiefly to dissolve metals such as gold and platinum.
2. It is used for cleaning and refining gold.

6.2 What are Bases?

According to Arrhenius theory, bases are substances that ionise in water to form hydroxyl ions (OH^-). There are some metal oxides which give salt and water on reaction with acids. These are also called bases. Bases that are soluble in water are called alkalis. A base reacts with an acid to give salt and water only.

Base + Acid → Salt + Water

For example, zinc oxide (ZnO) reacts with HCl to give the salt zinc chloride and water

$$ZnO_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_2O_{(l)}$$

Similarly, sodium hydroxide ionises in water to give hydroxyl ions and thus get dissolved in water. So it is an alkali.

$$NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$$

Bases contain one or more replaceable oxide or hydroxyl ions in solution. Table 6.3 enlists various bases and ions formed by them in water.

DO YOU KNOW? All alkalis are bases but not all bases are alkalis. For example: NaOH and KOH are alkalis whereas $Al(OH)_3$ and $Zn(OH)_2$ are bases.

6.2.1 Classification of Bases

Based on their Acidity

a) Monoacidic Base:

It is a base that ionises in water to give one hydroxide ion per molecule.

Example: NaOH, KOH

b) Diacidic Base:

It is a base that ionises in water to give two hydroxide ions per molecule.

Example: $Ca(OH)_2$. $Mg(OH)_2$

Table 6.3 Ions formed by bases in water.

Base	Molecular Formula	Ions formed		No. of replaceable hydroxyl ion
Calcium oxide	CaO	Ca^{2+}	O^{2-}	1
Sodium oxide	Na_2O	Na^+	O^{2-}	1
Potassium hydroxide	KOH	K^+	OH^-	1
Calcium hydroxide	$Ca(OH)_2$	Ca^{2+}	OH^-	2
Aluminium oxide	$Al(OH)_3$	Al^{3+}	OH^-	3

c) Triacidic Base:

It is a base that ionises in water to give three hydroxide ions per molecule.

Example: $Al(OH)_3$, $Fe(OH)_3$

Based on concentration

a) Concentrated Alkali

It is an alkali having a relatively high percentage of alkali in its aqueous solution.

b) Dilute Alkali

It is an alkali having a relatively low percentage of alkali in its aqueous solution.

Based on Ionisation

a) Strong Bases:

These are bases which ionise completely in aqueous solution.

Example: NaOH, KOH

b) Weak Bases

These are bases that ionise partially in aqueous solution.

Example: NH_4OH, $Ca(OH)_2$

DO YOU KNOW? The term acidity is used for base, which means the number of replaceable hydroxyl groups present in one molecule of a base.

6.2.2 Properties of Bases:

a) They have bitter taste.

b) Their aqueous solutions have soapy touch.

c) They turn red litmus blue

d) Their aqueous solutions conduct electricity

e) Bases react with metals to form salt with the liberation of hydrogen gas.

$$Zn + 2\,NaOH \rightarrow Na_2ZnO_2 + H_2\uparrow$$

f) Bases react with non-metallic oxides to produce salt and water. Since this is similar to the reaction between a base and an acid, we can conclude that non-metallic oxides are acidic in nature.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

g) Bases react with acids to form salt and water.

$$KOH + HCl \rightarrow KCl + H_2O$$

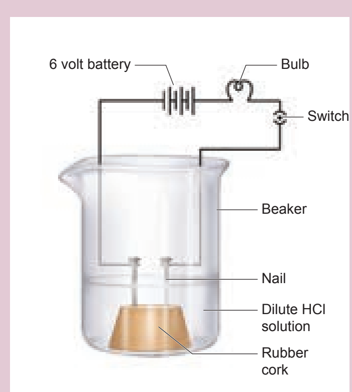
The above reaction between a base and an acid is known as Neutralisation reaction.

h) On heating with ammonium salts, bases give ammonia gas.

$$NaOH + NH_4Cl \rightarrow NaCl + H_2O + NH_3\uparrow$$

Activity 2

- Take solutions of hydrochloric acid or sulphuric acid.
- Fix two nails on a cork and place the cork in a 100 ml beaker.
- Connect the nails to the two terminals of a 6V battery through a bulb and a switch as shown in Figure.
- Now pour some dilute HCl in the beaker and switch on the current.
- Repeat the activity with dilute sulphuric acid, glucose and alcohol solutions. What do you observe now?
- Does the bulb glow in all cases?



> **DO YOU KNOW?** Few metals do not react with sodium hydroxide. For example: Cu, Ag, Cr

In the above activity you can observe that the bulb will start glowing only in the case of acids. But you will observe that glucose and alcohol solution do not conduct electricity. Glowing of the bulb indicates that there is a flow of electric current through the solution. The electric current is carried through the solution by ions.

Repeat the same activity using alkalis such as sodium hydroxide and calcium hydroxide.

6.2.3 Uses of Bases

(i) Sodium hydroxide is used in the manufacture of soap.

(ii) Calcium hydroxide is used in white washing of building.

(iii) Magnesium hydroxide is used as a medicine for stomach disorder.

(iv) Ammonium hydroxide is used to remove grease stains from cloths.

6.3 Tests for Acids and Bases

Take 10 ml of solution in a test tube and test with a litmus paper or indicators like phenolphthalein and methyl orange.

a) Test with a litmus paper:

An acid turns blue litmus paper into red. A base turns red litmus paper into blue.

b) Test with an indicator Phenolphthalein:

In acid medium, phenolphthalein is colourless. In basic medium, phenolphthalein is pink in colour.

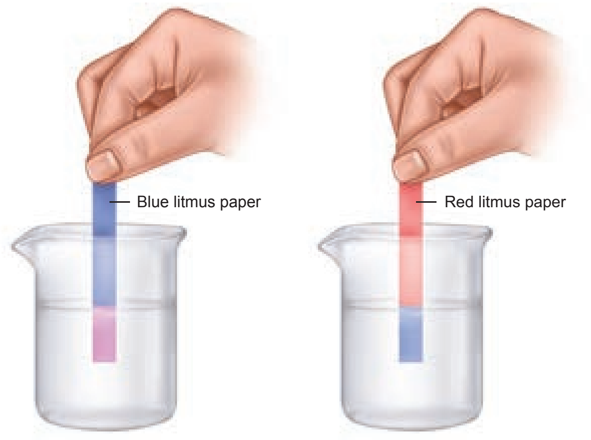


Figure 6.3 Test for acid and base using litmus paper

c) Test with an indicator Methyl orange:

In acid medium, methyl orange is pink in colour. In basic medium, methyl orange is yellow in colour.

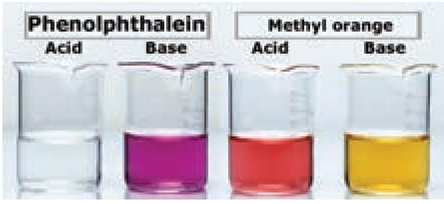
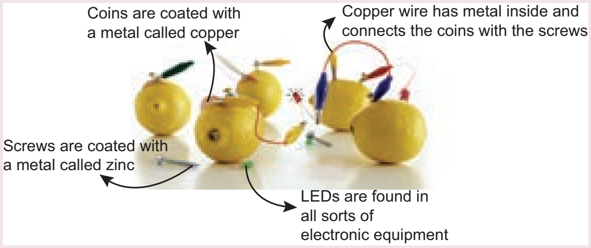


Figure 6.4 Test for acid and base using indicator

Table 6.4 Acid base indicator

Indicator	Colour in acid	Colour in base
Litmus	Blue to Red	Red to Blue
Phenolphthalein	Colourless	Pink
Methyl orange	Pink	Yellow

Try Yourself: Construct a Lemon cell as shown in picture.



Activity 3

Collect the following samples from the science laboratory – Hydrochloric acid, sulphuric acid and Nitric acid, Sodium hydroxide, Potassium hydroxide. Take 2 ml of each solution in a test tube and test with a litmus paper and indicators phenolphthalein and Methyl orange. Tabulate your observations.

Sample Solutions	Litmus Paper		Indicators	
	Blue	Red	Phenolphthalein	Methyl Orange
Hydrochloric acid				
Sulphuric acid				
Nitric acid				
Sodium hydroxide				
Potassium hydroxide				

6.4 How strong are Acid or Base solutions?

pH Scale

A scale for measuring hydrogen ion concentration in a solution is called pH scale. The 'p' in pH stands for 'potenz' in German meaning power. pH scale is a set of numbers from 0 to 14 which is used to indicate whether a solution is acidic, basic or neutral.

- ✓ Acids have pH less than 7
- ✓ Bases have pH greater than 7
- ✓ A neutral solution has pH equal to 7

6.4.1 How can we measure the pH of a given solution?

The pH of a solution can be determined by using a universal indicator. It contains a mixture of dyes. It comes in the form of a solution or pH paper.

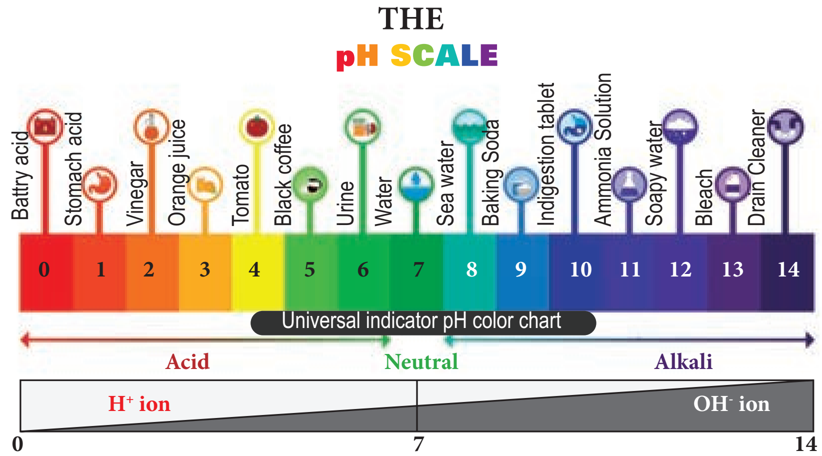


Figure 6.5 pH Scale

A more common method of measuring pH in a school laboratory is by using pH paper. pH paper contains a mixture of indicator.

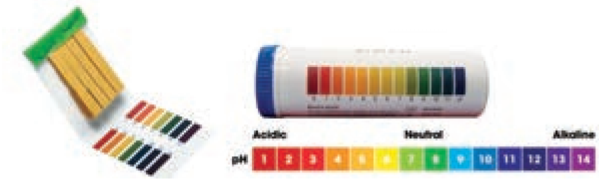


Figure 6.6 Indicators and pH paper

Activity 4

Take a jar with cabbage leaves and pour boiling water to it. Allow it to cool to room temperature and filter it. It is your own indicator used to find whether the given solution is acidic or basic. This juice produces a red colour when mixed with an acid and a green colour with a base.

Take any tooth paste. Add cabbage juice to it. It changes to green which shows that tooth paste is basic in nature. In the same way, test with lemon juice, tomato juice and pure water.

6.4.2 Importance of pH in everyday life

Are plants and animals pH sensitive?

Our body works within the pH range of 7.0 to 7.8. Living organisms can survive only in narrow range of pH change.

pH in our digestive system

It is very interesting to note that our stomach produces hydrochloric acid. It helps in the digestion of food without harming the stomach. During indigestion the stomach produces too much acid and this causes pain and irritation. pH of stomach fluid is approximately 2.0.

pH changes as the cause of tooth decay

White enamel coating of our teeth is calcium phosphate, the hardest substance in our body. Toothpastes which are generally basic and used for cleaning the teeth can neutralise the excess acid and prevent tooth decay.

pH of soil

In agriculture, the pH of soil is very important. Citrus fruits require slightly alkaline soil, while rice requires acidic soil and sugarcane requires neutral soil.

pH of rain water

The pH of rain water is approximately 7 which means that it is neutral and also represents its high purity. If the atmospheric air is polluted with oxide gases of sulphur and nitrogen, they get dissolved in rainwater and make its pH less than 7. Thus, if the pH of rain water is less than 7, then it is called acid rain. When acid rain flows into the rivers it lowers the pH of the river water. The survival of aquatic life in such rivers becomes difficult.

Table 6.5 pH value of solutions

The Solution	Approximate pH
Blood	7.3 – 7.5
Saliva	6.5 – 7.5
Gastric Juice	1.0 – 3.0
Soft Drinks	3.0
Sea Water	8.5
House hold Ammonia	12.0
Tomato Juice	4.0 – 4.4

6.5 What are Salts?

BPSLAU

When you say salt, you may think of the white stuff sprinkled on chips, but that is just one kind of salt called as common salt. Seawater contains many salts dissolved in it. Sodium chloride is separated from these salts.

There are many other salts used in other fields. Salts are the products of the reaction between acids and bases. Salts produce positive ions and negative ions when dissolved in water.

Acid + Base → Salt + Water

6.5.1 Types of Salts

(i) Normal Salts

A normal salt is obtained by complete neutralization of an acid by a base.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

(ii) Acid Salts

It is derived from the partial replacement of hydrogen ions of an acid by a metal. When a calculated amount of a base is added to a polybasic acid, acid salt is obtained.

$$NaOH + H_2SO_4 \rightarrow NaHSO_4 + H_2O$$

(iii) Basic Salts

Basic salts are formed by the partial replacement of hydroxide ions of a diacidic or triacidic base with an acid radical.

$$Pb(OH)_2 + HCl \rightarrow Pb(OH)Cl + H_2O$$

(iv) Double Salts

Double salts are formed by the combination of the saturated solution of two simple salts in equimolar ratio followed by crystallization. For example, Potash alum is a mixture of potassium sulphate and aluminium sulphate.

$$KAl(SO_4)_2.12H_2O$$

6.5.2 Properties of Salts

- ✓ Salts are mostly solids which melt as well as boil at high temperature.
- ✓ Most of the salts are soluble in water. For example, chloride salts of potassium and sodium are soluble in water. But silver chloride is insoluble in water
- ✓ They are odourless, mostly white, cubic crystals or crystalline powder with salty taste.
- ✓ Salt is hygroscopic in nature.

6.5.3 Water of Crystallisation

Many salts are found as crystals with water molecules they contain. These water molecules are known as water of crystallisation. Salts that contain water of crystallisation are called hydrated salts. The number of molecules of water hydrated to a salt is indicated after the dot in its chemical formula. For example, copper sulphate crystal have five molecules of water for each molecule of copper sulphate. It is written as $CuSO_4.5H_2O$ and named as copper sulphate pentahydrate. This water of crystallisation makes the copper sulphate blue. When it is heated, it loses its water molecules and becomes white.

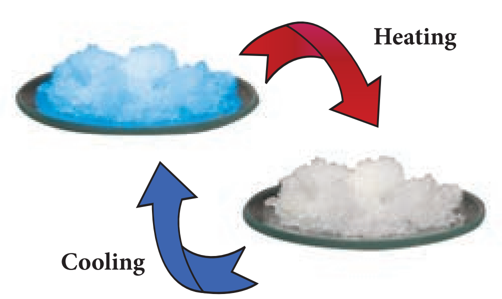


Figure 6.7 Hydrated Salt

Salts that do not contain water of crystallisation is called anhydrous salt. They generally found as powders. Fill in the blanks in the following table based on the concept of water of crystallisation:

6.5.4 Identification of Salts

(i) Physical examination of the salt.

The physical examination of the unknown salt involves the study of colour, smell and density. This test is not much reliable.

Activity 5

Fill in the blanks in the following table based on the concept of water of crystallisation.

Salt	Formula of anhydrous salt	Formula of hydrated salt	Name of hydrated salt
Zinc sulphate	$ZnSO_4$	$ZnSO_4 . 7H_2O$	
Magnesium chloride	$MgCl_2$		Magnesium chloride hexahydrate
Iron (II) sulphate		$FeSO_4.7H_2O$	Iron (II) sulphate heptahydrate
Calcium chloride	$CaCl_2$	$CaCl_2.2H_2O$	
Sodium thiosulphate	$Na_2S_2O_3$		Sodium thiosulphate pentahydrate

(ii) Dry heating Test.

This test is performed by heating a small amount of salt in a dry test tube. After all the water get evaporated, the dissolved salts are sedimented in the container.

(iii) Flame Test.

Certain salts on reacting with concentrated hydrochloric acid (HCl) form their chlorides. The paste of the mixture with con.HCl is introduced into the flame with the help of platinum wire.

Colour of the flame	Inference
Brick red	Ca^{2+}
Golden Yellow	Na^{2+}
Pink Violet	K^{+}
Green Fleshes	Zn^{2+}

(iv) When HCl is added with a carbonate salt, it gives off CO_2 gas with brisk effervescence.

6.5.5 Uses of Salts

Common Salt (NaCl)

It is used in our daily food and used as a preservative.

Washing Soda (Sodium Carbonate-)

i. It is used in softening hard water.

ii. It is used in glass, soap and paper industries.

Baking Soda (Sodium bicarbonate -$NaHCO_3$)

i. It is used in making of baking powder which is a mixture of baking soda and tartaric acid.

ii. It is used in soda-acid fire extinguishers.

iii. Baking powder is used to make cakes and bread, soft and spongy.

iv. It neutralizes excess acid in the stomach and provides relief.

Bleaching powder
(Calcium Oxychloride - $CaOCl_2$)

i. It is used as disinfectant.

ii. It is used in textile industry for bleaching cotton and linen.

Plaster of Paris (Calcium Sulphate Hemihydrate - $CaSO_4 .½ H_2O$)

i. It is used for plastering bones

ii. It is used for making casts for statues.

Activity 6

Boil about 100 ml of ground water in a vessel to dryness. After all the water get evaporated observe the inner wall of the vessel. Can you observe any deposits? This is the deposit of dissolved salts present in water.

Points to remember

- Acid is a substance which furnishes H^+ ions or H_3O^+ ions when dissolved in water.
- Base is a substance which releases OH^- ions when dissolved in water.
- Salt is the product of reaction between acids and bases.
- Acids and bases neutralize each other to form corresponding salts and water.
- Salts have various uses in everyday life and in industries.
- Acidic and basic solutions in water conduct electricity because they produce hydrogen and hydroxide ions respectively.
- When an acid reacts with a metal, hydrogen gas is evolved and a corresponding salt is formed.
- Phenolphthalein, Methyl orange are used as indicators to find out the given solution whether acid or base.
- Litmus paper is also used to find out the given solution whether acid or base.
- pH paper is find out the given solution whether acidic or basic in nature.
- Aquaregia is a mixture of hydrochloric acid and nitric acid optimally in a molar ratio of 3:1
- pH Scale is used to find out the power of hydrogen ion concentration in a solution.

A-Z GLOSSARY

Acids	It is a substance which furnishes H^+ ions H_3O^+ ions when dissolved in water
Bases	It is a substance which furnishes ionizes OH^- ions when dissolved in water
Salts	It is product of reaction between acids and bases
Indicators	Chemical substances used to find out whether the given solution is acid or base.
pH Scale	It is used to find out Hydrogen ion concentration in a solution.
pH Paper	It is used to find out whether the given solution is acidie or basic or neutral in nature.
Sulphuric acid	It is called as "King of Chemicals" and it is used to manufacture of most of the chemicals.
Aquaregia	It is the mixture of hydrochloric acid and nitric acid prepared optimally in a molar ratio of 3 : 1
Hygroscopic substance	Substance which absorbs water from the surroundings.

TEXT BOOK EXERCISES

BPXUNK

I. Choose the correct answer

1. $Zn + 2\,HCl \rightarrow ZnCl_2 + \ldots\uparrow (H_2, O_2, CO_2)$
2. Apple contains malic acid. Orange contains ______ (citric acid, ascorbic acid)
3. Acids in plants and animals are organic acids. Whereas Acids in rocks and minerals are ______ (Inorganic acids, Weak acids)

4. Acids turn blue litmus paper to ________ (Green, Red, Orange)
5. Since metal carbonate and metal bicarbonate are basic they react with acids to give salt and water with the liberation of ________ (NO_2, SO_2, CO_2)
6. pH value of human blood is ________ (7.0, 7.4, 7.6)
7. The nature of the tooth paste commonly used is ______ in nature (acidic, basic, neutral)
8. You are given pure water to test the pH value using pH paper. It shows ______colour (White, black, green)
9. The hydrated salt of copper sulphate has ______ colour (Red, White, Blue)

II. Answer in brief

1. Name any two metals which do not react with sodium hydroxide.
2. Write any four uses of acids.
3. Give the significance of pH of soil in agriculture.
4. When does the acid rain occur?
5. What are the uses of Plaster of Paris?
6. Two acids 'A' and 'B' are given. Acid A gives one hydrogen ion per molecule of the acid in solution. Acid B gives two hydrogen ions per molecule of the acid in solution.
   (i) Find out the acid A and acid B.
   (ii) Which acid is called the King of Chemicals?
7. Define aquaregia.
8. Correct the mistakes:
   a) Washing soda is used for making cakes and bread soft, spongy.
   b) Calcium sulphate hemihydrate is used in textile industry.
9. Find the odd one out: Lemon juice, Tomato juice, House hold ammonia, Coffee
10. What is neutralization reaction? Give an example.

III. Answer in detail

1. Why does distilled water not conduct electricity whereas rain water does?
2. Plaster of Paris should be stored in a moisture proof container. why?
3. Write any four uses of bases.
4. The solutions A, B, C, D and E when tested with universal indicator showed pH as 4, 1, 11, 7 and 9 respectively. Among these which solution is
   (i) neutral
   (ii) strongly alkaline
   (iii) strongly acidic
   (iv) weakly acidic
   (v) weakly alkaline
5. Write any five uses of salts.
6. Sulphuric acid is called King of Chemicals. Why is it called so?

REFERENCE BOOKS

1. Lakhmir Singh & Manjit Kaur chemistry
2. Dr. N.K. Verma - Practical chemistry

INTERNET RESOURCES

1. https:/www.thoughtco.com
2. Aquaregia Wikipedia
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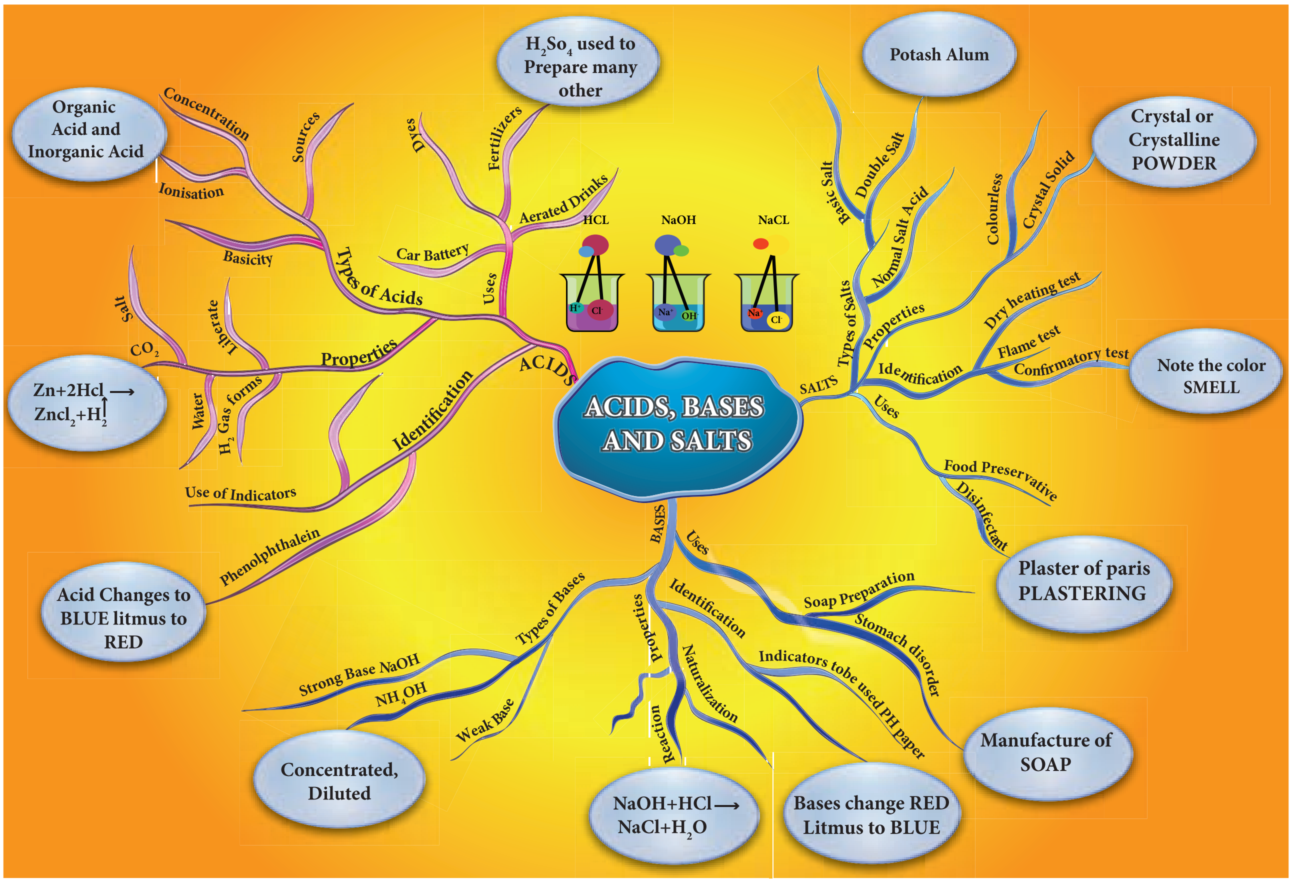
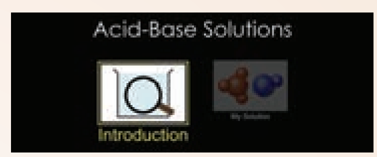


ICT CORNER

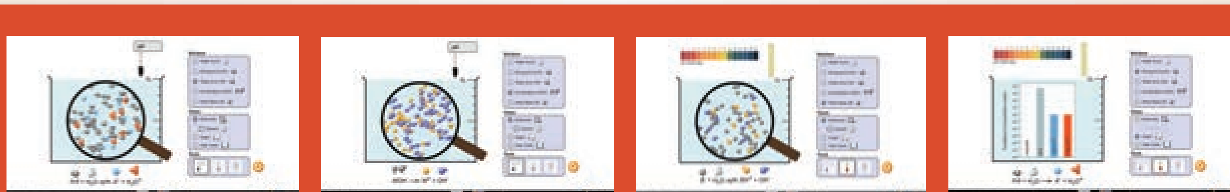
Acids, Bases and Salts.

This activity enables to explore the properties of acids and bases.



Steps

- Type the URL link given below in the browser or scan the QR code. You can view **"Acids and bases"**.
- Click the **'pH meter'** to explore the properties based on the pH value.
- Click the **'pH paper'** to explore the properties based on the colour of pH paper .
- Also you can see the nature of the acids, bases using the conductivity.



Step1 Step2 Step3 Step4

Browse in the link:

URL: https://phet.colorado.edu/en/simulation/acid-base-solutions

*Pictures are indicative only

B467_SCI_9_T2_EM

UNIT 7

Organization of Tissues

BQ2HCH

Learning Objectives

At the end of the lesson students will be able:

- To know the different types of tissues and their morphology.
- To identify how tissues are organized in specific patterns to form organs.
- To understand how these tissues work together in an integrated manner and perform life activities in plants and animals.
- To gain knowledge about the structural organisation of meristematic tissues, and permanent tissues of plants; epithelial tissues, connective tissues, muscular and nervous tissues of animals.
- To familiarize with the process, types and significance of cell division.

Introduction

Unicellular organisms, like bacteria and protozoans though made of single cells act as a site for diverse life activities such as digestion, respiration, excretion and reproduction. On the other hand, multicellular organisms, like higher plants and animals, are composed of millions of different types of cells that are grouped into different levels of organization. Multicellular organisms have specialized cells, tissues, organs and organ systems that perform specific functions. In this chapter, you will learn different types of plant and animal tissues and how they are modified to coordinate life activities.

Multicellular organisms usually develop from the zygote. Each zygote divides by the process of mitotic cell division. Repeated cell divisions produce large number of cells which undergo cellular differentiation. The process of cell division and cell differentiation lead to the development of specific organs consisting of specific groups of cells to perform specific functions in the body. Group of cells positioned and designed to perform a particular function is called a tissue. An organ is a structure made up of a collection of tissues that carry out specialized functions for example in plants the root, stem and leaves are organs; wherein tissues of leaves include epidermis, palisade tissue, spongy tissue, xylem and phloem. Similarly in animals stomach for example, is an organ that consists of tissues made of epithelial cells, gland cells and muscle cells.

7.1 Plant Tissues

Groups or mass of cells that are similar in origin, structure and function form a tissue. Plants are made up of vegetative and reproductive tissues.

In general plant tissues are classified into two types namely

i. Meristems or Meristematic tissues.

ii. Permanent tissues

7.2 Meristematic Tissues (Meristems)

The term "meristem" is derived from the greek word ' Meristos' which means divisible or having cell division activity. The term meristem was coined by Nageli (1858).

Meristematic tissues are group of immature cells that are capable of undergoing cell division. In plants, meristem is found in zones where growth can take place, for example, apex of stem, root, leaf primordia, vascular cambium, cork cambium, etc.,

Characteristic features of meristematic tissue

a) They are made of living cells

b) Cells are small, oval, polygonal or round in shape

c) They are thin walled with dense cytoplasm, large nuclei and small vacuoles.

d) They undergo mitotic cell division

e) They do not store food materials.

Meristems are classified based on (i) origin and development, (ii) origin of initiating cells (iii) position in plant body (iv) function

7.2.1 Types of Meristems

I. Classification based on origin and development:

Based on origin and development of initiating cells, meristems can be classified into three types namely i) Promeristem or primordial meristem ii) Primary meristem and iii) Secondary meristem

i) Promeristem or primordial meristem:

- A group of young meristematic cells of a growing organ.
- In plants, they occupy a small area at the tip of shoot and root.
- They further divide to form primary meristem.

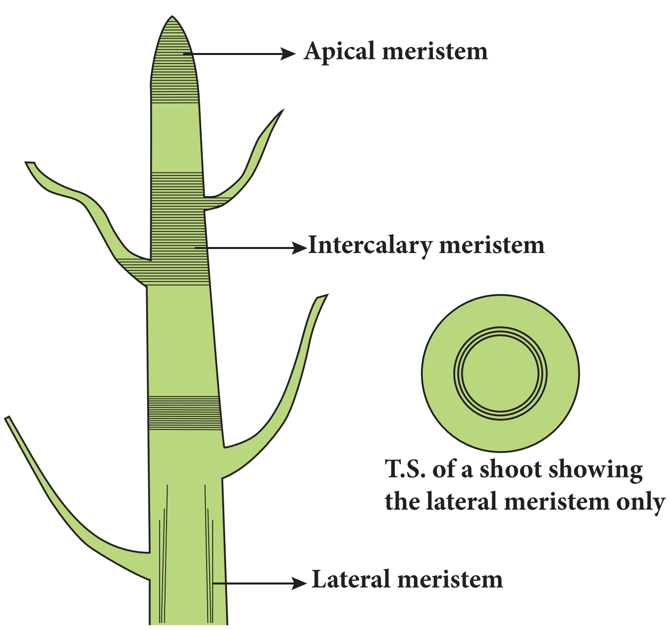


Figure 7.1 Longitudinal section of shoot apex showing location of meristems and young leaves.

ii) Primary meristem:

- They are present below the promeristem at shoot and root apices.
- These cells divide to form permanent tissues.

iii) Secondary meristem:

- It is derived from primary permanent tissues which have the capacity of division eg. cork-cambium, cambium of roots and inter fascicular cambium of stem.

II. Classification based on position:

On the basis of their position in the plant, meristems are of three types: i) Apical meristem ii) Intercalary meristem and iii) Lateral meristem.

i. Apical meristem:

- These are found at the apices or growing points of root, shoot and bring about increase in length. They include both pro-meristem as well as primary meristem.

ii. Intercalary meristem:

- It lies between the region of permanent tissues and is part of primary meristem which is detached due to formation of intermittent permanent tissues. It is found either at the base of leaf e.g. Pinus or at the base of internodes e.g. grasses.

iii. Lateral Meristem:

- These are arranged parallel to sides of origin and normally divide radially to give secondary permanent tissues. These increase the thickness of the plant part.

III. Classification based on function:

On the basis of their function, meristems have been classified into three types, namely: i) Protoderm meristem, ii) Procambium meristem and iii) Ground Meristem

i. Protoderm meristem:

- It is the outermost layer of the young growing region which develops to form epidermal tissues.

ii. Procambium meristem:

- It is composed of narrow, elongated, meristematic cells that give rise to the vascular tissues.

iii. Ground Meristem:

- It is composed of large, thick-walled cells which develop to form ground tissue system, e g. hypodermis, cortex and pith.

IV. Classification based on plane of divisions:

The growth pattern and plane of division of meristematic tissue is important to govern the mode of growth, On this basis tissues can be classified into three types, namely: i) Mass meristem ii) Rib or file meristem and iii) Plate meristem

i. Mass meristem:

In this type of meristem, cell divisions occur in all planes resulting in an increase in volume. It can be observed in meristems of cortex and pith.

ii. Rib or file meristem:

The cells divide only on one plane e.g. formation of filaments in algae.

iii. Plate meristem:

These cells divide in two planes resulting to an increase in the area of an organ e g. Leaf formation.

7.2.2 Functions of Meristematic Tissue:

Meristems are actively dividing tissues of the plant, that are responsible for primary (elongation) and secondary (thickness) growth of the plant.

7.3 Permanent Tissues

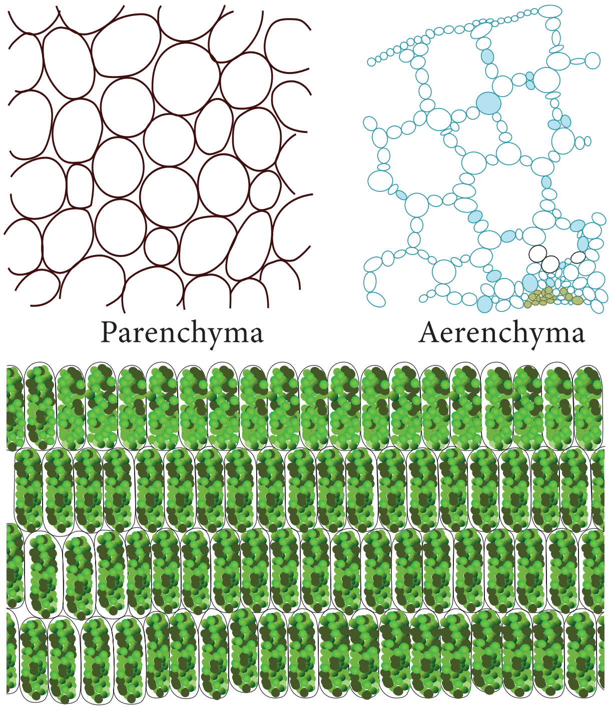
Permanent tissues are those in which, growth has stopped either completely or for the time being. At times, they become meristematic partially or wholly. Permanent tissues are of two types namely (i) simple tissue and (ii) complex tissue.

7.4 Simple Tissues

Simple tissue are homogeneous -composed of structurally and functionally similar cells. eg., Parenchyma, Collenchyma and Sclerenchyma.

7.4.1 Parenchyma

Parenchyma are simple permanent tissue composed of living cells. Parenchyma cells are thin walled, oval, rounded or polygonal in shape with well developed spaces among them. In aquatic plants, Parenchyma possesses intercellular air spaces, and is named as Aerenchyma. When exposed to light, parenchyma cells may develop chloroplasts and are known as Chlorenchyma.



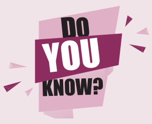
Parenchyma Aerenchyma

Chlororenchyma

Figure 7.2 Types of Parenchyma

Functions:

Parenchyma may store water in many succulent and xerophytic plants. It also serves the functions of storage of food reserves, absorption, buoyancy, secretion etc.,



In potato, Parenchyma vacuoles are filled with starch. In Apple, parenchyma stores sugar

7.4.2 Collenchyma

Collenchyma is a living tissue found beneath the epidermis. Cells are elongated with unevenly thickened non-lignified walls. Cells have rectangular oblique or tapering ends and persistent protoplast. They possess thick primary non-lignified walls.

Functions:

They provide mechanical support for growing organs.

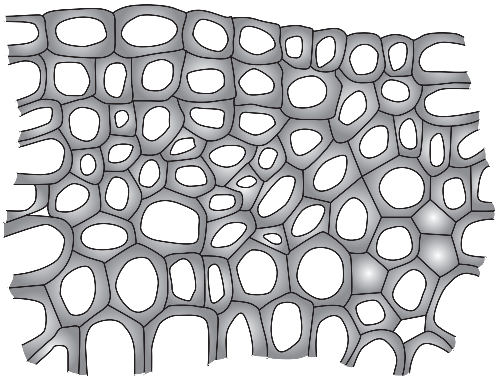


Figure 7.3 Collenchyma

7.4.3 Sclerenchyma

Sclerenchyma consists of thick walled cells which are often lignified. Sclerenchyma cells do not possess living protoplasts at maturity. Sclerenchyma cells are grouped into (i) fibres and (ii) sclereids.

Fibres are elongated sclerenchymatous cells, usually with pointed ends. Their walls are lignified. Fibres are abundantly found in many plants. The average length of fibres is 1 to 3 mm, however in plants like *Linum usitatissimum* (flax), *Cannabis sativa* (hemp) and *Corchorus capsularis* (jute), fibres are extensively longer ranging from 20 mm to 550 mm.

DO YOU KNOW? Jute is used in making of rope and fabrics.

Sclereids

Sclereids are widely distributed in plant body. They are usually broad, may occur in single or in groups. Sclereids are isodiametric, with liginified walls. Pits are prominent and seen along the walls. Lumen is filled with wall materials. Sclereids are also common in fruits and seeds.

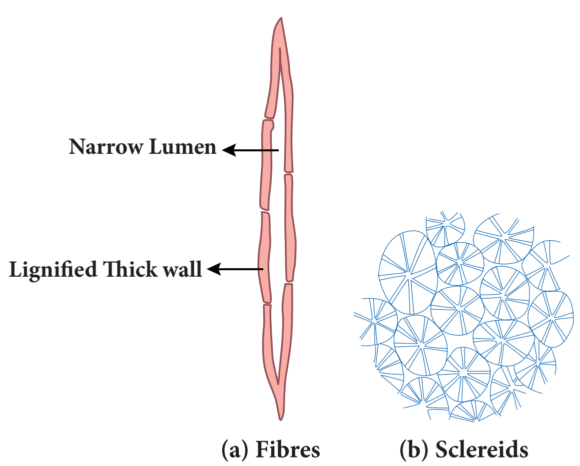


Figure 7.4 Sclerenchyma (a) Fibres, (b) Sclereids

Table 7.1 Differences between Parenchyma and Collenchyma

Parenchyma	Collenchyma
Cell wall is thin and uniform in thickness	It possesses well developed extra thickening at places adjacent to intercellular spaces
It serves as storage tissue.	It serves as mechanical tissue
It is found in outer and inner parts of plant organs	It is restricted to sub epidermal parts of plant organs.

Table 7.2 Differences between Collenchyma and Sclerenchyma

Collenchyma	Sclerenchyma
It consist of living cells	It consist of dead cells
Cells contain protoplasm	Cells are empty
Cell walls are made of cellulose	Cell walls are lignified
Thickening of cell wall is not uniform	Cell wall thickening is uniform
Lumen of the cell is wide	Lumen of the cell is narrow
Pits are simple straight	Pits are simple oblique sometimes branched
It provides mechanical support and elasticity to the plant body	It provides only mechanical support

Table 7.3 Differences between Sclereids and Fibres

Sclereids	Fibres
Usually broad	Elongated narrow thread like
End walls blunt	End walls tapering
Occur singly	Occur in bundles
Deep pits	Narrow pits

7.5 Complex tissues

Complex tissues are made of more than one type of cells that work together as a unit. Complex tissues consist of parenchyma and sclerenchyma cells. However, collenchymatous cells are not present in such tissues. Common examples are xylem and phloem.

Table 7.4 Differences between Meristematic tissue and Permanent tissue

Meristematic tissue	Permanent tissue
Component cells are small, spherical or polygonal and undifferentiated	Component cells are large, differentiated with different shapes
Cytoplasm is dense, and vacuoles are nearly absent	Usaually large central vacuole present in living permanent cells
Intercellular spaces absent	Intercellular spaces present
Cell wall thin and elastic	Cell wall thick
Nucleus is large and prominent	Nucleus is less conspicuous
Cells grow and divide regularly	Cells do not normally divide
Provides mechanical support and elasticity to the plant body	Provides only mechanical support

7.5.1 Xylem

Xylem is a conducting tissue which conducts water, mineral nutrients upward from root to leaves. Xylem is also meant for mechanical support to the plant body. Xylem is composed of different kinds of elements. They are (i) xylem tracheids (ii) xylem fibres (iii) xylem vessels and (iv) xylem parenchyma.

i. Xylem tracheids

They are elongated or tube-like dead cells with hard, thick and lignified walls. Their ends are tapering, blunt or chisel-like. These cells are devoid of protoplast. They have large lumen without any content. Their function is conduction of water and providing mechanical support to the plant.

ii. Xylem fibres

These cells are elongated, lignified and pointed at both the ends. Xylem fibres help in conduction of water and nutrients from root to the leaf and also provide mechanical support to the plant.

iii. Xylem vessels

They are long cylindrical, tube like structures with lignified walls and wide central lumen. These cells are dead as these do not have protoplast. They are arranged in longitudinal series in which the partitioned walls (transverse walls) are perforated, and so the entire structure looks-like a water pipe. Their main function is transport of water and minerals from root to leaf, and also to provide mechanical strength.

iv. Xylem parenchyma

Its cells are living and thin walled. The main function of xylem parenchyma is to store starch and fatty substances.

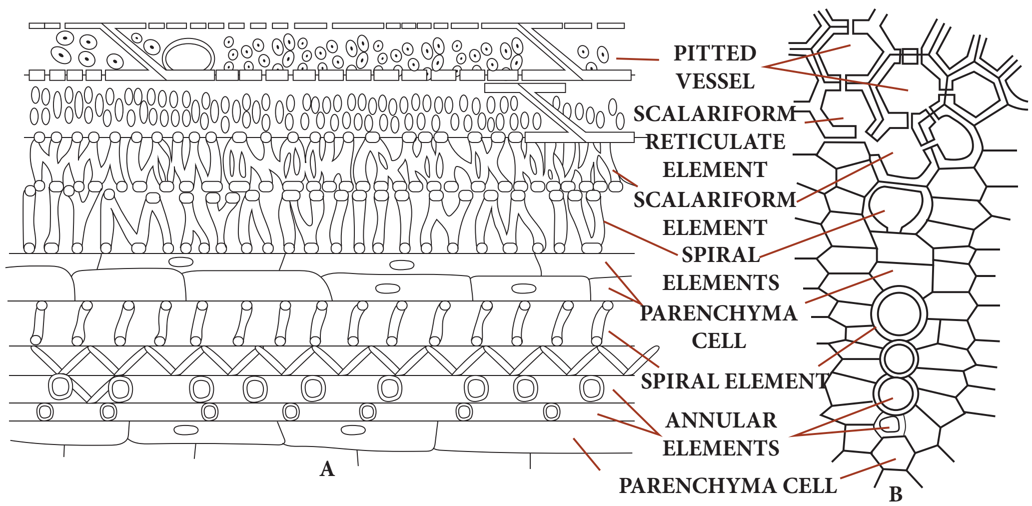


Figure 7.5 A. xylem longitudinal section B. xylem transverse section

7.5.2 Phloem

Phloem like xylem is a complex tissue and consists of the following elements.

(i) Sieve elements

(ii) Companion cells.

(iii) Phloem fibres

(iv) Phloem parenchyma

i. Sieve elements

The conducting elements of phloem are collectively called as Sieve elements. They may be segregated into less specialised sieve cells and more specialised sieve tube elements.

Sieve tubes are elongated, tube-like slender cells placed end to end. The transverse walls at the ends are perforated and are known as sieve plates. The main function of sieve tubes is translocation of food, from leaves to the storage organs of the plants.

ii. Companion cells

These are elongated cells attached to the lateral wall of the sieve tubes. A companion cell may be equal in length to the accompanying sieve tube element or the mother cell may be divided transversely forming a series of companion cells

iii. Phloem parenchyma

The phloem parenchyma are living cells which have cytoplasm and nucleus. Their function is to store food materials.

iv. Phloem fibers

Sclerenchymatous cells associated with primary and secondary phloem are commonly called phloem fibers. These cells are elongated, lignified and provide mechanical strength to the plant body.

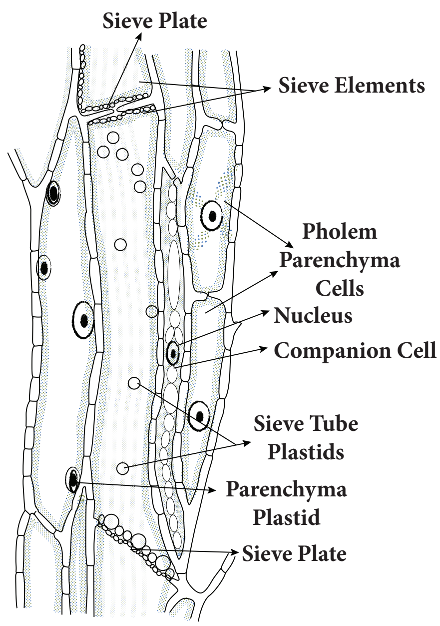
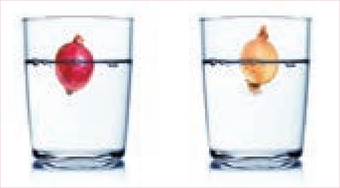


Figure 7.6 Longitudinal section of Phloem tissue

Activity 1

Take two glass jars and fill them with water. Now take two onion bulbs and place one in each jar as shown in figure given below:



i. Observe the growth of roots in both the bulbs for a few days.

ii. Measure the length of roots on day 1, 2 and 3

iii. On 3rd day cut the roots tips of the onion bulb in jar 2 by about 1 cm. After this observe the growth of roots in both the jars and measure their length each day for five more days and record the observations in tables like the table below.

	Length in mm				
	Day 1	Day 2	Day 3	Day 4	Day 5
Jar 1					
Jar 2					

From the above observation answer the following questions.

i. Which of the two onions has longer roots? Why?

ii. Do the roots continue growing even after we have removed their tip?

Activity 2

i. Take a plant stem and with the help of your teacher cut into very thin slices or sections.

ii. Now stain the slices with safranin. Place one neatly cut section on a slide and put a drop of glycerine.

iii. Cover with a cover slip and observe under a microscope. Observe the various types of cells and their arrangement.

Now answer the following on the basis of your observation.

i. Are all cells similar in structure?

ii. How many types of cells can be seen?

iii. Can we think of reasons why there would be so many types of cells.

We can also try to cut sections of plant roots. We can even try cutting sections of roots and stem of different plants.

Table 7.5 Differences between Tracheids and Vessels

Tracheids	Vessels
Formed from single cells	Made up of number of cells.
Ends are oblique and taper	ends are round and transverse.
Fraction of a cm in length	Several cms in length
Walls are thick, lumen-narrow	Walls are less thick, lumen- wide.

Table 7.6 Differences between Sieve cells and Sieve tubes

Sieve cells	Sieve tubes
Sieve cells have no companion cells	Sieve tubes always have companion cells
Sieve areas do not form sieve plates	Sieve areas are confined to Sieve plates
Cells are elongated and are unique long with tapering end walls	Cells consist of vertical cells placed one above the other forming long tubes connected at the walls by sieve pores
Sieve pores are smaller and numerous	Sieve pores are larger and fewer in number
Sieve cells are found in pteridophytes and gymnosperms	Sieve tubes are found in angiosperms

Table 7.7 Differences between Xylem and Phloem

Xylem	Phloem
Conducts water and minerals	Conducts organic solutes or food materials
Conduction is mostly unidirectional i.e., from roots to apical parts of the plant.	Conduction may be bidirectional from leaves to storage organs and growing parts or from storage organs to growing parts of plants.
Conducting channels are treacheids and vessels	Conducting channels are sieve tubes.
Component of xylem include Tracheid vessels, xylem parenchyma and xylem fibres.	Components are sieve elements, companion cells, phloem parenchyma and phloem fibres.

7.6 Animal Tissues

An assemblage of one or more types of specialized cells held together with extracellular material constitute the tissue. A group of cells that are similar in origin, form, structure and work together to perform a specific function is called a simple tissue, while a group of cells different in their structure and function but co-ordinate to perform a specific function is called a compound tissue. The study of cell is known as **Cytology** and tissues is known as **Histology**.

Animal tissues can be grouped into four basic types on the basis of their structure and functions.

a. Epithelial tissue.
b. Connective tissue
c. Muscular tissue
d. Nervous tissue

All these tissues originate in the embryonic stages from the three primary germ layers namely ectoderm, mesoderm and endoderm.

DO YOU KNOW?

Discovery: Maher- 1819 coined the term Histology

Marie Francies Xavier Bichat – Anatomist and Pathologist – Father of Histology – distinguished 21 types of tissues from which the organs of human body are formed.

7.7 Epithelial Tissues

It is the simplest tissue. An epithelial tissue is composed of one or more layers of cells covering the external surface of the body and internal organs. The cells are arranged very close to each other with less extracellular material. Epithelial cells lie on a non-cellular basement membrane and contain a special form of matrix protein called collagen. The epithelial tissue generally lacks blood vessels. The epithelium is separated by the underlying connective tissue which provides it with nutrients. The skin and lining of buccal cavity, blood vessels, organs of the alimentary canal, digestive glands like the pancreas and liver, alveloli of lungs and kidney tubules are all made up of epithelial tissues.

Types of epithelial tissue

1. **Simple epithelium** is composed of single layer of cells resting on a basement membrane.
2. **Compound epithelium** are composed of several layers of cells. Only the cells of the deepest layer rest on the basement membrane.

Functions of epithelial tissues

i. The skin which forms the outer covering of the body is composed of epithelial cells.These cells protect the underlying cells from drying, injury and microbial infections.

ii. Inside the body, they are found lining the mouth and alimentary canal and give protection to the organs

iii. They help in absorption of water and nutrients

iv. They are involved in elimination of waste products

v. Some epithelial tissues perform secretory function. They secrete a variety of biochemical substances such as sweat, saliva, mucus and enzymes.

7.7.1 Simple Epithelium

It is formed of **single layer** of cells. It forms a lining for the body cavities and ducts. It is also found on the secretory and absorptive surfaces. On the basis of structural

Activity 3

To identify an epithelial tissue

Given below are four steps for preparing a temporary mount of human cheek cell.

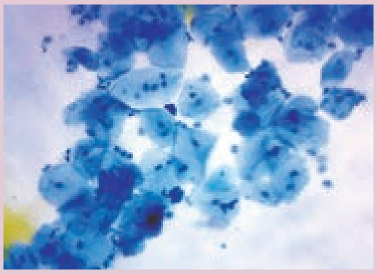
i. Rinse your mouth with water.

ii. Using a tooth pick or ice-cream stick, scrap superficial cells from inner side of the cheek and spread it on a clean glass slide.

iii. Dry the glass slide with the scrap cells taken from the inner side of cheek.

iv. Add two drops of methylene blue stain.

v. Identify the cells under low and high power of the microscope.



vi. Compare the cells observed under the microscope with the given picture. Name the type of epithelium.

modification of the cells, simple epithelium is further divided into following types.

(i) Squamous epithelium
(ii) Cuboidal epithelium
(iii) Columnar epithelium
(iv) Ciliated epithelium
(v) Glandular epithelium

DO YOU KNOW? Epithelial tissue in the skin functions as a water-proof membrane

i. **Squamous Epithelium** is made up of thin, **flat** cells with prominent nuclei. These cells have irregular boundaries and bind with neighbouring cells. The squamous epithelium is also known as **pavement membrane**, which form delicate lining of the buccal cavity, alveoli of lungs, proximal tubule of kidneys, blood vessels and covering of the skin and tongue. It protects the body from mechanical injury, drying and invasion of germs. It also helps in filtration by forming a selectively permeable membrane surface.

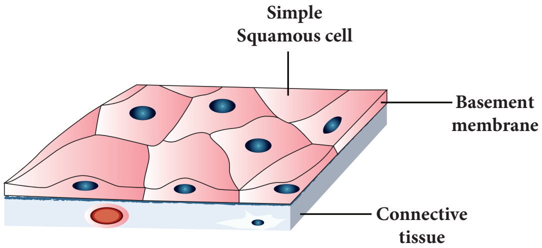


Figure 7.7 Squamous Epithelium

ii. **Cuboidal Epithelium** is composed of single layer of **cubical** cells. The nucleus is round and lies in the centre. This tissue is present in the thyroid vesicles, salivary glands, sweat glands and exocrine pancreas. It is also found in the intestine and tubular part of the nephron (kidney tubules) as microvilli that increase the absorptive surface area. Their main function is secretion and absorption.

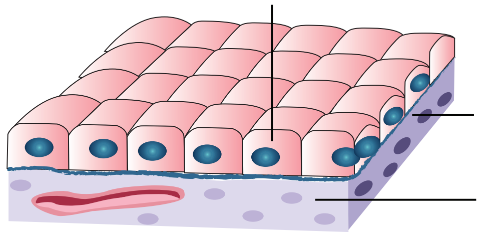


Figure 7.8 Cuboidal Epithelium

iii. **Columnar Epithelium** is composed of a single layer of **slender**, **elongated** and **pillar** like cells. Their nuclei are located at the base. It is found lining the stomach, gall bladder, bile duct, small intestine, colon, oviducts and also forms the mucous membrane. They are mainly involved in secretion and absorption.

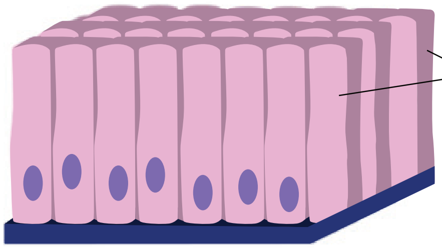


Figure 7.9 Columnar Epithelium

iv. **Ciliated Epithelium** Certain columnar cells bear numerous delicate hair like out growths called **cilia** and are called ciliated epithelium. Their function is to move particles or mucus in a specific direction over the epithelium. It is seen in the trachea of wind-pipe, bronchioles of respiratory tract, kidney tubules and fallopian tubes of oviducts.

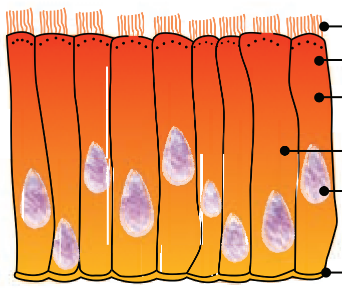


Figure 7.10 Ciliated Epithelium

v. **Glandular Epithelium** Epithelial cells are often modified to form **specialized gland** cells which secrete chemical substances at the epithelial surface. Sometimes a portion of the epithelial tissue folds inward to form a multicellular gland, which lines the gastric glands, pancreatic tubules and intestinal glands.

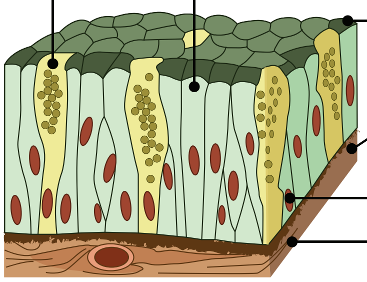


Figure 7.11 Glandular epithelium

7.7.2 Compound Epithelium

It consists of **more than one layer** of cells and gives a **stratified appearance**. Hence , they are also known as stratified epithelial cells. Being multilayered, they have limited role in secretion and absorption. The main function of this epithelium is to give protection to the underlying tissues against mechanical and chemical stress. They also cover the dry surface of the skin, the moist surface of the buccal cavity and pharynx.

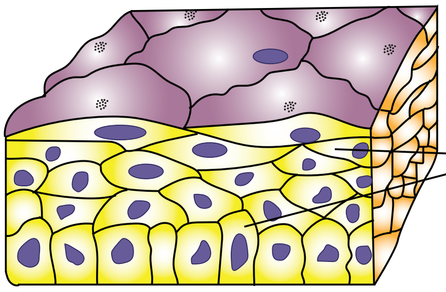


Figure 7.12 Compound Epithelium

7.8 Connective Tissue

It is one of the most abundant and widely distributed tissue. It provides **structural frame work** and gives **support** to different tissues forming organs. The components of the connective tissue are the intercellular substance known as the matrix, connective tissue cells and fibres. The matrix forms the main bulk of the connective tissue. The main function of the connective tissue is binding, supporting and packing together different organs of the body. It prevents the organs from getting displaced by body movements.

Connective tissue is classified as follows

i. Connective tissue proper (Areolar and Adipose tissue)

ii. Supportive connective tissue (Cartilage and Bone)

iii. Dense Connective tissue (Tendons and Ligaments)

iv. Fluid connective tissue (Blood and Lymph)

i. Connective tissue proper

Connective tissue proper consist of collagen fibres, elastin fibres and fibroblast cells.

a. Areolar tissue

It has cells and fibres loosely arranged in a semi fluid ground substance, matrix takes the form of fine threads crossing each other in every direction leaving small spaces called areolae. The matrix consists of collagen fibres, elastin fibres and fibroblast cells. It joins skin to muscles, fills space inside organs and is found around muscles, blood vessels and nerves. The matrix of this tissue plays an important role in diffusion of oxygen and nutrients from small blood vessels. It also helps in repair of tissues after injury and fixes skin to underlying muscles.

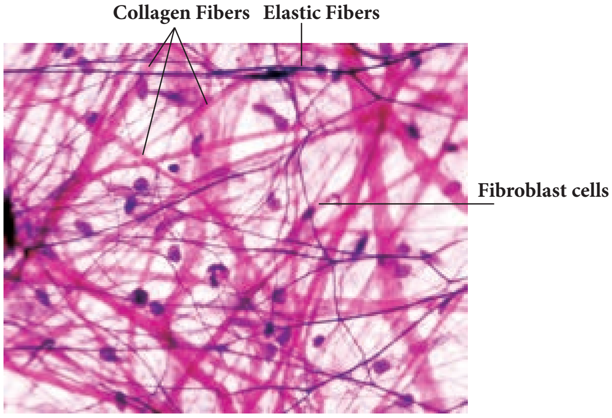


Figure 7.13 Areolar tissue

b. Adipose Tissue

Adipose tissue is the aggregation of **fat cells** or **adipocytes** and serves as fat reservoir. Each fat cell is a spherical or oval adipose cell and contains a large droplet of fat.

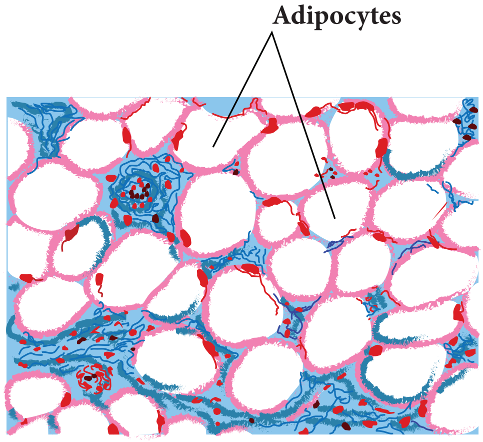


Figure 7.14 Adipose tissue

The fat cells are arranged into lobules separated by partitions of collagen and elastin fibres. They are found in subcutaneous tissue, between internal organs around the heart and kidneys. They keep the visceral organs in position and act as shock absorbers around the kidneys and eye balls. They also regulate the body temperature by acting as insulator.

DO YOU KNOW?

Number of fat cells in obese adults is about 60-100 billion while in non-obese adults is 30-50 billion.

ii. Supportive Connective Tissue

The supporting or skeletal connective tissues forms the endoskeleton of the vertebrate body. They support the body, protect various organs and help in locomotion. The supportive tissues include Cartilage and Bone.

a. Cartilage

They are soft, semi- rigid, flexible and are less vascular in nature. The matrix is composed of large cartilage cells called **chondrocytes**. These cells are present in fluid filled spaces known as **lacunae**.

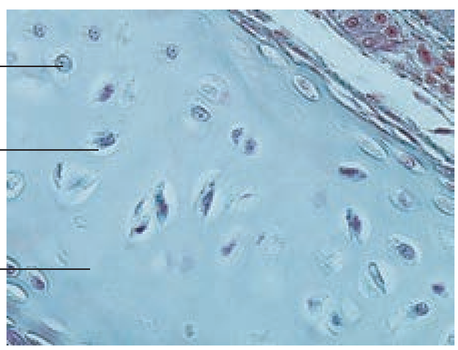


Figure 7.15a Cartilage

Cartilage is present in the tip of the nose, external ear, end of long bones, trachea and larynx. It smoothens the surface at joints. It provides support and flexibility to the body parts.

b. Bone

It is solid, rigid and strong, **non-flexible** skeletal connective tissue. The matrix of the bone is rich in calcium salts and collagen fibres which gives the bone its strength. The matrix of the bone is in the form of concentric rings called **lamellae**. The fluid filled spaces present between the lamellae are called lacunae in which are present the bone cells called **osteocytes** that communicate with each other by a network of fine canals called **canaliculi**. The hollow cavities of spaces are called marrow cavities filled with **bone marrow**. They provide shape and structural framework to the body. Bones support and protect soft tissues and organs.

Figure 7.15b T.S of Bone

iii. Dense Connective Tissue

It is a fibrous connective tissue densely packed with fibres and fibroblasts. It is the principal component of tendons and ligaments.

a. Tendons

They are cord like, strong, structures that join skeletal muscles to bones. Tendons have great **strength** and **limited flexibility**. They consist of parallel bundles of collagen fibres, between which are present rows of fibroblasts.

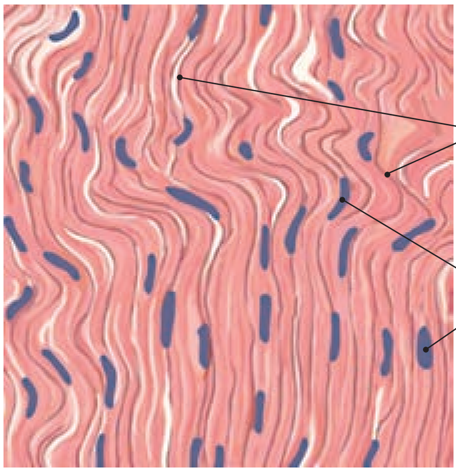


Figure 7.16 Tendon

b. Ligaments

They are **highly elastic** structures and have great strength which connect bones to bones. They contain very little matrix. They strengthen the joints and allow normal movement.

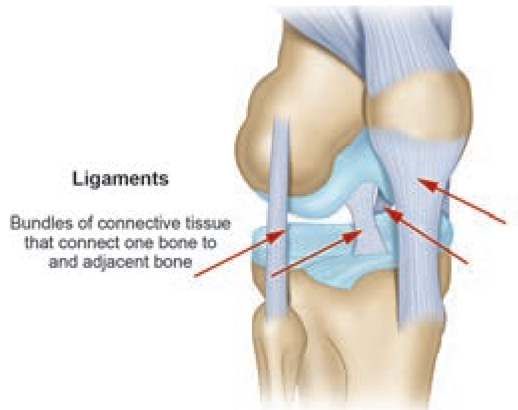


Figure 7.17 Ligament

> **DO YOU KNOW?**
>
> Protein fibres of matrix are made up of Yellow fibres of elastin and White fibres of collagen
>
> Nano fibres - Sharpey's fibres are minute fibres of tendon which enter into peristomium of bone. Aponeurosis is similar to tendon but fibres are interwoven and thinner.
>
> Sprain is caused by excessive pulling (stretching) of ligaments.

iv. Fluid connective tissue

The blood and the lymph are the fluid connective tissues which link different parts of the body. The cells of the connective tissue are loosely spaced and are embedded in an intercellular matrix.

a. Blood

Blood contains corpuscles which are red blood cells (**erythrocytes**), white blood cells (**leucocytes**) and **platelets**. In this fluid connective tissue, the blood cells move in a fluid matrix called plasma. The plasma contains inorganic salts and organic substances. It is a main circulating fluid that helps in the transport of substances.

Red blood corpuscles (Erythrocytes)

The red blood corpuscles are oval shaped, circular, biconcave disc-like and **lack nucleus** when mature (mammalian RBC). They contain a respiratory pigment called **haemoglobin** which is involved in the transport of oxygen to tissues.

White blood corpuscles (Leucocytes)

They are larger in size, contain **distinct nucleus** and are **colourless**. They are capable of amoeboid movement and play an important role in body's defense mechanism. WBC's are of two types

i. Granulocytes (with granules in the cytoplasm)

ii. Agranulocytes (without granules in the cytoplasm).

Granulocytes have irregular shaped nuclei and cytoplasmic granules. They include the **neutrophils**, **basophils** and **eosinophils**. **Agranulocytes** lack cytoplasmic granules and include the **lymphocytes** which have a spherical nucleus and the **monocytes** which have a large nucleus indented on one side. They engulf or destroy foreign bodies and neutralise their harmful effects.

Blood platelets

They are minute, anucleated, fragile fragments of giant bone marrow called **mega karyocytes**. They play an important role in **blood clotting** mechanism.

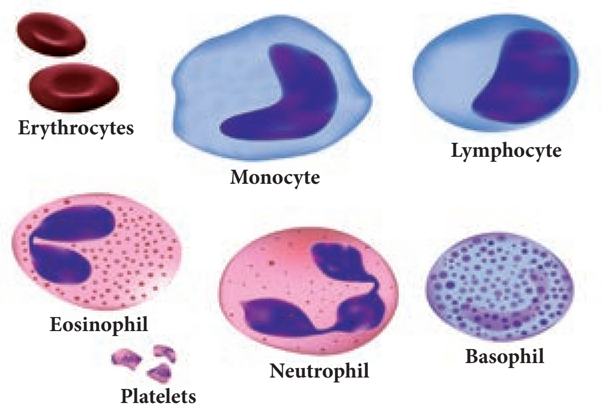


Figure 7.18 Blood cells

b. Lymph

Lymph is a colourless fluid filtered out of the blood capillaries. It consists of plasma and white blood cells. It mainly helps in the exchange of materials between blood and tissue fluids.

7.9 Muscular Tissue

Muscular tissues are made of muscle cells and form the major part of contractile tissue. The muscle cells are elongated, large sized and are composed of numerous **myofibrils**. Each muscle is made up of many long cylindrical fibres arranged parallel to one another. The movement of the body and limbs are brought about by the contraction and relaxation of **contractile proteins** present in muscle cells. According to their structure, location and functions, there are three main types of muscles

a. Skeletal muscle (or) striated muscle
b. Smooth muscle (or) non-striated muscle
c. Cardiac muscle

a. Skeletal muscle: These muscles are attached to the bones and are responsible for the body movements and are called skeletal muscles. They work under our control and are also known as **voluntary muscles**. The muscle fibres are elongated, non-tapering, cylindrical, unbranched and showing alternating dark and light bands, giving them the **striped** or **striated** appearance. These cells possess many nuclei (**multinucleate**). They occur in the muscles of limbs (biceps and triceps of arms).They undergo rapid contraction.

b. Smooth muscle: These muscles are spindle shaped with broad middle part and tapering ends. There is a single centrally located nucleus (**uninucleate**). These fibrils do not bear any stripes or striations and hence are called **non-striated**. They are not under the control of our will and so are called **involuntary muscles**. The walls of the internal organs such as the blood vessels, gastric glands, intestinal villi and urinary bladder contain this type of smooth muscle. Movement of food in the alimentary canal or the contraction and relaxation of blood vessels are involuntary movements.

c. Cardiac muscle: It is a contractile tissue present in the heart. The muscle fibres are **cylindrical**, **branched** and **uninucleate**. The branches join to form a network called as **intercalated disc** which are unique distinguishing features of the cardiac muscles. The intercellular spaces of the cardiac muscle are filled with loose connective tissue supplied with blood capillaries. The contraction of cardiac muscle is involuntary and rhythmic.

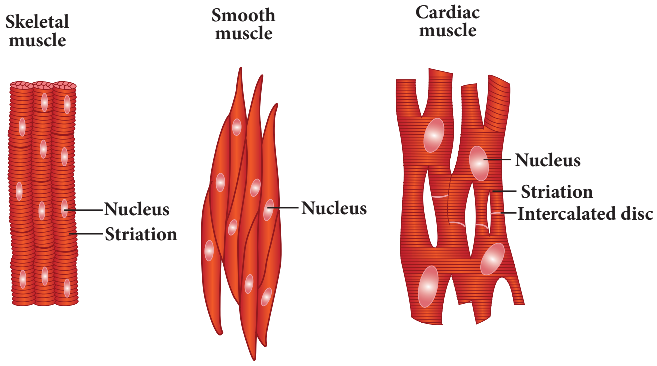


Figure 7.19 Muscle tissue

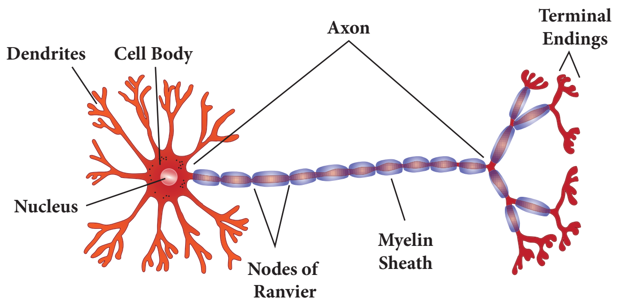


Figure 7.20 Neuron

They have the ability to receive stimuli from within or outside the body and send signals to different parts of the body. Many nerve fibres are bound together by the connective tissue.

Activity 4

Observe the picture and compare the structure of different types of muscle tissue. Identify their shape, number of nuclei and position of nuclei within the cell.

7.10 Nervous Tissue

Nervous tissue comprises of the nerve cells or neurons. They are the longest cells of the body. **Neurons** are the structural and functional units of the nervous tissue. The elongated and slender processes of the neurons are the nerve fibres. Each neuron consists of a **cell body** or **cyton** with nucleus and cytoplasm. The **dendrons** are short and highly branched protoplasmic processes of cyton. The **axon** is a single, long fibre like process that develops from the cyton and end up with fine terminal branches.

7.11 Cell division

Are you aware that all living organisms start their life from a single cell? You may wonder how a single cell then goes to form such a large organism. All cells reproduce by division, the division of cells into daughter cells is called cell division.

The growth and the development of every living organism depends on cell division. In 1846, Nageli pointed out that new cells are formed from the existing cells by division.

DO YOU KNOW?

Nerve cells do not undergo cell division due to the absence of centrioles, but they are developed from glial cells by neurogenesis

Microglia are modified neuroglial cells which are phagocytic in nature and found throughout the brain and spinal cord. These are also known as astroglea or oligodendroglea.

7.12 Types of Cell Division

The three types of cell division that occur in animal cells are

1. Amitosis - Direct Division
2. Mitosis - Indirect Division
3. Meiosis - Reduction Division

7.12.1 Amitosis

It is the simplest mode of cell division and occurs in unicellular animals, aging cells and in foetal membranes. During amitosis, nucleus elongates first, and a constriction appears in it which deepens and divides the nucleus into two, followed by this cytoplasm divides resulting in the formation of two daughter cells.

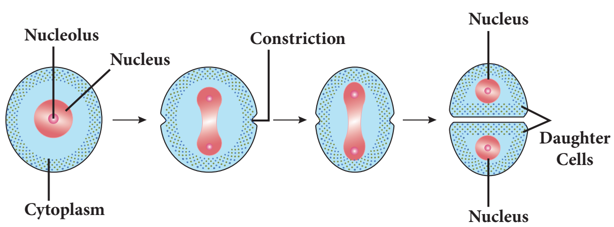


Figure 7.21 Amitosis

7.12.2 Mitosis

It was first discovered by Fleming in 1879. In this cell division one parent cell divides into two identical daughter cells, each with a nucleus having the same amount of DNA, same number of chromosomes and genes as the parent cells. It is also called as **equational division**.

Process of Mitosis

Mitosis consists of two events, they are

1. Karyokinesis
2. Cytokinesis

Interphase is the **resting phase** of the nucleus. It is the interval between two successive cell divisions. During this phase the cell prepares itself for the next division by synthesizing the substances essential for next cell division.

Karyokinesis

The division of the nucleus into two daughter nuclei is called Karyokinesis. It consists of four phases. They are:

a. Prophase
b. Metaphase
c. Anaphase
d. Telophase
e. Cytokinesis

a. Prophase (pro-first)

During this stage chromosomes become short and thick and are clearly visible inside the nucleus. Centrosome splits into two daughter centrioles, they move apart and occupy opposite poles of the cell. Each centriole is surrounded by radiating rays, termed as aster rays. Spindle fibres appear between the two centrioles. Nuclear membrane and nucleolus disappear gradually.

b. Metaphase (meta – after)

The duplicated chromosomes arrange on the equatorial plane and form the metaphase plate. Each chromosome gets attached to a spindle fibre by its centromere which is known as the chromosomal fibre. The centromere of each chromosome divides into two, each being associated with a chromatid.

c. Anaphase (ana – up, back)

The centromeres attaching the two chromatids divide and the two daughter chromatids of each chromosome separate and migrate towards the two opposite poles. The migration of the daughter chromosomes is achieved by the contraction of spindle fibres.

d. Telophase (tele – end)

Each chromatid (or) daughter chromosome lengthens, becomes thinner and turns into a network of chromatin threads. Spindle fibres breakdown and disappear. Nuclear membrane and nucleolus reappear in each daughter nucleus.

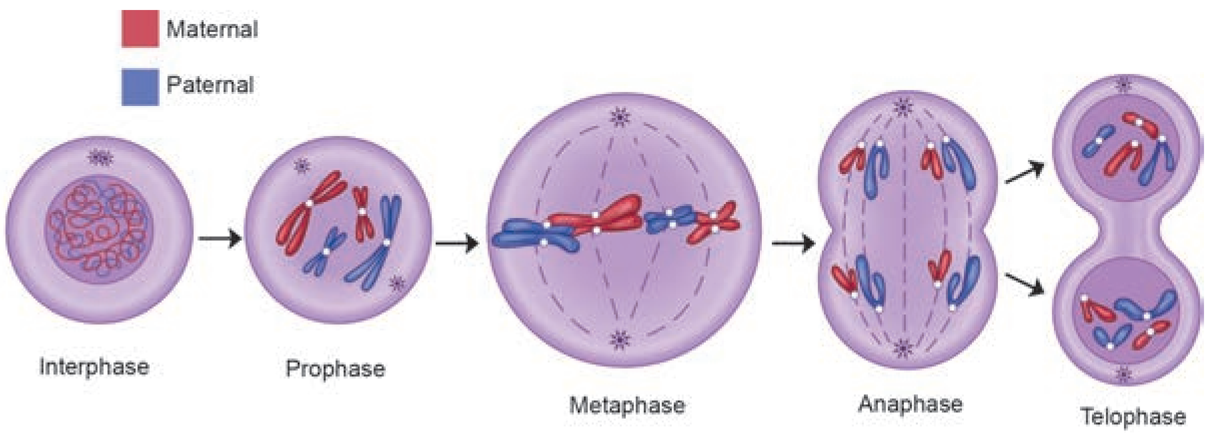


Figure 7.22 Events of Mitosis

e. Cytokinesis

The division of the cytoplasm into two daughter cells is called cytokinesis. A constriction appears in the middle of the cell membrane, which deepens and finally divides the cytoplasm into two, thus producing two new daughter cells from a parent cell.

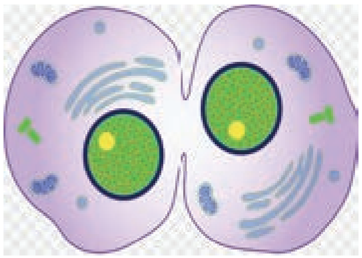


Figure 7.23 Cytokinesis

Significance of Mitosis

1. This equational division results in the production of diploid daughter cells with equal distribution of genetic material (DNA). It maintains the diploid (2n) number of chromosomes in daughter cells.
2. In multicellular organisms growth, organ development and increase in body size are accomplished through the process of mitosis
3. Mitosis helps in repair of damaged and wounded tissues by renewal of the lost cells.
4. It is involved in replacement of old and dead cells.

INFO BIT

Age of our body cells

- Cells of the eye lens, nerve cells of cerebral cortex and most muscle cells last a life time but once dead are not replaced.
- Epithelial cells lining the gut last only about 5 days.
- Average life of other gut cells is about 15 years.

Duration of cell replacement

- Skin cells- about every 2 weeks.
- Bone cells- about every 10 years.
- Liver cells- about every 300 – 500 days.
- Red blood cells last for about 120 days and are replaced.

7.12.3 Meiosis

The term meiosis was coined by Farmer in 1905. It is the kind of cell division that produces the sex cells or the gametes. It is also called reduction division because the chromosome number is reduced to haploid (n) from diploid (2n). Meiosis produces four daughter cells from a parent cell.

Meiosis consists of two divisions. They are,

A. **Heterotypic Division** or First Meiotic Division

B. **Homotypic Division** or Second Meiotic Division

A. Heterotypic division

It divides the diploid cell into two haploid cells. The daughter cells resulting from this division are different from the parent cell in the chromosome number (Heterotypic). This consists of 5 stages.

a. Prophase I

b. Metaphase I

c. Anaphase I

d. Telophase I

e. Cytokinesis I

a. Prophase I

Prophase I takes a longer duration and is sub divided into five stages.

1. Leptotene
2. Zygotene
3. Pachytene
4. Diplotene
5. Diakinesis

Leptotene

The chromosomes become uncoiled and assume long thread like structures and take up a specific orientation inside the nucleus. They form a **bouquet stage**.

Zygotene (Zygon-adjoining)

Two homologous chromosomes approach each other and begin to pair. Pairing of homologous chromosomes is called as **synapsis**.

Pachytene (Pachus-thick)

The chromosomes are visible as long paired twisted threads. The pairs so formed are called **bivalents**. Each bivalent now contains four chromatids (**tetrad stage**). Homologous chromosomes of each pair begin to separate, they do not completely separate, but remain attached together at one or more points by X- shaped arrangements known as **chiasmata**. The chromatids break at these points, broken segments maybe interchanged (crossing over). As a result, the **genetic recombination** takes place.

Diplotene

Each individual chromosome of each bivalent begins to split longitudinally into two similar chromatids. The homologous chromosomes repel each other and separate. Chiasmata begin to move along the length of the chromosome from the centromere towards the end resulting in **terminalization**.

Diakinesis

The paired chromosomes are shortened and thickened. The nuclear membrane and nucleolus begin to disappear. Spindle fibres make their appearance.

b. Metaphase I

The chromosomes move towards the equator and finally they orient themselves on the equator. The two chromatids of each chromosome do not separate as in Mitosis. The centromere does not divide.

c. Anaphase I

Each homologous chromosome with its two chromatids and undivided centromere move towards the opposite poles of the cell. This stage of the chromosome is called Diad.

d. Telophase I

The haploid number of chromosomes after reaching their respective poles become uncoiled and elongated. The nuclear membrane and the nucleolus reappear and thus two daughter nuclei are formed.

e. Cytokinesis I

The cytoplasmic division occurs and two haploid cells are formed.

B. Homotypic Division

In this division, the two haploid cells formed during first meiotic division divide into four haploid cells. The daughter cells are similar to parent cell in the chromosome number (Homotypic). It consists of five stages.

a. Prophase – II

b. Metaphase – II

c. Anaphase – II

d. Telophase – II

e. Cytokinesis – II

a. Prophase II

The centriole divides into two, each one moves to opposite poles. Asters and spindle fibres appear. Nuclear membrane and nucleolus disappear.

b. Metaphase – II

The chromosomes get arranged on the equator. Two chromatids are separated.

c. Anaphase - II

The separated chromatids become daughter chromosomes and move to opposite poles due to the contraction of the spindle fibres.

d. Telophase – II

The daughter chromosomes are centered. The nuclear membrane and the nucleolus appear.

e. Cytokinesis – II

It occurs after nuclear division and two cells are formed from each haploid daughter cell, resulting in the formation of four cells with haploid number of chromosomes.

Significance of Meiosis

i. The constant number of chromosomes in a given species is maintained by meiotic division.

ii. Crossing over causes genetic variations among the species from one generation to the next.

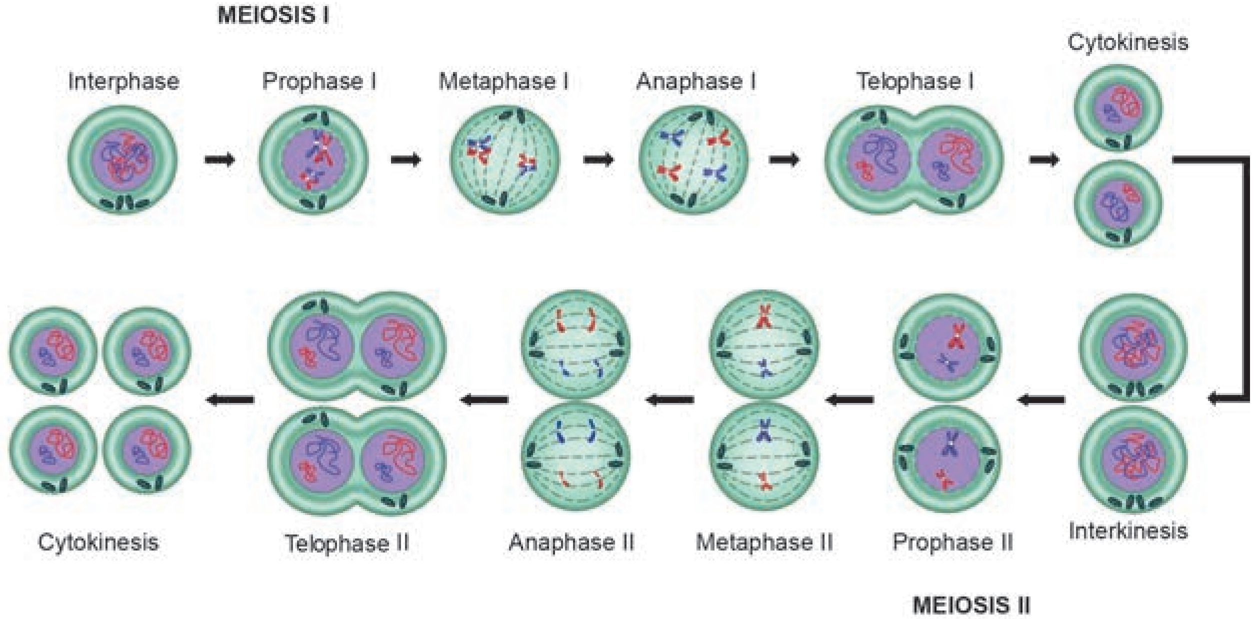


Figure 7.24 Events of Meiosis

Table 7.8 Differences between Mitosis and Meiosis

Mitosis	Meiosis
Occurs in somatic cells.	Occurs in reproductive cells
Involved in growth and occurs continuously throughout life.	Involved in gamete formation only during the reproductively active age.
Consists of single division	Consists of two divisions
Two diploid daughter cells are formed.	Four haploid daughter cells are formed.
The chromosome number in the daughter cell is similar to the parent cell (2n).	The chromosome number in the daughter cell is just half (n) of the parent cell.
Identical daughter cells are formed	Daughter cells are not similar to the parent cell and are randomly assorted.

Info bit

STEM CELLS

They are undifferentiated cells which undergo unlimited divisions and give rise to one or more different types of cells. Embryonic stem cells differentiate into different tissues and organs.

Stem cells are used in the treatment of certain degenerative diseases

In present days umblical cord blood is collected at the time of child birth and is being stored in stem cell banks to treat any diseases in the future

Activity 5

Search atleast 10 words related to the chapter

	Y	B	B	T	I	S	S	U	E			
E	E	M	O	S	X	Y	L	E	M			
G	S	E	N	E	L	C	S	U	M			
A	S	R	E	E	V	A	Z	H	A			
L	L	I	N	T	E	R	C	A	L	A	R	Y
I	E	S	A	D	I	P	O	S	E	A		
T	V	T	H	L	A	T	E	R	A	L		
R	E	E	N	E	U	R	O	N	A			
A	Y	M	C	A	M	B	L	U	M			
C	E	A	S	L	E	R	E	L	F	S		

Points to Remember

- Group of cells positioned and designed to perform particular function is called a tissue. An organ is a structure made up of a collection of tissues that carry out specialized functions
- Plants are made up of vegetative tissues and reproductive tissues. In general plant tissues are classified into two types namely Meristems or Meristematic tissues and Permanent tissues
- Meristems are actively dividing tissues of the plant, that are responsible for primary (elongation) and secondary (thickness) growth of the plant.
- Permanent tissues are of two types simple tissue and complex tissue. Simple tissue are homogeneous -composed of structurally and functionally similar cells. eg., Parenchyma, Collenchyma and Sclerenchyma
- Complex tissues are made of more than one type of cells that work together as a unit, they are Xylem and Phloem
- Animal tissues can be grouped into four basic types on the basis of their structure and functions. Epithelial tissue, Connective tissue, Muscular tissue, Nervous tissue.
- Simple epithelium is formed of single layer of cells is divided into following types. They are squamous epithelium cuboidal epithelium, columnar epithelium, ciliated epithelium and glandular epithelium
- Compound Epithelium consists of more than one layer of cells and gives a stratified appearance.
- The components of the connective tissue are the intercellular substance known as the matrix, connective tissue cells and fibres. They comprise areolar, adipose tissue, cartilage. bone, tendons, ligaments, blood and lymph
- The muscular tissues are made of muscle cells and form the major part of contractile tissue. Nervous tissue comprises of the nerve cells or neurons
- The three types of cell division that occur in animal cells are Amitosis (Direct division), Mitosis (Indirect division) and Meiosis (Reduction division)

A-Z GLOSSARY

Aerenchyma	Cortex of submerged roots of certain swamp plants aerating cortical tissue in floating portions of some aquatic plants.
Areolar tissue	It is a loose connective tissue made up of white fibres (made of collagen) and yellow fibres (made of elastin)
Bivalent	A pair of homologous chromosomes before their duplication in meiosis. It is also called diad
Blood	A red coloured fluid connective tissue consisting of plasma and blood cells (erythrocytes, leucocytes and platelets)
Cartilage	A non-porous connective tissue
Centromere	A particular structure in between chromosomal arms of chromosomes to which microtubules of the mitotic and meiotic spindle are attached. It is called kinetochore or primary constriction.
Chiasma	The point of contact and interchange between chromatids of two homologous chromosomes.
Chromatids	One of the two identical longitudinal halves of a chromosome which share a common centromere with a sister chromatid
Chromosome	They are elongated rod like structures formed during nuclear division. They represent the physical sites of nuclear genes which are arranged in linear order. Each species has a characteristic number of chromosome.
Collenchyma	Parenchymatous peripheral supporting tissue with cells more or less elongated and thickened either at the angles or on walls adjoining intercellular spaces or tangentially.
Companion cell	A narrow cell retaining its nucleus derived from a cell giving rise to sieve tube element in phloem of angiosperms.
Connective Tissue	Serves to 'connect' or 'bind' the cells of other tissues in the body and give them rigidity and support.
Crossing over	Process in which genes are exchanged between non-sister chromatids of homologous chromosomes
Diploid	An individual or cell having two complete sets of chromosomes
Fibroblasts	Cells of the connective tissue. They form ground substance and fibres
Haploid	An individual or cell having a single complete set of chromosome.

Histology	The branch of biology that deals with the study of tissues (Histo:Tissues. Logos, Study)
Homologous chromosome	Chromosomes occurring in pairs one derived from each of the two parents. Each member of such a pair is the homolog of the other.
Intercalary meristem	Situated between regions of permanent tissue at base of nodes and leaves in many monocotyledons.
Interphase	It is the longest resting phase of the cell between two cell divisions
Isodiametric	Having equal diameter of cells or other structures.
Ligament	Consists of yellow fibres and connect one bone to another bone.
Lymph	Fluid connective tissue consisting of plasma and mainly white blood cells.
Meristem tissue	Formed of cells all capable of diversification as found at growing points meristematic tissue
Neuron	Structural and functional unit of nerve cell. It comprises the cell body or cyton, dendrites, dendron and the axon.
Osteocytes	Bone cells present between the lamellae in fluid filled spaces called lacunae.
Parenchyma	Generally soft and thin walled relatively undifferentiated cells which may vary in structure and function as pith or mesophyll
Phloem parenchyma	Thin walled parenchyma associated with sieve tube of phloem
Sclerenchyma	Plant tissue of thickened end of the hard cells or vessels
Synapsis	Pairing of homologous chromosomes occurring in prophase -I of meiosis
Tendon	Made up of white fibres and connects muscle to bones
Tetrad	Four haploid cells arising from meiosis formed from four associated chromatids during synapsis.
Xylem woody tissue	Lignified portion of vascular bundle

ICT CORNER

Tissues and organs

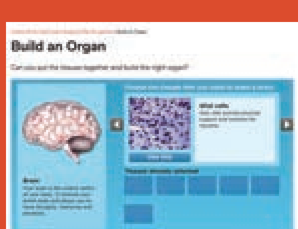
Explore this activity to know about the various types of tissues.

Step 1: Copy and paste the link given below or type the URL in the browser. Allow 'Adobe Flash Player' to run in the system.

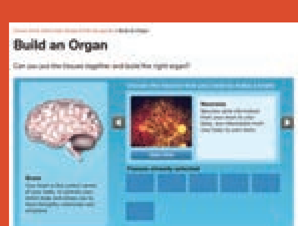
Step 2: Then choose an organ from the list to know about the tissues that are in a particular organ.

Step 3: Keep selecting the tissues by clicking the 'Use this' option, if you need that particular tissue for that organ.

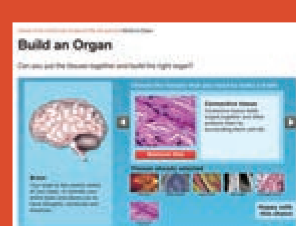
Step 4: Once you finish selecting the tissues you will find a pop-up called 'Happy with this choice.' Click on it to know whether your choice is correct or you should try again. In this way you can build different organs.



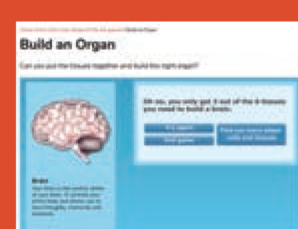
Step1



Step2



Step3



Step4

Browse in the link:

URL: https://www.centreofthecell.org/learn-play/games/build-an-organ/

B467_SCI_9_T2_EM

TEXT BOOK EXERCISES

BQBDE5

Section A

Ia. Match the following

1.	Sclereids	Chlorenchyma
2.	Chloroplast	Sclerenchyma
3.	Simple tissue	Collenchyma
4.	Companion cell	Xylem
5.	Trachieds	Phloem

Ib. Match the contents of Column I, II and III

Column I	Column II	Column III
Columnar Epithelium	Absorption	Anchoring of muscle
Bones	Axon	Dendrites
Neurons	Body framework	Secretion
Areolar Tissue	Ground substance	Ciliated
Tongue	Trachea	Fibroblasts
Epithelium	Striated muscle	Visceral tissue

II. Choose the correct answer.

1. A meristematic tissue consists of
   a. Immature cells which are in a state of division and growth
   b. Mature cells
   c. Non-living cells
   d. Sclerenchyma cells
2. The tissue composed of living thin walled polyhedral cell is
   a. Parenchyma b. Collenchyma
   c. Sclerenchyma d. None of above
3. The fibres consists of
   a. Parenchyma b. Sclerenchyma
   c. Collenchyma d. None of above
4. Chlorenchyma is known to develop in the
   a. cytoplasm of chlorella
   b. mycelium of a green mould such as aspergillus
   c. spore capsule of moss
   d. pollen tube of pinus.
5. Companion cells are closely associated with
   a. sieve elements. b. vessel elements
   c. Trichomes d. guard cells.
6. Which of the following is a complex tissue.
   a. parenchyma b. collenchyma
   c. xylem d. sclerenchyma
7. Aerenchyma is found in
   a. Epiphytes b. hydrophytes
   c. halophytes d. xerophytes
8. Two long bones of the hand are dislocated in a person met who with an accident . Which among the following may be the possible reason.
   a. Tendon injury
   b. Break of skeletal muscle
   c. Ligament tear
   d. Rupture of Areolar tissue
9. Unstraited muscles are found in
   a. Blood vessels
   b. Gastrointestinal tract
   c. Urinary bladder
   d. All of these
10. Which of the following is not found in a neuron?
   a. Sarcolemma b. Dendrite
   c. Neurolemma d. Axon

11. Long, unbranched multinucleated cells are
   a. Striated muscle cells
   b. Smooth muscles
   c. Cardiac muscles
   d. None of the above.

12. White fibres of connective tissue are made up of
   a. Elastin b. Reticular fibres
   c. Collagen d. Myosin

13. Brush bordered epithelium is found in
   a. Stomach b. Small intestine
   c. Fallopian tube d. Trachea

14. Smooth muscles occur in
   a. Uterus b Artery
   c. vein d. All of the above.

15. Which muscles act involuntary?
   (i) Striated muscles
   (ii) Smooth muscles
   (iii) Cardiac muscles
   (iv) Skeletal muscles
   a. (i) and (ii) b. (ii) and (iii)
   c. (iii) and (iv) d. (i) and (iv)

16. Nerve cell does not contains
   a. Axon b. Nerve endings
   c. Tendons d. Dendrites

17. Tendon connects
   a. Cartilage with muscles
   b. Bone with muscles
   c. Ligament with muscles
   d. Bone with bone.

18. In a certain type of cell division the diploid number of chromosome is reduced to half. This kind of division occurs in
   a. Testis
   b. Ovary
   c. Both ovary and testis
   d. All body cells.

III. Fill in the blanks

1. The __________ tissues are made up of more than one type of cells and these wok together as a unit.
2. __________ tissues provides mechanical support to organs.
3. Parenchyma, collenchyma, Sclerenchyma are __________ type of tissue.
4. ________ and ________ are complex tissues.
5. Epithelial cells with cilia are found in __________ of our body.
6. Lining of small intestine is made up of __________.
7. The two types of skeletal connective tissues are ________ and ________.
8. Humans have 46 chromosomes. Their sperms and eggs will have ________ chromosomes each.
9. During pairing of chromosomes in meiosis,the ________ chromosomes come to lie side by side.

IV.State whether True or false. If false, write the correct statement

1. Epithelial tissue is protective tissue in animal body.
2. Epithelial layer does not allow regulation of materials between body and external environment.
3. Bone and cartilage are two types of areolar connective tissue.
4. Striated and non- striated tissues are types of epithelial tissues.
5. As growth occurs in an individual the skin cells divide only to replace such cells that are lost from the surface.
6. Parenchyma is a simple tissue.

7. Phloem is made up of Tracheids.
8. Vessels are found in collenchymas.

Section B

1. Very short answer questions

1. Give two types of Sclerenchyma.
2. Name the components of xylem and phloem.
3. Name the tissue that connects muscle to bone in humans.
4. Name tissue that stores fat in our body.
5. Name the connective tissue with a fluid matrix.
6. Name the tissue present in the brain.

II. Short answer Questions

1. What are intercalary meristems? How do they differ from other meristems?
2. How would you differentiate between meristematic and permanent tissue?
3. What is complex tissue? Name the various kinds of complex tissues.
4. Differentiate fibres from sclereids.
5. Mention the most abundant muscular tissue found in our body.State its function
6. Which tissue is the main component of tendons and ligaments? How do they differ in function?
7. What are the fibres present in the matrix of loose connective tissue ?
8. How are collagen fibres organized in dense connective tissues
9. What is skeletal connective tissue? How is it helpful in the functioning of our body?
10. Which tissue is called middleman between tissue cells and blood? Why?
11. Why should gametes be produced by meiosis during sexual reproduction?
12. In which stage of mitosis the chromosomes align in an equatorial plate? How?
13. Write one point of difference between
    a) Bone and cartilage
    b) Simple and compound epithelial tissue.
14. Why is blood considered to be a connective tissue?
15. Give the sequence of the events occurring during prophase of mitosis.
16. Why is meiosis called reductional division and mitosis as equational division?

III. Long Answer Questions :

1. What are permanent tissues? Describe the different types of simple permanent tissue.
2. What are meristems? Describe the distribution and functions of various types of meristems.
3. Write about the elements of Xylem
4. List out the differences between mitosis and meiosis.
5. Give one reason for the following
    a. Blood is fluid connective tissue
    b. Skeletal muscles contain contractile proteins
    c. Heart muscles are involuntary in nature

Section C

I. Assertion and Reason

Direction : In each of the following questions, a statement of Assertion is given and a corresponding statement of Reason is given just below it. Of statements, given below, mark the correct answer as

a. If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

b. If both Assertion and Reason are true that Reason is not the correct explanation of Asssertion.

c. If Assertion is true but Reason is false.

d. If both Assertion and Reason are false

1. Assertion: Non-striated muscles are said to be voluntary in nature.

   Reason: Non-striated muscles are under the control of our will.

2. Assertion: Materials are exchanged between epithelial and connective tissues by diffusion.

   Reason: Blood vessels are absent in epithelial tissue.

II. Value Based Questions - Thinking Skills

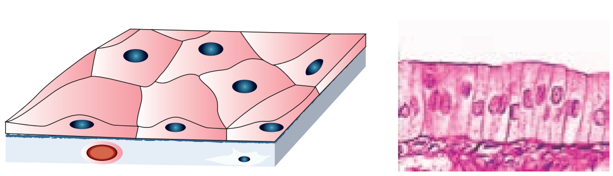
1. What is the consequence that occur if all blood platelets are removed from the blood?
2. Which are not true cells in the blood? Why?
3. Identify the figure given below

   (a) Label the parts a, b and c

   (b) What is the chemical composition of the tissue?

   (c) What is the function of c?

4. Identify figures A and B



A B

   a. ________ epithelium forms the outer lining of the buccal cavity.

   b. ________ epithelium consist of cells that are tall and pillar-like.

   c. Which one allows diffusion of substances?

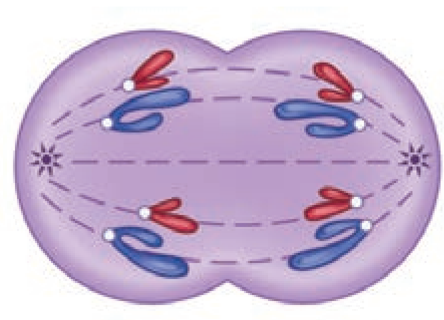
   d. Which is called pavement epithelium?

   e. Which epithelium lines the gastrointestinal tract and epiglottis?

5. If cell (A) has undergone one mitotic division and another cell (B) has completed its meiotic division. The number of cells produced in A and B would be

   Cell A : **Cell B :**

6. Identify the stage of mitosis from the following picture given below . List the chromosomal events in this stage.



7. Identify the following relationship

Cuboidal	:	Epithelial
Cardiac	:	________
Granulocytes	:	________
Osteocytes	:	________

8. You are now familiarised with various plant and animal tissues. Point out any five differences between these tissues.

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INTERNET RESOURCES

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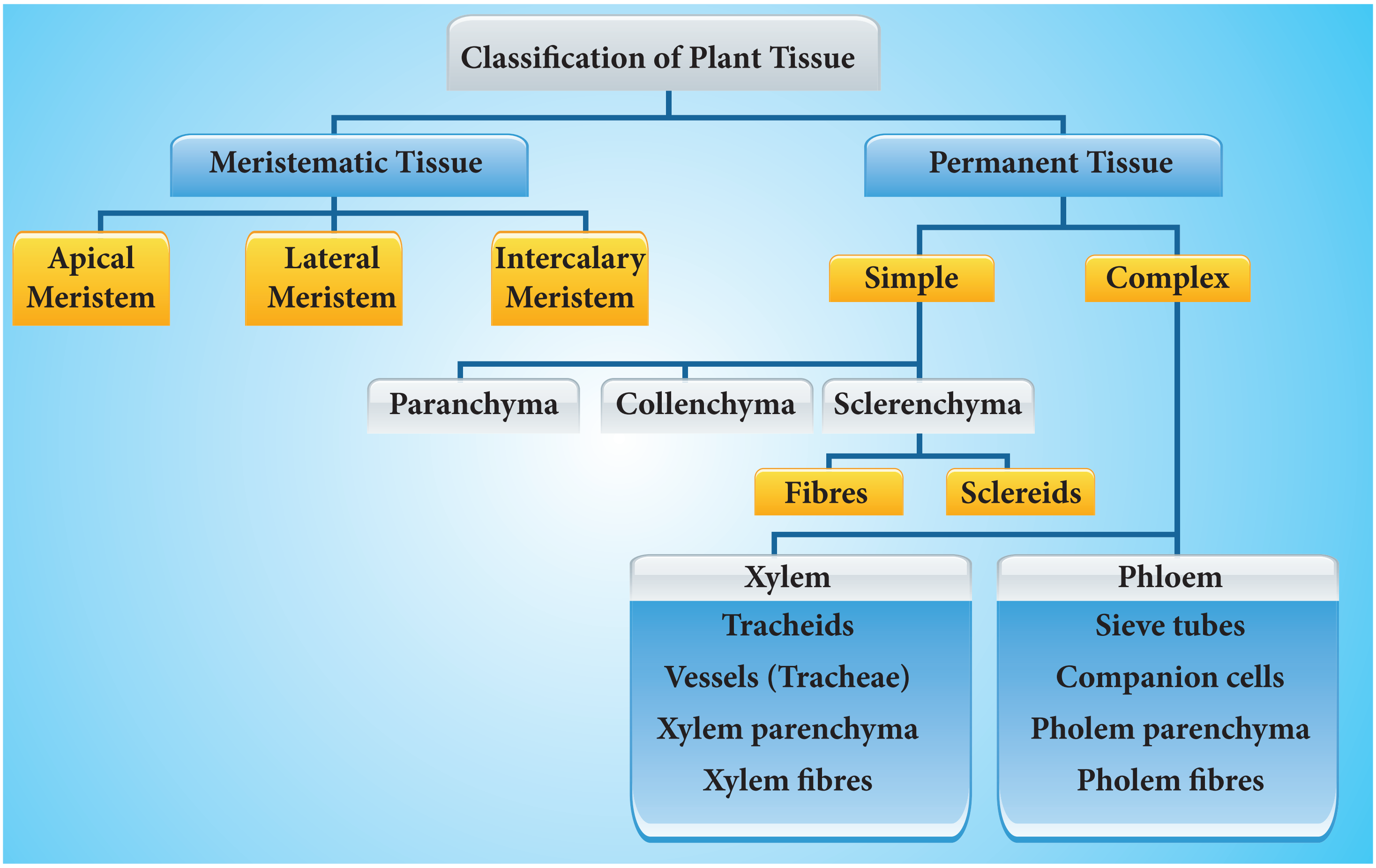
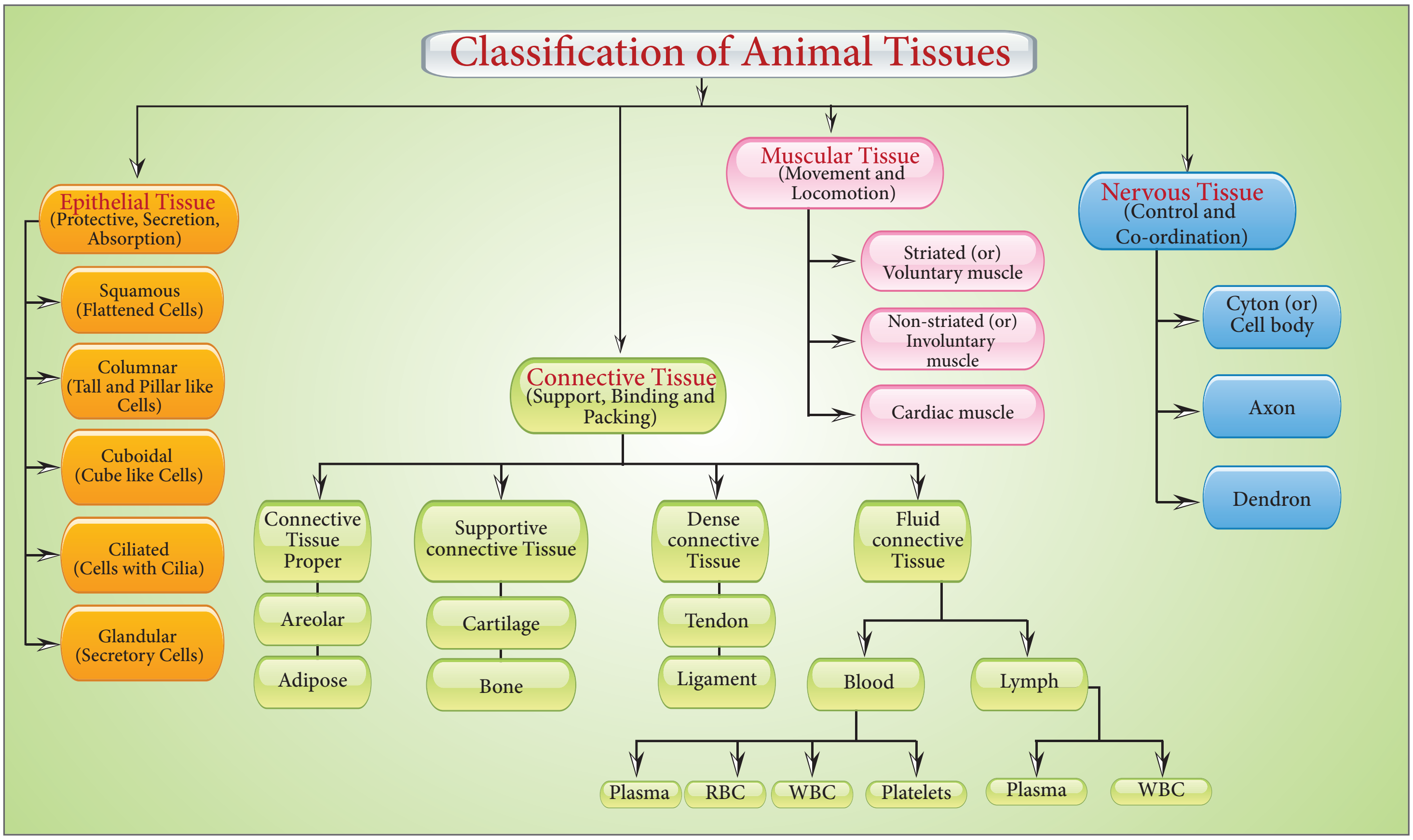

Classification of Plant Tissue
Meristematic Tissue
Permanent Tissue
Apical Meristem
Lateral Meristem
Intercalary Meristem
Simple
Complex
Paranchyma
Collenchyma
Sclerenchyma
Fibres
Sclereids
Xylem
Tracheids
Vessels (Tracheae)
Xylem parenchyma
Xylem fibres
Phloem
Sieve tubes
Companion cells
Pholem parenchyma
Pholem fibres


Classification of Animal Tissues
Epithelial Tissue (Protective, Secretion, Absorption)
Squamous (Flattened Cells)
Columnar (Tall and Pillar like Cells)
Cuboidal (Cube like Cells)
Ciliated (Cells with Cilia)
Glandular (Secretory Cells)
Muscular Tissue (Movement and Locomotion)
Striated (or) Voluntary muscle
Non-striated (or) Involuntary muscle
Cardiac muscle
Nervous Tissue (Control and Co-ordination)
Cyton (or) Cell body
Axon
Dendron
Connective Tissue (Support, Binding and Packing)
Connective Tissue Proper
Areolar
Adipose
Supportive connective Tissue
Cartilage
Bone
Dense connective Tissue
Tendon
Ligament
Fluid connective Tissue
Blood
Lymph
Plasma
RBC
WBC
Platelets
Plasma
WBC

UNIT 8

Organ Systems in Animals

BQGLRV

Learning Objectives

At the end of the chapter the student will

- Define the terms Digestion, Excretion and Reproduction
- Understand the various parts of the alimentary canal and the process of digestion
- Understand the role of enzymes in the process of digestion
- Identify the products of excretion and learn the related organs involved in the process of excretion
- Understand the role of skin in excretion
- Understand the parts and functions of excretory system
- Learn the mechanism of urine formation in man
- Learn the organs and functions of male and female human reproductive system

Introduction

Living organisms are evolved from the simplest form to complex level of organization such as unicellular and multicellular, tissue level, organ level and organ systems level of organization. Cells are the basic fundamental units of an organism. These are grouped to form tissues, the tissues into organs and the organs form the organ systems forming an entire organism. The different organs and organ systems of an organism function by depending on one another with harmonious coordination. When we ride a bicycle, our muscular system and skeletal system work together to move our arms for steering and legs for pedalling. Our nervous system directs our arms and legs to work. Simultaneously, respiratory, digestive and circulatory systems work to provide energy to the muscles. All the systems work together in coordination to maintain the body in a homeostatic condition of an organism.

8.1 Organ Systems in Animals

Organ and organ systems have appeared first in the Phylum platyhelminthes and continues till mammals. Similar groups of cells form tissues like muscle tissue, nervous tissue, etc. Tissues are organised to form organs like heart, brain, etc. Two or more organs together form organ systems and perform common functions like digestion, circulation, nerve impulse transmission in co-ordination via digestive system, circulatory system, nervous system respectively. Division of labour is found among the various organ systems (Table 1).

Table 8.1: Organ Systems in Animals

Organ Systems	Organs	Function
Integumentary system	Skin and skin glands	Protection, Excretion, etc.
Skeletal system	Skull, Vertebral column, Sternum, Girdles and Limbs	Give support, shape and form to the body.
Muscular system	Muscle fibres	Contraction and relaxation resulting movement.
Nervous system	Brain, spinal cord and nerves.	Conduction of nerve impulse.
Circulatory system	Heart, blood and blood vessels	Transportation of respiratory gases, nutritive substances and waste products.
Respiratory system	Respiratory tract and Lungs	Breathing
Digestive system	Digestive tract and digestive glands	Digestion, Absorption, Egestion
Excretory system	Kidneys, ureters, urinary bladder and urethra.	Elimination of nitrogenous waste products.
Reproductive system	Testes and ovary	Gametes formation and development of secondary sexual characters.
Sensory system	Eyes, nose, ears, tongue and skin	Sight, smell, hearing, taste and touch.
Endocrine system	Pituitary, Thyroid, Parathyroid, Adrenals, Pancreas, Pineal body, Thymus, Reproductive glands, etc.	Co-ordinates the functions of all organ systems.

In this chapter we shall learn about the structure and functions of various organ systems like digestive system, excretory system and reproductive system in human beings.

8.2 Human Digestive System

The food we eat not only contain simple substances like vitamins and minerals but also contain complex substances such as carbohydrates, proteins and fats. The body cannot use these complex substances unless they are converted into simple substances. The five stages of nutrition process include ingestion, digestion, absorption, assimilation and egestion.

The process of nutrition begins with intake of food, called **ingestion**. The breakdown of large complex insoluble food molecules into small, simpler soluble and diffusible particles by the action of digestive enzymes is called **digestion**. Parts of the body concerned with the digestion of food form the **digestive system**.

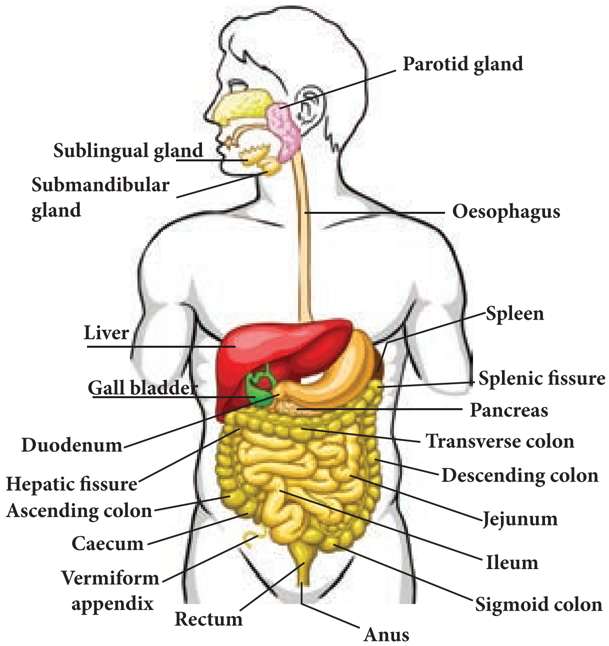


Figure 8.1 Parts of human digestive system

8.2.1 Organs of digestive system

The digestive system consists of two sets of organs. They are as follows;

Alimentary canal (digestive tract/gastro-intestinal tract) It is the passage of food starting from the mouth and ends with the anus.

The glands associated with the digestive system are the salivary glands, gastric glands, pancreas, liver and intestinal glands.

8.2.2 Structure of the Alimentary Canal

Alimentary canal is a muscular coiled, tubular structure. It consists of mouth, buccal cavity, pharynx, oesophagus, stomach, small intestine (consisting of duodenum, jejunum and ileum), large intestine (consisting of caecum, colon and rectum) and anus.

Mouth: The mouth leads into the buccal cavity. It is bound by two soft, movable upper and lower lips. The **buccal cavity** is a large space bound above by the palate (which separates the wind pipe and food tube), below by the throat and on the sides by the jaws. The jaws bear teeth.

Teeth: Teeth are hard structures meant for holding, cutting, grinding and crushing the food. In human beings two sets of teeth **(Diphyodont)** are developed in their life time. The first appearing set of 20 teeth called temporary or milk teeth are replaced by the second set of thirty two permanent teeth, sixteen in each jaw. Each tooth has a root fitted in the gum **(Theocodont)**. Permanent teeth are of four types **(Heterodont)**, according to their structure and function namely **incisors, canines, premolars** and **molars**.

Table 8.2: Types of teeth and their functions

Types of teeth	Number of teeth	Functions
Incisors	8	Cutting and biting
Canines	4	Tearing and piercing
Premolars	8	Crushing and grinding
Molars	12	Crushing, grinding and mastication

Dental formula represents the number of different type of teeth present in each half of a jaw (upper and lower jaw). The types of teeth are denoted as incisors (i), canine (c), premolars (pm) and molars (m). The **dental formula** is presented as:

For Milk teeth in each half of upper and lower jaw:

$$\frac{2, 1, 2}{2, 1, 2} = 10 \times 2 = 20$$

For Permanent teeth in each half of upper and lower jaw:

$$\frac{2, 1, 2, 3}{2, 1, 2, 3} = 16 \times 2 = 32$$

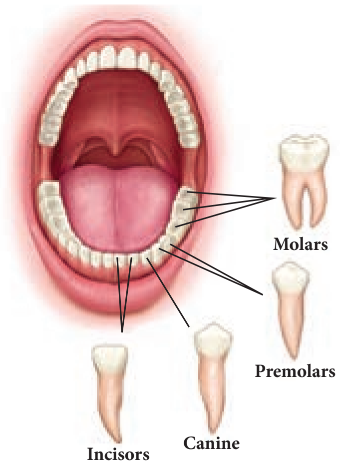


Figure 8.2 Different kinds of teeth

Activity 1

Look at the pictures given below and answer the questions that follow:

1. Are the teeth of animals similar to ours?
2. How is the shape of their teeth related to their food habit?

Salivary glands: Three pairs of salivary glands are present in the mouth cavity. They are: parotid glands, sublingual glands and submaxillary or submandibular glands

i. **Parotid glands** are the largest salivary glands, which lie in the cheeks in front of the ears (in Greek Par - near ; otid - ear).

ii. **Sublingual glands** are the smallest glands and lie beneath the tongue.

iii. **Submaxillary** or **Submandibular glands** lie at the angles of the lower jaw.

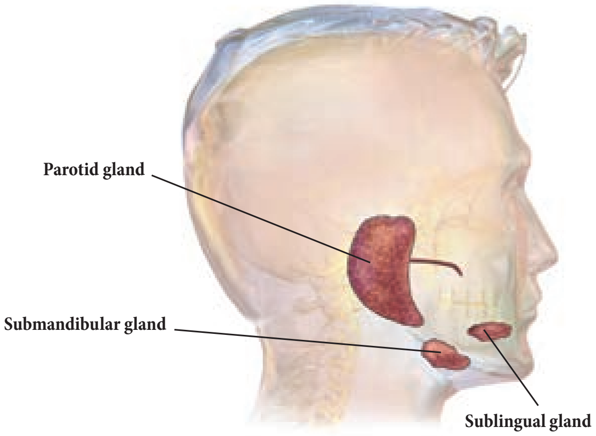


Figure 8.3 Salivary glands

The salivary glands secrete a viscous fluid called saliva, approximately 1.5 liters per day. It digests starch by the action of the enzyme **ptyalin** (amylase) in the saliva which converts starch (polysaccharide) into maltose (disaccharide). Saliva also contain an antibacterial enzyme called **lysozyme**.

Tongue: The tongue is a muscular, sensory organ which helps in mixing the food with the saliva. The taste buds on the tongue help to recognize the taste of food.

More to Know

- The tongue is connected underneath by a membrane called the **frenulum**. This runs between the tongue and the floor of the mouth. It prevents from swallowing our own tongue.

The masticated food in the buccal cavity becomes a bolus which is rolled by the tongue and passed through pharynx into the oesophagus by swallowing. During swallowing, the epiglottis (a muscular flap-like structure at the tip of the glottis, beginning of trachea) closes and prevents the food from entering into trachea (wind pipe).

Pharynx

The pharynx is a membrane lined cavity behind the nose and mouth, connecting them to the oesophagus. It serves as a pathway for the movement of food from mouth to oesophagus.

Oesophagus

Oesophagus or the food pipe is a muscular-membranous canal about 22 cm in length. It conducts food from pharynx to the stomach by peristalsis (wave-like movement) produced by the rhythmic contraction and relaxation of the muscular walls of alimentary canal.

Stomach

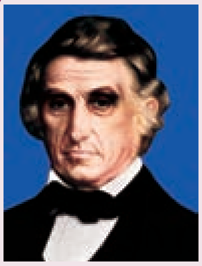
The stomach is a wide J-shaped muscular organ located between oesophagus and the small intestine. The gastric glands present in the inner walls of the stomach secrete gastric juice. The gastric juice is colourless, highly acidic, containing mucus, hydrochloric acid and enzymes rennin (in infants) and pepsin.

Inactive pepsinogen is converted to active **pepsin** which acts on the proteins in the ingested food. **Hydrochloric acid** kills the bacteria swallowed along with food and makes the medium acidic while the mucus protects the wall of the stomach. The action of the gastric juice and churning of food in the stomach convert the bolus into a semi-digested food called **chyme**. The chyme moves to the intestine slowly through the pylorus.

Connecting Concepts

Rennin: Causes curdling of milk protein caesin and increases digestion of proteins

Renin: Converts angiotensinogen to angiotensin and regulate the absorption of water and Na^+ from glomerular filtrate



William Beaumont (1785-1853)

William Beaumont was a surgeon who was known as the "Father of Gastric Physiology". Based on his observations he concluded that the stomach's strong hydrochloric acid played a key role in digestion.

Small intestine The small intestine is the longest part of the alimentary canal, which is a long coiled tube measuring about 5 – 7 m. It comprises three parts- duodenum, jejunum and ileum.

1. **Duodenum** is C-shaped and receives the bile duct (from liver) and pancreatic duct (from pancreas).
2. **Jejunum** is the middle part of the small intestine. It is a short region of the small intestine. The secretion of the small intestine is intestinal juice which contains the enzymes like **sucrase**, **maltase**, **lactase** and **lipase**.
3. **Ileum** forms the lower part of the small intestine and opens into the large intestine. Ileum is the longest part of the small intestine. It contains minute finger like projections called **villi** (one millimeter in

length) where absorption of food takes place. They are approximately 4 million in number. Internally, each villus contains fine blood capillaries and lacteal tubes,

The small intestine serves both for digestion and absorption. It receives (i) the bile from liver and (ii) the pancreatic juice from pancreas in the duodenum. The intestinal glands secrete the intestinal juices.

Liver: It is the largest digestive gland of the body which is reddish brown in colour. It is divided into two main lobes, right and left lobes. The right lobe is larger than the left lobe. On the under surface of the liver, gall bladder is present. The liver cells secrete **bile** which is temporarily stored in the gall bladder. Bile is released into small intestine when food enters in it. It has **bile salts** (sodium glycolate and sodium tauraglycolate) and **bile pigments** (bilirubin and biliviridin). Bile salts help in the digestion of fats by bringing about their **emulsification** (conversion of large fat droplets into small ones).

Functions of Liver

- Controls blood sugar and amino acid levels
- Synthesizes foetal red blood cells
- Produces fibrinogen and prothrombin, used for clotting of blood
- Destroys red blood cells
- Stores iron, copper, vitamins A and D.
- Produces heparin (an anticoagulant)
- Excretes toxic and metallic poisons
- Detoxifies substances including drugs and alcohol

Pancreas

It is a lobed, leaf shaped gland situated between the stomach and duodenum. **Pancreas** acts both as an **exocrine gland** and as an **endocrine gland**. The exocrine part of the pancreatic gland secretes pancreatic juice which contains three enzymes- lipase, trypsin and amylase which acts on fats, proteins and starch respectively. The gland's upper surface bears the **islets of Langerhans** which have endocrine cells and secrete hormones in which **α (alpha) cells** secrete **glucagon** and **β (beta) cells** secrete **insulin**.

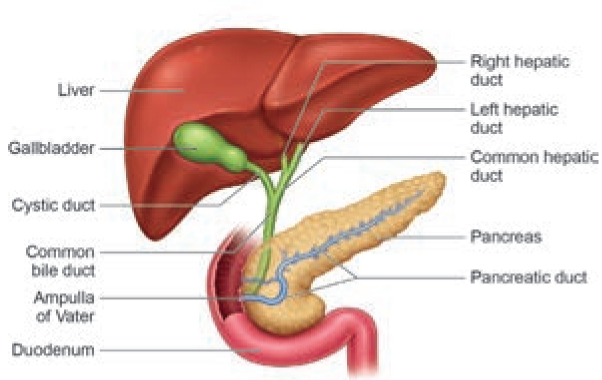


Figure 8.4 Bile duct and Pancreatic duct opening into duodenum

The intestinal glands secrete intestinal juice called **succus entericus** which contains enzymes like maltase, lactase, sucrase and lipase which act in an alkaline medium. From the duodenum the food is slowly moved down to ileum, where the digested food gets absorbed

Absorption of food

Absorption is the process by which nutrients obtained after digestion are absorbed by villi and circulated throughout the body by blood and lymph and supplied to all body cells according to their requirements.

Assimilation of food

Assimilation means the incorporation of the absorbed food materials into the tissue cells as their internal and homogenous component. The final products of fat digestion (fatty acids and glycerol) are again converted

Table 8.3: Chart showing the Digestive Enzymes

Digestive glands	Enzymes	Substrate (nutrient)	Product of digestion
Salivary glands	Ptyalin (Salivary amylase)	Starch	Maltose
Gastric glands	Pepsin	Proteins	Peptones
	Rennin (in infants)	Milk protein or caseinogen	Curdles milk to produce casein protein
Pancreas	Pancreatic amylase	Starch	Maltose
	Trypsin	Proteins and peptones	Peptides and amino acids
	Chymotrypsin	Protein	Proteoses, Peptones, Polypeptide, tri and dipepetides
	Pancreatic lipase	Emulsified fats	Fatty acids and Glycerol
Intestinal glands	Maltase	Maltose	Glucose and Glucose
	Lactase	Lactose	Glucose and Galactose
	Sucrase	Sucrose	Glucose and Fructose
	Lipase	Fats	Fatty acids and Glycerol

into fats and excess fats are stored in adipose tissue. The excess sugars are converted into a complex polysaccharide, glycogen in the liver. The amino acids are utilized to synthesize different proteins required for the body.

DO YOU KNOW?

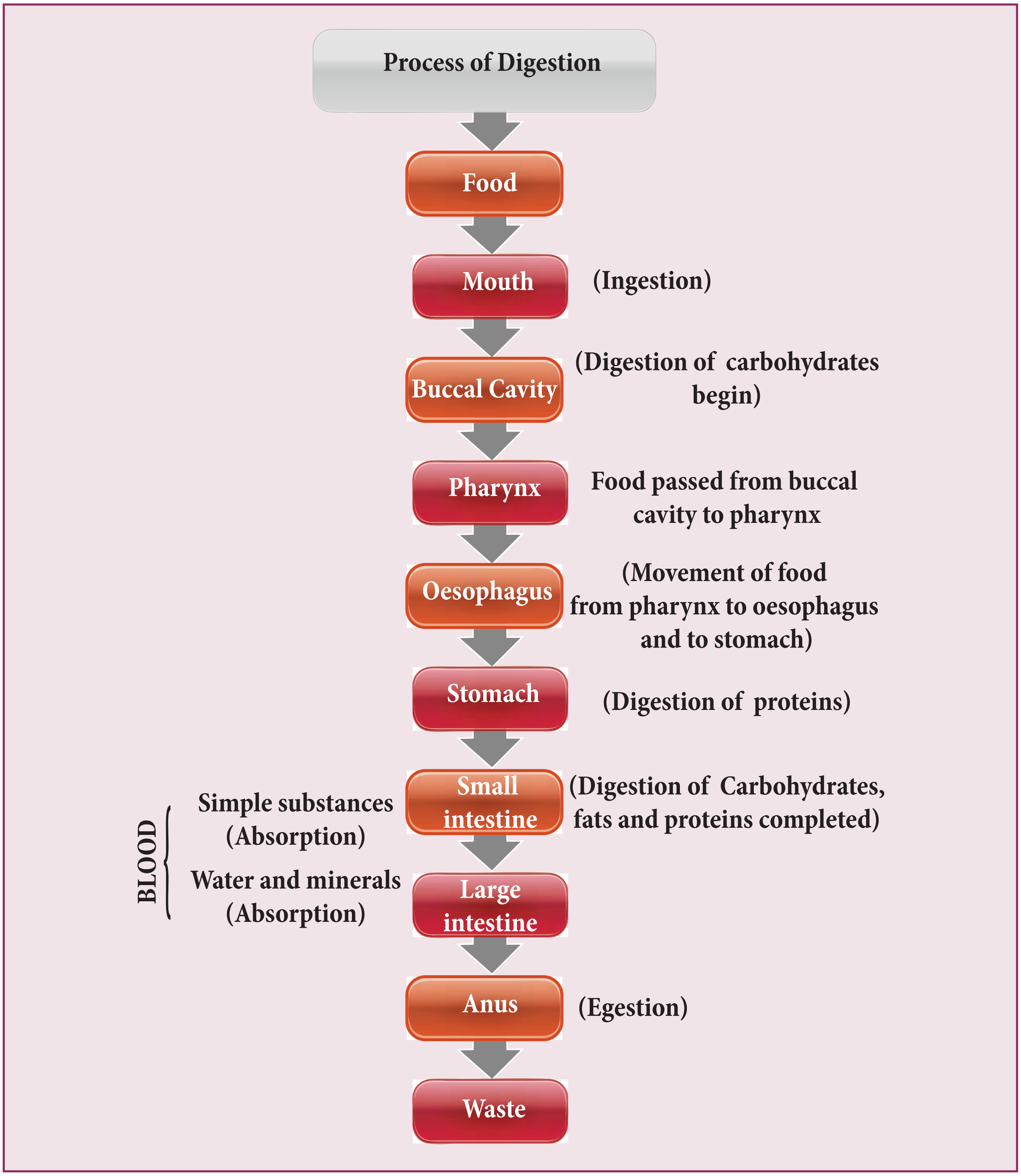
The small intestine is about 5m long and is the longest part of the digestive system. The large intestine is a thicker tube, but is about 1.5 m long

Large intestine

The unabsorbed and undigested food is passed into the large intestine. It extends from the ileum to the anus. It is about 1.5 meters in length. It has three parts- **caecum, colon** and **rectum**.

The caecum is a small blind pouch like structure situated at the junction of the small and large intestine. From its blind end a finger – like structure called **vermiform appendix** arises. It is a **vestigeal (functionless) organ** in human beings.

The colon is much broader than ileum. It passes up the abdomen on the right (**ascending colon**), crosses to the left just below the stomach (**transverse colon**) and down on the left side (**descending colon**). The rectum



is the last part which opens into the anus. It is kept closed by a ring of muscles called anal sphincter which opens when passing stools.

Egestion: The undigested or unassimilated portion of the ingested food material is thrown out from the body through the anal aperture as faecal matter. This is known as **egestion** or **defaecation**.

Activity 2

Construct a model of the human digestive system using simple materials like funnel , pipe , cellotape and clean bag. Label its parts and write which parts help in the various steps of digestion.

Activity 3

To know the action of saliva on starch.

Take two test tubes, one ml starch solution, one ml saliva, dilute iodine solution

1. Mark A and B on two test tubes
2. Add 1 ml of starch solution in each test tube.
3. Now add 1 ml of saliva to test tube A only.
4. Leave both the test tubes undisturbed for about 20-30 minutes.
5. Now add a few drops of dilute iodine solution in both the test tubes and observe.

Write the results.

What indicates the appearance of the blue colour in test tube B ?

Why the blue colour does not appear in test tube A ?

8.3 Human Excretory System

Metabolic activities continuously take place in living cells. All metabolic products produced by the biochemical reactions are not utilized by the body because certain nitrogenous toxic waste substances are also produced. They are called excretory products. In human beings **urea** is the major excretory product. The tissues and organs associated with the removal of waste products constitute the excretory system.

The human excretory system consists of a pair of kidney, which produce the urine, a pair of ureters which conduct the urine from kidneys to the urinary bladder, where urine is stored temporarily and urethra through which the urine is voided by bladder contractions.

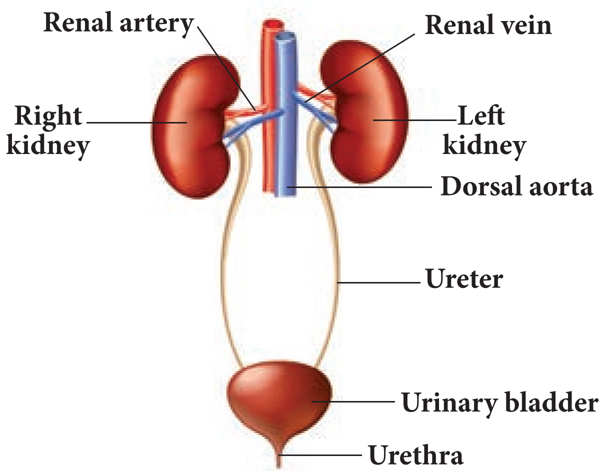


Figure 8.5 Excretory system

If the waste products are accumulated and not eliminated, they become harmful and poisonous to the body. Hence, excretion plays an important role in maintaining the homeostatic condition of the body.

Some of the excretory organs other than kidneys are **skin** (removes small amounts of water, urea and salts in the form of sweat) and **lungs** (eliminate carbon-dioxide and water vapour through exhaling).

8.3.1 Skin

Skin is the outer most covering of the body. It stretches all over the body in the form of a layer. It accounts for 15% of an adult's human body weight. There are many structures and glands derived from the skin. It eliminates metabolic wastes through perspiration.

The human body functions normally at a temperature of about 37^{0}C. When it gets hot sweat glands start secreting sweat, which contains water with small amounts of other chemicals like ammonia, urea, lactic acid and salts (mainly sodium chloride). The sweat passes through the pores in the skin and gets evaporated.

8.3.2 Kidneys

Kidneys are bean-shaped organs reddish brown in colour. The kidneys lie on either side of the vertebral column in the abdominal cavity attached to the dorsal body wall. The right kidney is placed lower than the left kidney as the liver takes up much space on the right side. Each kidney is about 11 cm long, 5 cm wide and 3 cm thick. The kidney is covered by a layer of fibrous connective tissue, the renal capsules, adipose capsule and a fibrous membrane.

Internally the kidney consists of an outer dark region, the **cortex** and an inner lighter region, the **medulla**. Both of these regions contain **uriniferous tubules** or **nephrons**. The medulla consists of multitubular conical masses called the medullary pyramids or renal pyramids whose bases are adjacent to cortex. On the inner concave side of each kidney, a notch called **hilum** is present through which blood vessels and nerves enter in and the urine leaves out.

Ureters: Ureters are thin muscular tubes emerging out from the hilum. Urine enters the ureter from the renal pelvis and is conducted along the ureter by peristaltic movements of its walls. The ureters carry urine from kidney to urinary bladder.

Urinary bladder: Urinary bladder is a sac-like structure, which lies in the pelvic cavity of the abdomen. It stores urine temporarily.

Urethra: Urethra is a membranous tube, which conducts urine to the exterior. The urethral sphincters keep the urethra closed and opens only at the time of **micturition** (urination).

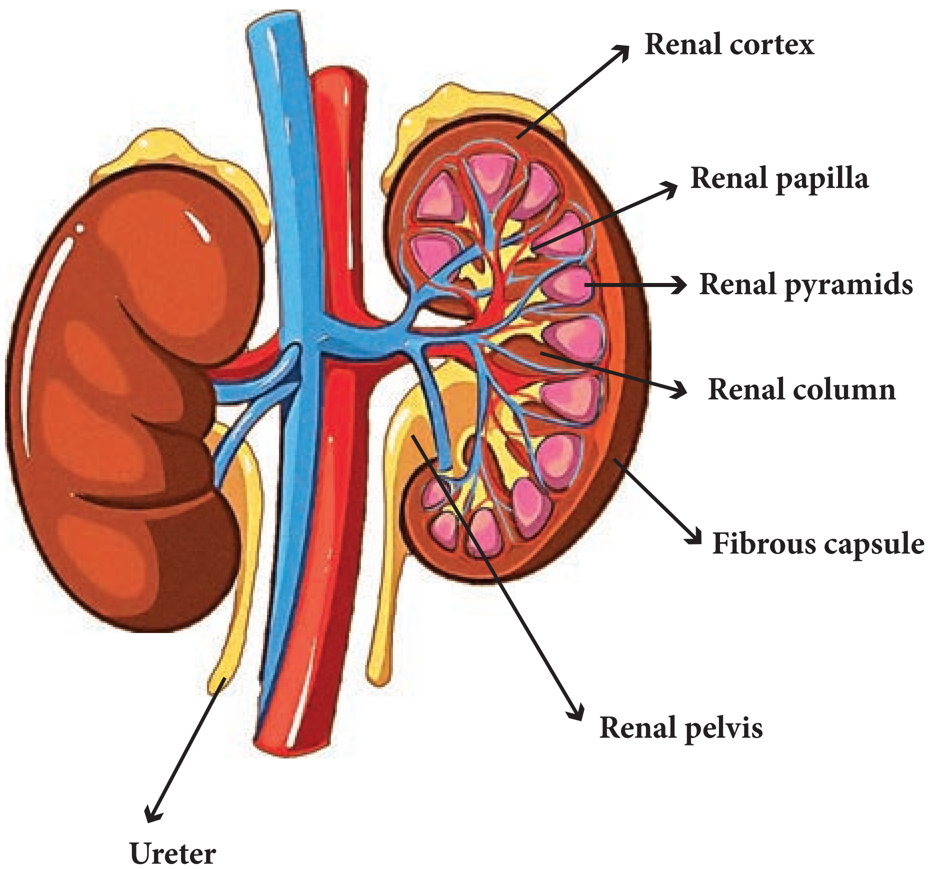


Figure 8.6 Longitudinal section of human kidney

Functions of kidney

1. Maintain the fluid and electrolytes balance in our body.
2. Regulate acid-base balance of blood.
3. Maintain the osmotic pressure in blood and tissues.
4. Help to retain the important plasma constituents like glucose and amino acids.

8.3.3 Structure of Nephron

Each kidney consists of more than one million nephrons. **Nephrons or uriniferous tubules** are structural and functional units of the kidneys. Each nephron consists of **Renal corpuscle** or **Malphigian corpuscle** and **renal tubule**. The renal corpuscle consists of a cup-shaped structure called **Bowman's capsule** containing a bunch of capillaries called **glomerulus**. Blood enters the glomerular capillaries through **afferent** arterioles and leaves out through **efferent** arterioles. The Bowman's capsule continues as the renal tubule which consists of three regions **proximal convoluted tubule**, U-shaped hair pin loop, **the loop of Henle** and the **distal convoluted tubule**. The distal convoluted tubule which opens into the **collecting tubule**. The nitrogenous wastes are drained into renal pelvis which leads to ureters and stored in the urinary bladder. Urine is expelled out through the urethra.

8.3.4 Mechanism of Urine Formation

The process of urine formation includes the following three stages.

- Glomerular filtration
- Tubular reabsorption and
- Tubular secretion

Glomerular filtration: Urine formation begins with the filtration of blood through epithelial walls of the glomerulus and Bowman's capsule. The filtrate is called as the glomerular filtrate. Both essential and non-essential substances present in the blood are filtered.

Tubular reabsorption: The filtrate in the proximal tubule consists of essential substances such as glucose, amino acids, vitamins, sodium, potassium, bicarbonates and water that are reabsorbed into the blood by a process of **selective reabsorption**.

Tubular secretion: Substances such as H^+ or K^+ ions are secreted into the tubule. Certain substances like potassium and a large number of drugs like penicillin and aspirin are passed into the filtrate in the distal convoluted tubule. This tubular filtrate is finally known as urine, which is **hypertonic** in man. Finally the urine passes into collecting ducts to the pelvis and through the ureter into the urinary bladder by urethral peristalsis (waves of constriction in the ureters). The relaxation of sphincter muscles located at the opening of the urinary bladder into the urethra. When the urinary bladder is full the urine is expelled out through the urethra. This process is called **micturition**. A healthy person excretes one to two litres of urine per day.

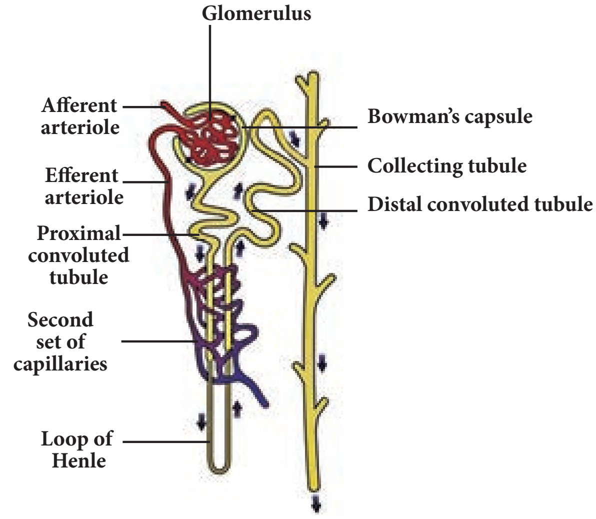


Figure 8.7 Structure of Nephron

Route of urine flow

Glomerulus
(Ulltrafiltration)

Bowman's capsule
(Receives glomerular filtrate)

Promixal convoluted tubule
(Reabsorbs most water and much of glucose, sodium and chloride ions)

Descending and ascending limb (loop of Henle)
Some absorption of water and sodium ions

Distal convoluted tubule
Reabsorbs remaining chlorides and some water. Walls secrete potassium and foreign chemicals such as penicillin & other drugs to the forming urine.

Collecting tubule

Collecting duct (Urine)

Ureter

Urinary bladder (Stores urine temporarily)

Urethra

Route of elimination of urine

DO YOU KNOW?

Two healthy kidneys contain a total of about 2 million nephrons, which filter about 1700-1800 litres of blood. The kidneys reabsorb and redistribute 99% of the blood volume and only 1% of the blood filtered becomes urine.

Dialysis or Artificial kidney

When kidneys lose their filtering efficiency, excessive amount of fluid and toxic waste accumulate in the body. This condition is known as **kidney** (renal) **failure**. For this, an artificial kidney is used to filter the blood of the patient. The patient is said to be put on dialysis and the process of purifying blood by an artificial kidney is called **haemodialysis**. When renal failure cannot be treated by drug or dialysis, the patients are advised for kidney transplantation.

DO YOU KNOW?

First kidney transplant

In 1954, Joseph E.Murray and his colleagues at Peter Bent Brigham Hospital in Boston performed first succesful kidney transplant between Ronald and Richard Herrick who were identical twins. The recepient Richard Herrick died after 8 years of transplantation

8.4 Human Reproductive System

All living organisms develop from pre-existing organisms. The capacity to reproduce is one of the most important characteristics of living beings. This process is aimed to preserve individual species and is called 'self perpetuation'.

There is a distinct sexual dimorphism in human beings i.e., males are visibly different from females in physical build up, external genital organs and secondary sexual characters. Thus, the structures associated with reproduction are different in males and females. The reproductive systems of male and female consist of many organs which are distinguished as primary and secondary sex organs. The primary sex organs are gonads, which produce gametes (sex cells) and secrete sex hormones. The secondary sex organs include the genital ducts and glands which help in the transportation of gametes and enable the reproductive process. They do not produce gametes or sex hormones.

The reproductive organs become functional after attaining sexual maturity. In males, sexual maturity is attained at the age of 13-14 years. In females, it is attained at the age of 11-13 years. This age is known as the age of puberty. During sexual maturity, hormonal changes takes place in males and females and secondary sexual characters are developed under the influence of these hormones.

8.4.1 Male reproductive system

Human male reproductive system consists of testes (primary sex organs), scrotum, vas deferens, urethra, penis and accessory glands.

Testes: A pair of testes or testicles lies outside the abdominal cavity of the male. These testes are the male gonads, which produces male gametes **(sperms)** and male sex hormone (**Testosterone**). Along the inner side of each testis lies a mass of coiled tubules called **epididymis**. The **Sertoli cells** of the testes provide nourishment to the developing sperms.

Scrotum: The scrotum is a loose pouch-like sac of skin which is divided internally into right and left **scrotal sacs** by muscular partition. The two testes lie in the respective scrotal sacs. It also contains many nerves and blood vessels. The **scrotum** acts as a **thermoregulator organ** and provides an optimum temperature for the formation of sperms. The sperms develop at a temperature of 1-3^{0}C lower than the normal body temperature.

Vas Deferens: It is a straight tube which carries the sperms to the **seminal vesicles**. The sperms are stored in the seminal plasma of seminal vesicle, which is rich in fructose, calcium and enzymes. Fructose is a source of energy for the sperm. The **vas deferens** along with seminal vesicles opens into ejaculatory duct. The ejaculatory duct expels the sperm and secretions from seminal vesicles into the urethra.

Urethra: It is contained inside the penis and conveys the sperms from the vas deferens which pass through the urethral opening.

The accessory glands associated with the male reproductive system consist of seminal vesicles, prostate gland and Cowper's glands. The secretions of these glands form seminal fluid and mixes with the sperm to form semen. This fluid provides nutrition and helps in the transport of sperms.

The Leydig cells of the testes secrete the male sex hormone testosterone which controls spermatogenesis and plays a role in the development of male secondary sexual characters like growth of beard, moustache, body hair and hoarse voice.

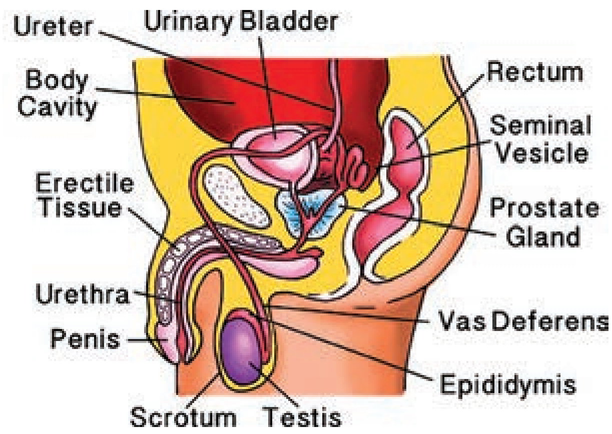


Figure 8.8 Male reproductive system

DO YOU KNOW?

The sperm is the smallest cell in the male body. A normal male produces more than 500 billion sperm cells in his life time. The process of formation of sperms is known as spermatogenesis.

8.4.2 Female reproductive system

The female reproductive system consists of ovaries (primary sex organs), oviducts, uterus and vagina.

Ovaries: A pair of almond-shaped ovaries is located in the lower part of abdominal cavity near the kidneys in female. The ovaries are the female gonads, which produce female gametes **(eggs** or **ova)** and secrete female sex hormones (**Oestrogen** and **Progesterone**). A mature ovary contains a large number of ova in different stages of development. Only one ovum usually ripens every month. One mature ovum is released from either side of the ovary at an interval of every 28 days (**menstrual cycle**). The process of release of ovum from the ovary is known as **ovulation**.

More to Know

An ovum is the largest human cell. The process of formation of ova is known as **oogenesis**.

Fallopian tubes (Oviducts): These are paired tubes originating from uterus, one on either side. The terminal part of **fallopian tube** is funnel-shaped with finger-like projections called **fimbriae** lying near the ovary. The fimbriae pick up the ovum released from ovary and push it into the fallopian tube.

Uterus: Uterus is a pear-shaped muscular, hollow structure present in the pelvic cavity. It lies between urinary bladder and rectum. Development of foetus occurs inside the uterus. The narrower lower part of uterus is called **cervix**, which leads into vagina.

Vagina: The uterus narrows down into a hollow muscular tube called vagina. It connects cervix and the external genitalia. It receives the sperms, acts as birth canal during child birth (**parturition**) and also serves as passage for menstrual flow.

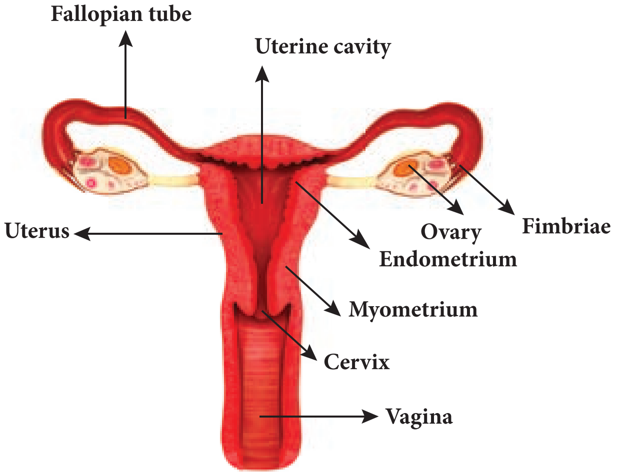


Figure 8.9 Female reproductive system

The female sex hormone **oestrogen** is secreted by the **graafian follicle** of the ovum. It controls the development of accessory sex organs and secondary sexual characters. It regulates menstrual cycle and fertility. **Progesterone** is secreted by the **corpus luteum**. It prepares the uterus for implantation of fertilized ovum, formation of placenta and for maintaining pregnancy.

Points to Remember

- All the organ systems work together in coordination to maintain the body in a homeostatic condition of an organism. Division of labour is found among the various organ systems.
- Parts of the body concerned with the digestion of food form the digestive system.
- Alimentary canal is a muscular coiled, tubular structure. It consists of mouth, buccal cavity, pharynx, oesophagus, stomach, small intestine (consisting of duodenum, jejunum and ileum), large intestine (consisting of caecum, colon and rectum) and anus.
- The five stages of nutrition process include ingestion, digestion, absorption, assimilation and egestion
- The small intestine serves both for digestion and absorption
- Absorption is the process by which nutrients obtained after digestion are absorbed by villi and circulated throughout the body by blood and lymph
- The tissues and the organs associated with the removal of the waste products constitute the excretory system.

- The human excretory system consists of a pair of kidney, which produce the urine, a pair of ureters which conduct the urine from kidneys to the urinary bladder, where urine is stored temporarily and urethra through which the urine is voided by bladder contractions
- The process of urine formation includes the following three stages. Glomerular filtration. tubular reabsorption and tubular secretion
- In condition of kidney (renal) failure, an artificial kidney is used to filter the blood of the patient. The patient is said to be put on dialysis and the process of purifying blood by an artificial kidney is called haemodialysis
- The reproductive systems of male and female consist of many organs which are distinguished as primary and secondary sex organs.
- The primary sex organs are gonads, which produce gametes (sex cells) and secrete sex hormones. The secondary sex organs include the genital ducts and glands which help in the transportation of gametes and enable the reproductive process.

A-Z GLOSSARY

Emulsification	Conversion of large fat droplets into smaller ones.
Enzymes	Substances produced by living organisms which acts as a catalyst to bring about specific biochemical reactions.
Graffian follicle	Mature follicle containing oocyte, present in the ovary. Only one Graffian follicle matures in a month and secretes the hormone estrogen.
Homeostasis	The tendency of the body to seek and maintain a balance condition or equilibrium within its internal environment, even when faced with external challenges.
Mastication (Chewing)	The process by which food is crushed and ground by teeth.
Metabolism	Sum total of all chemical and energy changes taking place in an organism.
Nutrition	The process of providing or obtaining the food necessary for health and growth.
Osmoregulation	The maintenance of constant osmotic pressure in the fluids of an organism by the control of water and salt concentrations.
Regurgitation	The act of bringing swallowed food back into the mouth.
Toxic substances	Substances that can be poisonous or cause health effects to living organisms

TEXT BOOK EXERCISES

I. Choose the correct answer

1. Which of the following is not a salivary gland?
   a. sublingual   b. lachrymal
   c. submaxillary   d. parotid

2. Stomach of man mainly digests ___________
   a. carbohydrates   b. proteins
   c. fat   d. sucrose

3. To prevent the entry of food into the trachea, the opening is guarded by ____________
   a. epiglottis   b. glottis
   c. hard palate   d. soft palate

4. Bile helps in the digestion of ______________
   a. proteins   b. sugar
   c. fats   d. carbohydrates

5. Excretion means ______________
   a. taking in oxygen from the air and giving out carbon dioxide
   b. disposal of harmful germs and worms from our body
   c. distribution of digested food to the body tissues through blood
   d. removal of nitrogenous wastes generated in the body

6. The structural and functional unit of the kidney is _______________
   a. villi   b. liver
   c. nephron   d. ureter

7. Which one of the following substance is not a constituent of sweat?
   a. urea   b. protein
   c. water   d. salt

8. The common passage meant for transporting urine and sperms in male is _______
   a. ureter   b. urethra
   c. vas deferens   d. scrotum

9. Which of the following is not a part of female reproductive system?
   a. Ovary   b. uterus
   c. testes   d. fallopian tube

II. Fill in the blanks

1. The opening of the stomach into the intestine is called __________.
2. The muscular and sensory organ which helps in mixing the food with saliva is _________.
3. Bile, secreted by liver is stored temporarily in ______.
4. The longest part of alimentary canal is ______________
5. Organs which are concerned with the formation, storage and elimination of urine constitute the __________.
6. The human body functions normally at a temperature of about _________.
7. In the process of urine formation, maximum amount of water from the glomerular filtrate is reabsorbed in the ____.

8. The largest cell in the human body of a female is __________.

III. State whether the following statements are true or false. If false, correct the wrong statements:

1. Nitric acid in the stomach kills microorganisms in the food.
2. During digestion, proteins are broken down into amino acids.
3. Glomerular filtrate consists of many substances like amino acids, vitamins, hormones, salts, glucose and other essential substances.
4. Besides the normal constituents, the urine may pass out excess vitamins and not the antibiotics.
5. The process of release of ovum from ovary is called gestation.

IV. Identify the following parts:

1. It conducts food from pharynx to stomach by peristalsis-
2. Finger-like projections which enhances the absorbing capacity of small intestine-
3. The bunch of capillaries inside the Bowman's capsule-
4. Thin muscular tubes which carry urine from kidney to urinary bladder-
5. Small sac-like muscular structures that encloses testes-

V. Very short answer questions

1. Arrange the following five steps of nutrition in correct sequence: (digestion, assimilation, ingestion, egestion, absorption)
2. The stomach secretes gastric juice, which contains hydrochloric acid. What is its function?
3. How is the small intestine designed to absorb digested food?
4. Why do we sweat?
5. State any two vital functions of human kidney.
6. How is it possible to control the urge to pass urine?
7. Write the names of male and female sex hormone.

VI. Short answers questions

1. Define the following terms:

   a. Digestion b. Osmoregulation
   c. Emulsification d. Ovulation

2. Name the types of teeth present in an adult human being. Mention the functions of each.
3. What are the end products of digestion of starch, proteins and fats respectively?
4. Explain the structure of nephron.
5. Differentiate the following terms:

   a. Excretion and secretion
   b. Absorption and assimilation
   c. Sperm and ovum
   d. Ingestion and egestion
   e. Diphyodont and heterodont
   f. Incisors and canines

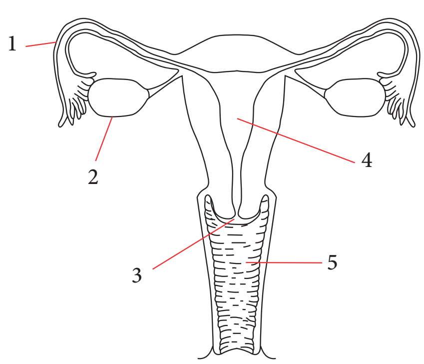
6. What are the functions of ovaries and uterus in female reproductive system?
7. Match the following:

Organ	Elimination
Skin	a. Urine
Lungs	b. Sweat
Intestine	c. Carbon dioxide
Kidneys	d. undigested food

8. Give reasons for the following:
   a. Scrotum remains outside the body of human males.
   b. The wall of the stomach is not digested by its own enzyme.
9. Complete the following table:

Enzymes	Nutrient (Substrate)	End products of digestion
Erepsin (peptidase)	proteins and peptides	---------
Maltase	----------	glucose
Sucrase	sucrose	------------ --- and-------- ---
Lactase		glucose and galactose
-----------	fats	fatty acids and glycerol

VII. Match the parts of the given figure with the correct option.



1	2	3	4	5
a. Fallopian tube	Oviduct	Uterus	Cervix	Vagina
b. Oviduct	Cervix	Vagina	Ovary	Vas deferens
c. Ovary	Oviduct	Uterus	Vagina	Cervix
d. Fallopian tube	Ovary	Cervix	Uterus	Vagina

VIII. Long answer questions

1. Describe the alimentary canal of man
2. Explain the structure of kidney and the steps involved in the formation of urine

IX. Assertion and Reason

Direction: In each of the following questions, a statement of Assertion is given and a corresponding statement of Reason is given just below. Of the four statements, given below, mark one as the correct answer.

a. If both Assertion and Reason are true and Reason is the correct explanation of Assertion
b. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion
c. If Assertion is true but Reason is false
d. If both Assertion and Reason are false

1. Assertion: Urea is excreted out through the kidneys

   Reason: Urea is a toxic substance. Excess accumulation of urea in blood may lead to death

2. Assertion: In both the sexes gonads perform dual function

   Reason: Gonads are also called primary sex organs

X. Thinking skills

1. If pepsin is lacking in gastric juice, then which event in the stomach will be affected?

   a. digestion of starch into sugars

   b. breaking of proteins into peptides

   c. digestion of nucleic acids

   d. breaking of fats into glycerol and fatty acids

2. Rearrange the jumbled sequence of the different parts of alimentary canal in proper sequence. (Oesophagus, Small intestine, Stomach, Large intestine, anus, mouth, rectum)

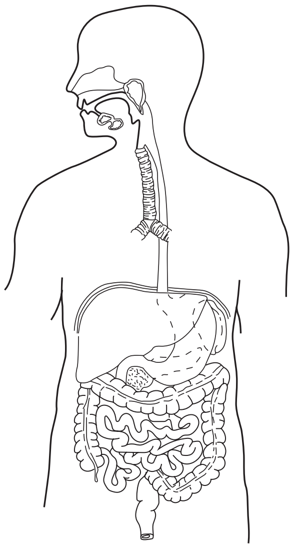
3. Select the substances given below that need to be excreted from the body. (urea, amino acids, carbon dioxide, uric acid, glucose)

4. Name the blood vessel that (a) enter malphigian capsule and (b) leaves malphigian capsule

5. Rearrange the jumbled words and fill in the blanks in the following passage to make it a meaningful description.

   The human urinary system consists of a pair of _______ (nyedik), which form the urine; a pair of _________ (ertreu), which conduct the _________ (neuri) from kidneys to the _______ (naryuri drebdal) for storage of urine and a _____ (reuhrat) through which the urine is voided by bladder contractions.

6. Label the parts of the alimentary canal of man and write any one function of each organ



XI. Discuss and answer:

1. Why do you think that urine analysis is an important part of medical diagnosis?

2. Why your doctor advises you to drink plenty of water?

3. Can you guess why there are sweat glands on the palm of our hands and the soles of our feet?

REFERENCE BOOKS

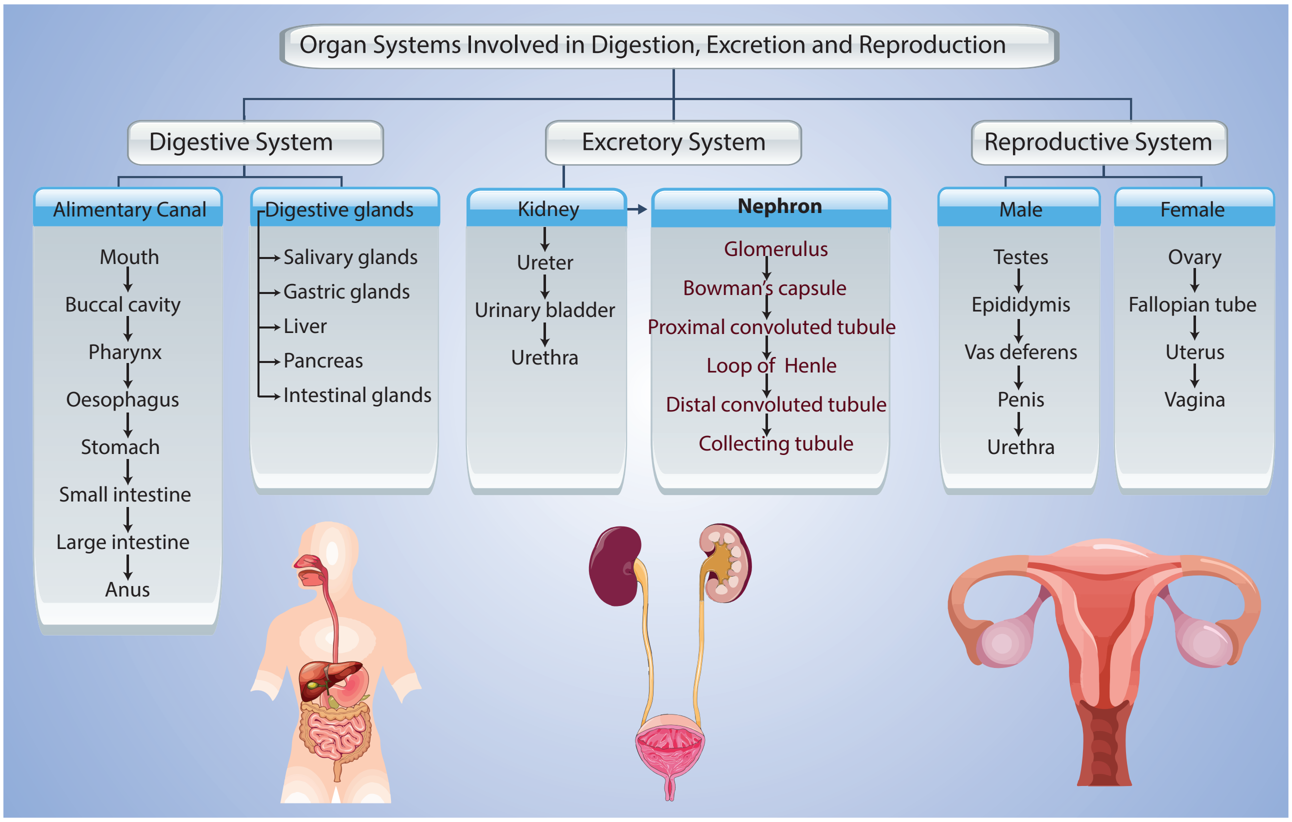
Verma P.S and Agarwal, V.K. Animal Physiology, S. Chand and Company, New Delhi

INTERNET RESOURCES

https://www.britannica.com/science/human-digestive-system

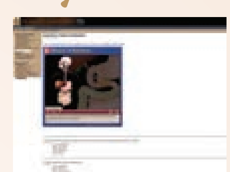
https://biologydictionary.net/excretory-system/

https://www.britannica.com/science/human-reproductive-system



ICT CORNER

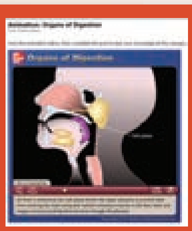
Human digestive system



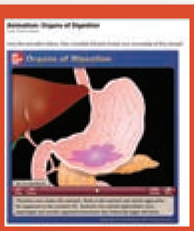
This activity enables to explore the functions of every part in the digestive system

Steps

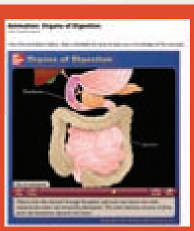
- Type the URL link given below in the browser or scan the QR code. You can view **"the digestive system"**.
- Click the **go to interactive mode** to explore the functions of each part you want to learn.
- Every part and its function can be learnt by clicking that particular part that we want to learn.
- Also you can see the process of digestion by clicking **go to animation mode**.



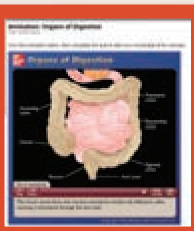
Step1



Step2



Step3



Step4

Browse in the link:

URL: http://highered.mheducation.com/sites/0072495855/student_view0/chapter26/animation__organs_of_digestion.html

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UNIT 9

Parts of Computer

Learning Objectives

BQU5HF

After completing this chapter, the students will be able to:

- Know the Input unit, CPU and the Output unit.
- Understand the memory unit.
- Differentiate the input and output devices.
- Link the connections in Computer.

Introduction

Is it easy to connect our sprawling planet to a point? If it is easy, then how would it be possible? The answer to these questions in today's world is the Computer. In this Modern World computer eases the effort and speeds up the processes to a great extent. Now-a-days the usage of computer plays an important role in every walk of life. So, it is apt time to learn about computers. To start, it is necessary to note that there are three key units in the computer. Understanding of this three units will make us to operate a computer in ease. In this section, let us learn what are the three units? and what are the functions of each of these units?

9.1 Parts of a Computer

Three parts of the computer are :

- Input Unit
- Central Processing Unit (CPU)
- Output Unit

Input Unit

The input unit helps to send the data and commands for the processing. The devices that are used to enter data are called input devices.

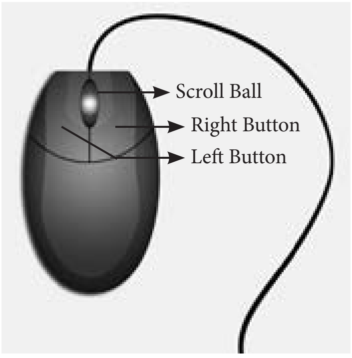
Keyboard, Mouse, Scanner, Barcode reader, Microphone-Mic., Web camera, Light Pen are some of the input devices.

Keyboard

Keyboard and mouse are the important input units. Keyboard plays an important role in a computer as an input device. Numbers and alphabet plays a role of Data in computer. Keyboard helps to enter data. Keyboard has

two types of keys, namely number keys and alphabet keys. The keys with numbers are called number keys and the keys with letters are called alphabet keys.

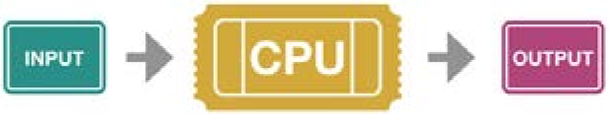
Mouse



Mouse is an essential part of the computer. Mouse has two buttons and a scroll ball in the middle. The mouse is used to move the pointer on a computer screen. Right button is used to select files and to open the folder. Left button is used to carryout corrections in the file. The page on the monitor can be moved up and down using the scroll ball.

CPU (Central Processing Unit)

CPU is the brain of the Computer. The data is processed in the CPU. The CPU has namely three parts.



1. Memory Unit
2. Arithmetic Logic Unit (ALU)
3. Control Unit

Memory Unit

The memory unit in the computer saves all data and information temporarily. The data is measured in units which is called as Bit. A Bit has a single binary value either 0 or 1. We can classify memory unit into two types namely primary and secondary memory. Memory can be expanded externally with the help of Compact Disk (CD), Pendrive, etc.

Arithmetic Logic Unit

Arithmetic and Logic unit performs all arithmetic computations like addition, subtraction, multiplication and division.

Control Unit

The control unit controls the functions of all parts of the computer.

Output Unit

The Output unit converts the command received by the computer in the form of binary signals into easily understandable characters. Monitor, Printer, Speaker, scanner are some of the Output devices.

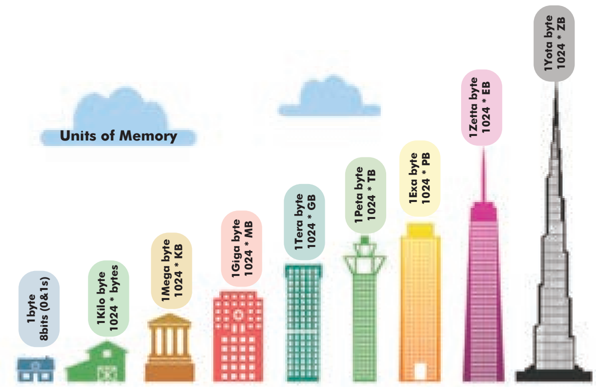
Of the various output devices, monitor is the important output device because it is the link to the computer. Monitor screen looks like TV screen. The input data in the form of Alphabets, Numbers, Pictures or Cartoons and Videos will be displayed on a monitor. There are two types of monitor namely,

1. Cathode Ray Tube monitors (CRT)
2. Thin Film Transistor Monitors (TFT)

Now a days computer system has TFT monitor as they occupy less space and emit less heat than CRT monitors.

9.2 classification of Computer

The computers can be classified as follows based on their design, shape, speed, efficiency, working of the memory unit and their applications.



- Mainframe Computer
- Mini Computer
- Micro or personal computer
- Super computer

9.2.1 Personal computer and its types

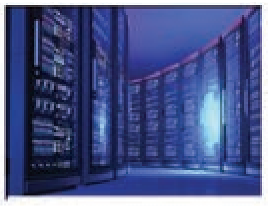
Personal computer comes under the microcomputer. Based on the memory and efficiency in PC they can be classified as

1. Desktop, 2. Laptop, 3. Tablet


Mainframe computer


Mini computer


Micro personal computer


Super computer

DO YOU KNOW?

A DVD is capable of storing 6 times more data than a CD.

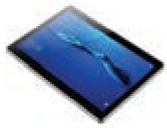
VDU stands for VISUAL DISPLAY UNIT.

9.3 Connecting the computer

You must have seen tube light and fan working by connection through electric wire. Likewise various parts of the computer are linked through connecting cables. We call computer as system as it is connected with one another. Do you know how these parts are connected? There are many cables used to connect these parts. These cables are called as connecting cables. These cables are found in different sizes. Each cable has its own specific use. Let us see the different types of cables and its uses.


Desktop


Laptop


Tablet

9.3.1 Types of Cables

Video Graphics Array (VGA), High Definition Multimedia Interface (HDMI), Universal Serial Bus (USB), Data cable, Power Cord, Mic cable, Ethernet cable

1. VGA Cable:

It is used to connect the computer monitor with the CPU.

2. USB cable /cord:

Devices like Printer, Pendrive, Scanner, Mouse, Keyboard, web camera, and Mobile phone devices are connected with the computer using USB cord or cable.

3. HDMI Cable:

HDMI cable transmits high quality and high bandwidth streams of audio and video. It connects monitor, projector with the computer.

4. Data Cable:

Data cable transmits data and it is used to connect tablet, mobile phones to the CPU for data transfer.

5. Audio jack:

The audio jack is used to connect the speaker to the computer.

6. Power cord:

Power cord temporarily connects an appliance to the main electricity supply.

7. Mic cable:

To connect the Mic to the CPU, Mic wire/cord is used.

8. Ethernet:

Ethernet cable helps to establish internet connectivity.

9.3.2 Wireless Connections

Bluetooth, Wi-Fi are used to connect to internet without using any connecting cables / devices.

1. Bluetooth

Mouse, Keyboard can be connected to the computer using the Bluetooth. Using Bluetooth the data can be shared with nearby devices

2. Wi-Fi

Net connectivity can be obtained using the Wi-Fi without any connecting cables. Any data from anywhere can be shared using Wi-Fi.

BQZDV6

TEXT BOOK EXERCISES

I. Choose the correct answer:

1. Which one of the following is an output device?

   a) Mouse b) Keyboard
   c) Speaker d) Pendrive

2. Name the cable that connects CPU to the Monitor

   a) Ethernet b) VGA
   c) HDMI d) USB

3. Which one of the following is an input device?

   a) Speaker b) Mouse
   c) Monitor d) Printer

4. Which one of the following is an example for wireless connections?

   a) Wi-Fi b) Electric wires
   c) VGA d) USB

5. Pen drive is ________________ device.
   a) Output   b) Input
   c) Storage   d) Connecting cable

II. Match the following:

VGA	-	Input device
Bluetooth	-	Connecting cable
Printer	-	LDMI
Keyboard	-	Wireless connection
HDMI	-	Output device

III. Short answer:

1. Name the parts of a computer.
2. Bring out any two differences between input and output devices.

Activity

Look at the magic of connecting cables to desktop computer with 4,3,2,1 formula, start from 4 proceed till 1. Now your computer is ready to use.

By connecting the various parts of a computer we can assemble a computer. For the construction activity, students have to use 4-3-2-1 formula.

A system consist of mouse, key board, monitor, CPU, power cables, and connecting cables Students have to connect the four parts of a computer in row 4, using the cables in row 3, through the power cables in row 2 to construct a system

Using the 4-3-2-1 formula we can connect the parts of the computer				
4				
	Mouse	Keyboard	Monitor	CPU
3				
		VGA	USB (connecting cable)for Keyboaard	USB (connecting cable)for Mouse
2				
			USB (connecting cable)for CPU	USB (connecting cable)for Monotor
			1	
				A complete computer

PRACTICAL - TABLE OF CONTENTS

Sl. No.	Name of the Experiment	Time
1.	Melting point of wax	40 minutes
2.	Verification of Ohm's law	40 minutes
3.	Mapping of magnetic field	40 minutes
4.	Identifying an acid or a base	40 minutes
5.	Identification of Plant and Animal tissues	40 minutes

I. MELTING POINT OF WAX

BR41J3

Aim:

To determine the melting point of wax using cooling curve.

Principle:

The determination of melting point is based on latent heat which is the amount of heat required to change a unit mass (1gm) of a substance from one state to another state without changing its temperature.

Materials Required:

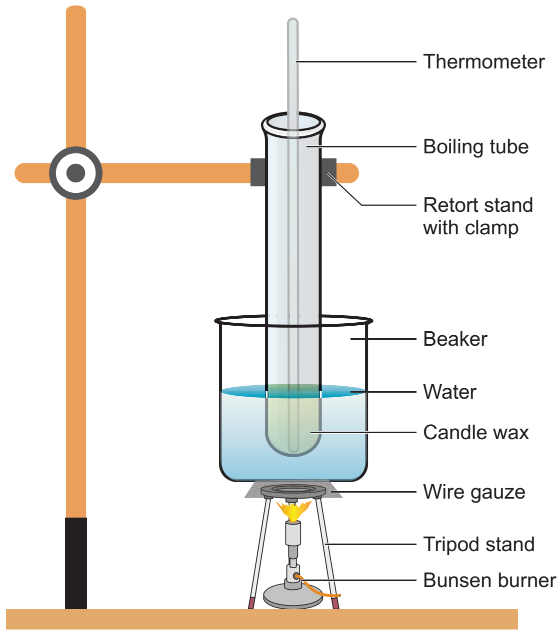
Beaker, burner, thermometer, boiling tube, retort stand and clamp,wire gauze, tripod stand, candle wax, stop watch, bowl of sand.

Procedure:

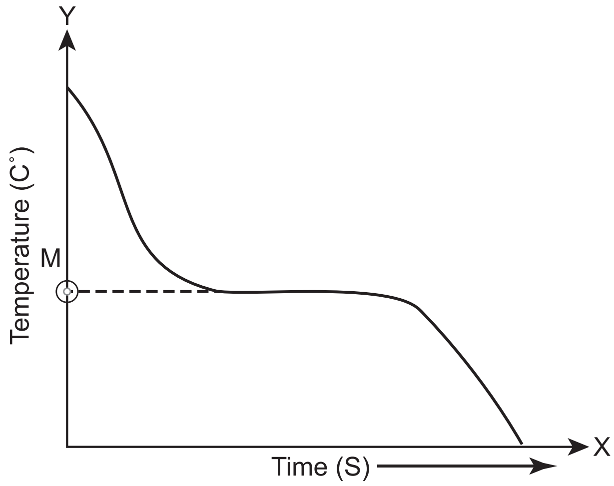
- Melt the wax in a warm water bath.
- When the wax is melted entirely, remove it from the bath, dry it and then bury it in sand.
- Record the temperature each 30 seconds while the liquid is being converted to solid.
- At the same time watch for constant temperature at which liquid and solid are present.

Melting point of wax= Constant Temperature over a period of time

Diagram



Graph



Observation and Tabulation:

S.No	Time (Second)	Temparature

The temperature at the point M denotes the melting point of wax

Suggestion:

With the help of ICT corner, the teacher can show the live video of the experiment of melting point of wax using the link www.kau.edu.sa

II. VERIFICATION OF OHM'S LAW

BR99HT

Aim:

To verify Ohm's law.

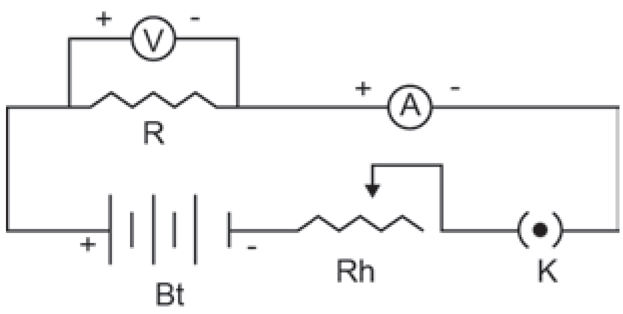
Apparatus required:

A resistor of 5 ohm, voltmeter (0 to 5 volt), an ammeter (0 to 2A), battery of 5 Volt, a plug key, a rheostat.

Formula:

V=IR where V is the voltage, I is the current and R is the resistance.

Circuit diagram:



R - Resistor
V - Voltmeter
A - Ammeter
Bt - Battery
Rh - Rheostat
K - Key

Procedure:

Connect the circuit as above. Connect the resistor, ammeter, battery, rheostat & key in series. Connect the voltmeter parallel to the resistor as shown in figure.

Now by using a Rheostat fix the voltages from 0 in steps of 1 Volt and note down the corresponding value of current I from the ammeter. Make a table.

S.No	Potential Difference (V) volt	Current (I) ampere

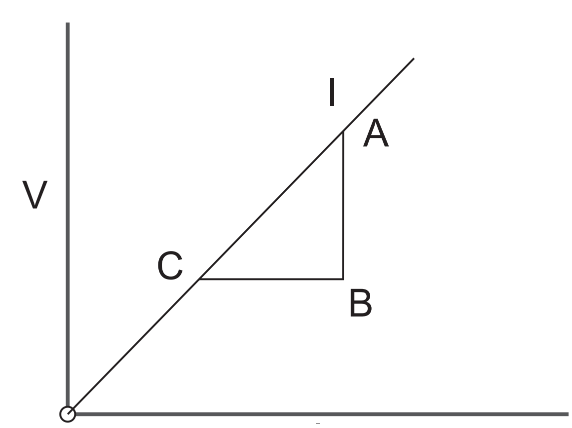
Graph

Plot a graph taking I along X- axis and V along Y-axis.

You will get a straight line

Draw a triangle ABC & find the slope.

Slope = AB /BC = R, the resistance of the resistor which will be 5 ohms.



Result:

Ohm's law is verified by the above experiment.

III. MAPPING OF MAGNETIC FIELD

BRCHKQ

Aim

To map the magnetic field of a Bar Magnet when it is placed in Magnetic Meridian with its North- pole pointing towards North.

Apparatus required:

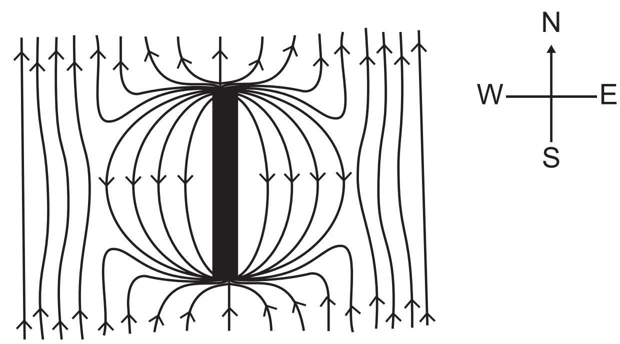
Drawing Board, board pin, compass needle, white paper and bar magnet.

Procedure:

1. A white sheet of paper is fastened to the drawing board using board pins or sellotape. (When doing this all magnetic and magnetic materials are moved far away from the drawing board)

2. A small plotting compass needle is placed near the edge of the paper and the board is rotated until the edge of the paper is parallel to the magnetic needle. This position should not be disturbed throughout the experiment.

Diagram



3. The compass needle is placed at the centre of the paper. The ends of the needle i.e the new positions of the North and South Pole are marked when the needle comes to rest. These points are joined and straight line is obtained. This is the magnetic meridian.

4. Cardinal directions NEWS is drawn near the corner of the paper. The bar magnet is placed on the line at the centre of the paper with its north pole facing the geographic north. The outline of the bar magnet is drawn.

5. The plotting compass is placed near the North Pole and the ends of the needle are marked. Move the compass to a new position such that its south end occupies the positions previously occupied by its north pole. In this way proceed step by step till the South Pole of the magnet is reached.

6. The lines of the magnetic forces are drawn by joining the plotted points around the magnet. In the same way several magnetic lines of force are drawn around the magnet as shown in the figure.

7. The Curved lines represent the magnetic field of the magnet. The direction of the lines is shown by arrows heads.

Result:

The magnetic lines of force are mapped when the bar magnet is placed. Direction of the lines is shown by arrows heads.

IV. IDENTIFYING AN ACID OR A BASE

BRI5YG

Aim:

To identify the presence of an acid or a base in a given sample.

Materials Required:

Test tubes, glass rod, phenolphthalein, methyl orange, litmus paper, sodium carbonate salt and Dilute HCl(sample1), Aqueous NaOH(Sample 2)

TEST FOR ACID (use sample 1)

S.No.	Experiment	Observation (Colour change)	Inference (Acid/ Base)
1.	Add a few drops of phenolphthalein with the 5 ml of sample solution	No change in colour	Presence of acid
2.	Add a few drops of methyl orange with the 5 ml of sample solution	Turns pink in colour	Presence of acid
3.	Add a pinch of sodium carbonate salt with the 5 ml of sample solution	Brisk effervescence occurs	Presence of acid
4.	Dip blue litmus paper in the given sample solution	Turns to red in colour	Presence of acid

TEST FOR BASE (use sample 2)

S.No.	Experiment	Observation (Colour change)	Inference (Acid/ Base)
1.	Add a few drops of phenolphthalein with the 5 ml of sample solution	Turns pink in colour	Presence of base
2.	Add a few drops of methyl orange with the 5 ml of sample solution	Turns yellow in colour	Presence of base
3.	Add a pinch of sodium carbonate salt with the 5 ml of sample solution	No brisk effervescence	Presence of base
4.	Dip red litmus paper in the given sample solution	Turns to blue in colour	Presence of base

Result:

The given solution contains ……………………

V. IDENTIFICATION OF PLANT AND ANIMAL TISSUES

BRLSHD

Aim:

To identify the structural features of plant and animal tissues from permanent prepared slides.

Observation:

Identify the given plant and animal tissues.

A) Simple tissues- parenchyma, collenchyma, sclerenchyma

B) Complex tissues-xylem and phloem

C) Epithelial tissue- columnar epithelium, ciliated epithelium

D) Connective tissue- section of bone

E) Muscle tissue- skeletal muscle, smooth and cardiac muscle

F) Nerve tissue

Draw a labelled sketch and write the location and function of the tissues observed.

GLOSSARY

Acids – அமிலங்கள்
Alkalis – எரிகாரங்கள்
Aquaregia – இராஜதிராவகம்
Abundant Elements – அதிக அளவு காணப்படும் தனிமம்
Alloys - உலோகக் கலவைகள்
Adipose tissue – நிணத்திசு. இரத்தச்சவ்வு,கொழுப்பிழையம்
Anion – எதிர்மின் அயனி
Alternating current – மாறு மின்னோட்டம்
Bases – காரங்கள்
Battery – மின்கல அடுக்கு
Bone – எலும்பு
Buccal cavity – வாய்க்குழி
Brittleness – நொறுங்கும் தன்மை
Classificarion – வகைப்படுத்துதல்
Composition – சேர்மங்களில் தனிமங்களின் தொகுப்பு
Catalyst – கிரியா ஊக்கி (வினையை வேகப் படுத்தும் தனிமம்)
Conventional current – மரபு மின்னோட்டம்
Conduction – வெப்பக்கடத்தல்
Convection – வெப்பச்சலனம்
Change of state – நிலைமாற்றம்
Condensation – குளிர்தல்
Compound epithelium – கூட்டு புறப்படலம்
Connective Tissue – இணைப்புத்திசு, இணைப்பிழையம்
Complex tissue – கூட்டுத்திசு
Cardiac muscle – இதயத்தசை
Cartilage – குருத்தெலும்பு
Chemical bond – வேதிப்பிணைப்பு
Covalent bond – சக பிணைப்பு
Coordinate covalent bond – ஈதல் சகபிணைப்பு
Cation – நேர்மின் அயனி
Digestion – செரிமானம்
Digestive gland – செரிமான சுரப்பி
Ductile – கம்பியாக நீட்டக் கூடிய
Direct current – நேர் மின்னோட்டம்
Dental Formula – பற்சூத்திரம்
Dialysis – கூழ்மப்பிரிப்பு
Electronic configuration – எலக்ட்ரான்களின் அமைப்பு
Electric lines of force – மின்விசைக் கோடுகள்
Electric charge – மின்னூட்டம்
Electric current – மின்னோட்டம்
Electrode – மின்வாய்
Electrolyte – மின்பகு திரவம்
Electric cell – மின்கலம்
Electric circuit – மின்சுற்று

GLOSSARY

Electric energy	–	மின்னாற்றல்
Electrical resistance	–	மின்தடை
Equator	–	பூமத்திய ரேகை
Electromagnet	–	மின்காந்தம்
Excretion	–	கழிவு நீக்கம்
Electrostatic	–	நிலைமின்னியல்
Fuse	–	மின்னுருகு இழை
Fixed resistor	–	நிலையான மின்தடை
Freezing	–	உறைதல்
Fibres	–	இழைகள், நார்கள்
Generator	–	மின்னியற்றி
Glomerular filtration	–	குளாமருலர் வடிகட்டுதல்
Halogens	–	உப்பீனிகள்
Heat capacity	–	வெப்பஏற்புத்திறன்
Hydration	–	நீரேற்றம்
Hygroscopic	–	நீரை ஈர்த்தல்
IUPAC	–	தூய மற்றும் பயன்பாட்டு வேதியலுக்கான சர்வதேசக் கழகம்
Inner Transition Elements	–	உள் இடை நிலைத் தனிமம்
Inert gases / Noble gases	–	அரிய வாயு / மந்த வாயு
Internal energy	–	அகஆற்றல
Iron filings	–	இரும்புத் துகள்கள்
Indicators	–	நிறங்காட்டிகள்
Ions	–	அயனிகள்
King of Chemicals	–	வேதிப் பொருள்களின் அரசன்
Ionic bond	–	அயனி பிணைப்பு
Latent heat	–	உள்ளுறை வெப்பம்
Ligament	–	தசை நாண், தசை நார்
Malleable	–	தகடாகும் தன்மையுடைய
Metalloids	–	உலோகப் போலிகள்
Melting	–	உருகுதல்
Mineral	–	கனிமம்
Magnetic field	–	காந்தப்புலம்
Magnetic materials	–	காந்தப்பொருட்கள்
Meristems	–	ஆக்குத்திசு
Mitosis	–	நேர்முகப்பிரிவு, இழையுருப்பிரிவு, கலப்பிரிவு
Meiosis	–	குன்றல் பிரிவு, ஒடுக்கற் பிரிவு
Metal	–	உலோகம்
Non metal	–	அலோகம்
Neutralisation	–	நடுநிலையாக்கல்
Non polar solvant	–	முனைவற்ற கரைப்பான்
Kidney	–	சிறுநீரகம்
Large intestine	–	பெருங்குடல்
Liver	–	கல்லீரல்,
Octaves	–	எண்மம்

Octet rule	–	எண்ம விதி
Oxidation	–	ஆக்ஸிஜனேற்றம்
Oxidation number	–	ஆக்ஸிஜனேற்ற எண்
Periodic	–	ஆவர்த்தன
Properties	–	பண்புகள்
Periodic Table	–	ஆவர்த்தன அட்டவணை
Potential difference (Voltage)	–	மின்னழுத்த வேறுபாடு
Pump	–	இறைப்பான்
Potential difference (Voltage)	–	மின்னழுத்த வேறுபாடு
Penetrate	–	ஊடுருவுதல்
Permanent Tissues	–	நிலைத்த திசுக்கள்
Phloem	–	புளோயம் (பட்டையம்)
Polar solvant	–	முனைவுற்ற கரைப்பான்
Plaster of Paris	–	பாரிஸ் சாந்து
Radioactive Element	–	கதிரியக்க தனிமங்கள்
Resistor	–	மின்தடையம்
Rheostat	–	மின்தடை மாற்றி
Remote control	–	தொலையுணர்வி
Radiation	–	வெப்பக்கதிர்வீச்சு
Red blood Corpuscles	–	இரத்த சிகப்பணுக்கள்
Renal failure	–	சிறுநீரகச்செயலிழப்பு
Reduction	–	ஒடுக்கம்
Temperature	–	வெப்பநிலை
Specific Heat Capacity	–	தன்வெப்பஏற்புத்திறன்
Specific latent heat	–	தன் உள்ளுறை வெப்பம்
Sublimation	–	பதங்கமாதல்
Simple epithelium	–	எளிய புறப்படலம்
Skeletal muscle	–	எலும்புத்தசை
Small intestine	–	சிறுகுடல், மணிக்குடல்
Stomach	–	வயிறு, இரைப்பை
Salts	–	உப்புகள்
Triads	–	மும்மை
Transition Elements	–	இடை நிலத் தனிமம்
Trip switch	–	முறிசாவி
Transformer	–	மின்மாற்றி
Tendons	–	தசை நாண் (நாண்)
Tubular reabsorption	–	குழாய்வழித்திரும்ப உறிசுதல்
Underactive	–	குறைந்த அளவு வினை புரியும் தன்மை கொண்ட
Valance Electrons	–	இணை திறன் கொண்ட எலக்ட்ரான்கள்
Variable resistor	–	மாறு மின்தடை
Vaporization	–	ஆவியாதல்
Valency	–	இணைதிறன்
White blood corpuscles	–	இரத்த வெள்ளையணுக்கள்
Xylem	–	சைலம் (மரவியம்)

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