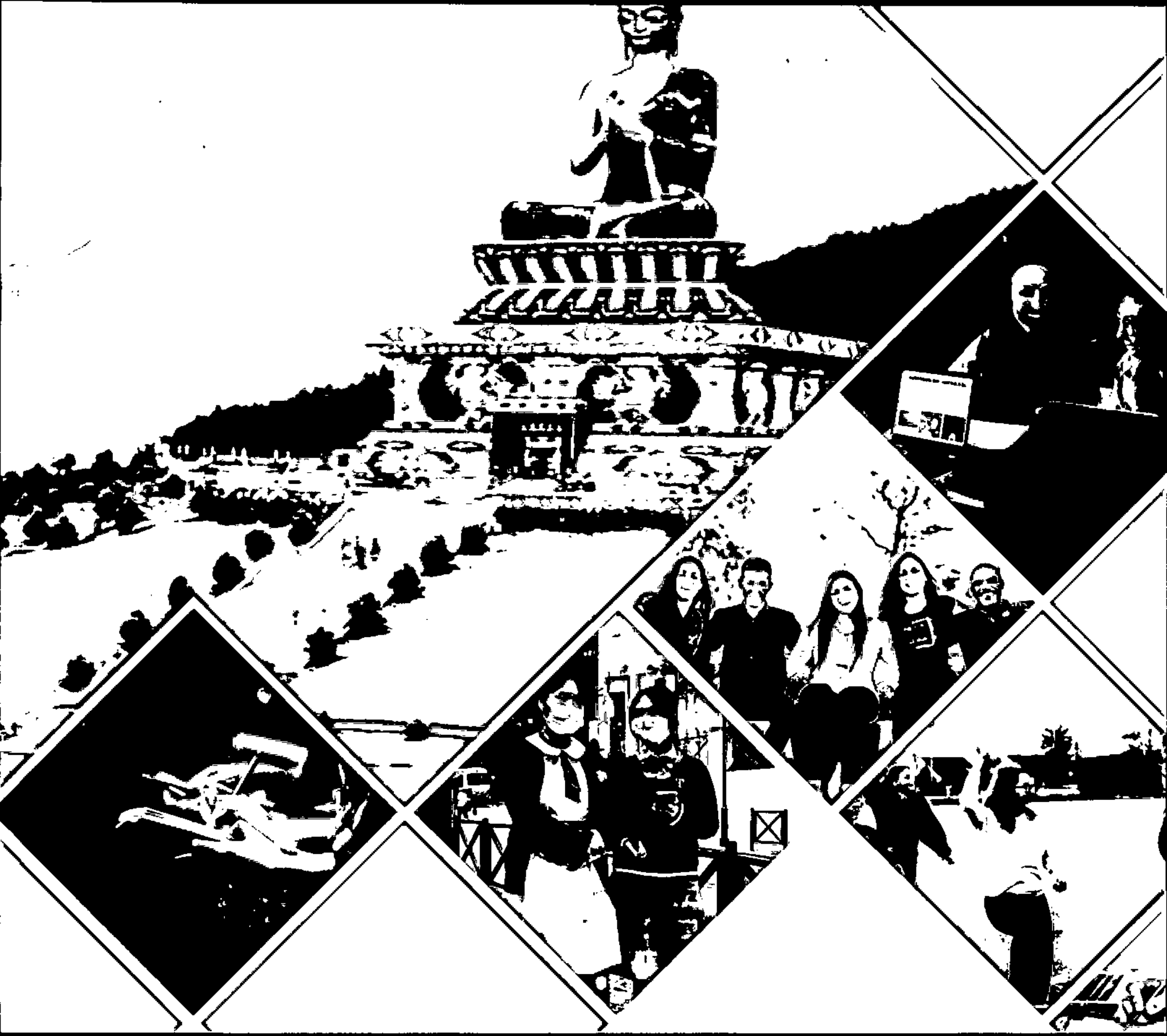
BOARD OF OPEN SCHOOLING AND SKILL EDUCATION
Near Indira Bypass, NH-10, Gangtok, East Sikkim- 737102
Telephone : 03592-295335, 94066 46682 Email : bosse.org.in



The Pathways To Higher Studies

Science And Technology

Class-X

SCIENCE

CLASS 10

Syllabus

Theme: Materials

Unit I: Chemical Substances-Nature and Behaviour

Chemical reactions: Chemical equation, Balanced chemical equation, implication of a balanced chemical equation, types of chemical reactions: Combination, decomposition, displacement, double displacement, precipitation, neutralization, oxidation and reduction.

Acids, bases and salts: Their definitions in terms of furnishing of H+ and OH- ions, General properties, examples and uses, concept of pH scale (Definition relating to logarithm not required), importance of pH in everyday life; preparation and uses of Sodium Hydroxide, bleaching powder, baking soda, Washing soda and Plaster of Paris.

Metals and nonmetals: Properties of metals and non-metals; Reactivity series; Formation and properties of ionic compounds.

Carbon compounds: Covalent bonding in carbon compounds. Versatile nature of carbon. Homologous series.

Periodic classification of elements: Need for classification, early attempts at classification of elements (Dobereiner's Triads, Newland's Law of Octaves, Mendeleev's Periodic Table), Modern periodic table, gradation in properties, valency, atomic number, metallic and non-metallic properties.

Theme: The World of the Living

Unit II: World of Living (50 Periods)

Life processes: 'Living Being'. Basic concept of nutrition, respiration, transport and excretion in plants and animals.

Reproduction: Reproduction in animals and plants (asexual and sexual) reproductive health-need and methods of family planning. Safe sex vs HIV / AIDS. Child bearing and women's health.

Heredity and Evolution: Heredity; Mendel's contribution - Laws for inheritance of traits: Sex determination: brief introduction.

Theme: Natural Phenomena

Unit III: Natural Phenomena

Reflection of light by curved surfaces; Images formed by spherical mirrors, centre of curvature, principal axis, principal focus, focal length, mirror formula (Derivation not required), magnification.

Refraction; Laws of refraction, refractive index.

Refraction of light by spherical lens; Image formed by spherical lenses; Lens formula (Derivation not required); Magnification. Power of a lens.

Refraction of light through a prism, dispersion of light, scattering of light, applications in daily life.

Theme: How Things Work

Unit IV: Effects of Current

Electric current, potential difference and electric current. Ohm's law; Resistance, resistivity, Factors on which the resistance of a conductor depends. Series combination of resistors, parallel combination of resistors and its applications in daily life. Heating effect of electric current and its applications in daily life. Electric power, Interrelation between P, V, I and R.

Magnetic effects of current: Magnetic field, field lines, field due to a current carrying conductor, field due to current carrying coil or solenoid; Force on current carrying conductor, Fleming's Left-Hand Rule, Electric Motor, Electromagnetic induction. Induced potential difference, Induced current. Fleming's Right Hand Rule.

Theme: Natural Resources

Unit V: Natural Resources

Our environment: Eco-system, Environmental problems, Ozone depletion, waste production and their solutions. Biodegradable and non-biodegradable substances.

Theme: Materials

Unit I: Chemical Substances-Nature and Behaviour

1 CHEMICAL REACTIONS

Chemical reactions: Chemical equation, Balanced chemical equation, implication of a balanced chemical equation, types of chemical reactions: Combination, decomposition, displacement, double displacement, precipitation, neutralization, oxidation and reduction.

Objective of the Chapter

The main objective of the unit is to make student understand about:

- Chemical reactions
- Types of chemical reactions

INTRODUCTION

As you know from your earlier studies, a chemical reaction involves breaking of old chemical bonds and formation of new chemical bonds. This change may happen spontaneously or it may be facilitated by external forces or energy. Chemistry is all about chemical reactions. In your day to day life, you could observe many chemical reactions. A clear understanding of these reactions is essential in order to manipulate them for the sake of human life and environment. So, chemistry mainly focuses on chemical reactions. Let us try to find the answer for the following questions:

- You need energy to play, walk, run or to perform various physical activities. Where do you get the energy from?
- How do plants grow and get their food? How does a car move use fuel?
- Why does iron rust on its exposure to water or air?

You get energy from the digestion of the food you eat. Plants grow by absorbing nutrients from the Earth and get their food by photosynthesis. The combustion of a fuel makes the car to move. Oxidation of iron causes rusting. So, all these processes are chemical changes i.e. the materials, which undergo changes are converted into some other new materials. For example, by burning petrol, the hydrocarbons present in it are converted into carbon dioxide and water. In this chapter, let us discuss the nature and types of chemical reactions.

What happens during a chemical reaction?

- In a chemical reaction, the atoms of the reacting molecules or elements are rearranged to form new molecules.

- Old chemical bonds between atoms are broken and new chemical bonds are formed.
- Bond breaking absorbs energy whereas bond formation releases energy

How are chemical reactions represented?

When methane reacts with oxygen, it forms carbon dioxide and water. How can you represent this reaction? It can be written as a word equation as shown below:

Methane + Oxygen → Carbon dioxide + Water

But this equation does not give the chemical composition of the reactants and products. So, to learn the characteristics of a chemical reaction, it is represented by a chemical equation. In the chemical equation, the chemicals of the reaction are represented by their chemical formulas. The compounds or elements, which undergo reactions (reactants) are shown to the left of an arrow and the compounds formed (products) are shown to the right of the arrow. The arrow indicates the direction of the reaction. Thus, the aforesaid reaction can be written as follows:

$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$

But this is also an incomplete chemical equation. Because, the law of conservation of matter states that matter cannot be created or destroyed. You cannot create new atoms by a chemical reaction. In contrast, they are rearranged in different ways by a chemical reaction to form a new compound. So, in a chemical equation, the number of atoms of the reactants and that of the products must be equal. The number of hydrogen and oxygen atoms in the reactants and the products are not equal in the given equation. On balancing the number of atoms, the following equation can be obtained:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Further, the chemical equation provides information on the physical state of the substances and the conditions under which the reaction takes place.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Methane Oxygen Carbon Dioxide Water

$$\underset{\text{Methane}}{CH_{4(g)}} + \underset{\text{Oxygen}}{2O_{2(g)}} \rightarrow \underset{\text{Carbon dioxide}}{CO_{2(g)}} + \underset{\text{Water}}{2H_2O_{(g)}}$$

A balanced chemical equation is the simplified representation of a chemical reaction which describes the chemical composition, physical state of the reactants and the products, and the reaction conditions.

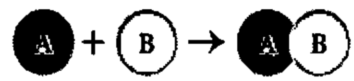
TYPES OF CHEMICAL REACTIONS

1. **Classification based on the nature of rearrangements of atoms**

   So far you studied about a chemical reaction and how it can be described as a chemical equation. A large number of chemical reactions are taking place around us every day. Are they taking place in a similar way? No. Each reaction involves different kinds of atoms and hence the way they react also differs. Thus, based on the manner by which the atoms of the reactants are rearranged, chemical reactions are classified as follows.

(a) Combination reactions

A combination reaction is a reaction in which two or more reactants combine to form a compound. It is otherwise called 'synthesis reaction' or 'composition reaction'. When a reactant 'A' combines with 'B', it forms the product 'AB'. The generalised scheme of a combination reaction is given below:



Example: Hydrogen gas combines with chlorine gas to form hydrogen chloride gas.

$H_2(g) + Cl_{2(g)} \rightarrow 2HCl_{(g)}$

Depending on the chemical nature of the reactants, there are **three classes** of combination reactions:

Element + Element → Compound

In this type of combination reaction, two elements react with one other to form a compound. The reaction may take place between a metal and a non-metal or two non-metals.

Example 1: When solid sulphur reacts with oxygen, it produces sulphur dioxide. Here both the reactants are non-metals.

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

Example 2: Sodium, a silvery-white metal, combines with chlorine, a pale-yellow green gas, to form sodium chloride, an edible compound. Here one of the reactants is a metal (sodium) and the other (chlorine) is a non-metal.

$$2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$$

Test Yourself:

Identify the possible combination reactions between the metals and non-metals given in the following table and write their balanced chemical equations:

Metals	Non-metals
Na, K, Cs, Ca, Mg	F, Cl, Br, I

Compound + Element → Compound

In this case, a compound reacts with an element to form a new compound. For instance, phosphorous trichloride reacts with chlorine gas and forms *phosphorous pentachloride.*

$$PCl_{3(l)} + Cl_{2(g)} \rightarrow PCl_{5(s)}$$

Compound + Compound → Compound

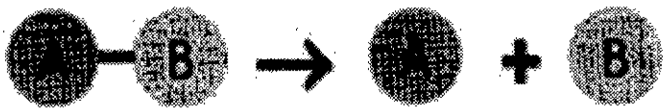
It is a reaction between two compounds to form a new compound. In the following reaction, silicon dioxide reacts with calcium oxide to form calcium silicate.

$$SiO_{2(s)} + CaO_{(s)} \rightarrow CaSiO_{3(s)}$$

Most of the combination reactions are exothermic in nature. Because, they involve the formation of new bonds, which releases a huge amount of energy in the form of heat.

(b) *Decomposition reactions*

In a decomposition reaction, a single compound splits into two or more simpler substances under suitable conditions. It is the opposite of the combination reaction. The **generalised scheme** of a decomposition reaction is given below:



Breaking of bonds is the major phenomenon in a decomposition reaction and hence it requires energy to break the bonds, depending on the nature of the energy used in the decomposition reaction.

There are three main classes of decomposition reactions. They are

(i) Thermal Decomposition Reactions

(ii) Electrolytic Decomposition Reactions

(iii) Photo Decomposition Reactions

(i) Thermal Decomposition Reactions

In this type of reaction, the reactant is decomposed by applying heat. For example, on heating mercury (II) oxide is decomposed into mercury metal and oxygen gas. As the molecule is dissociated by the absorption of heat, it is otherwise called 'Thermolysis'. It is a class of compound to element/element decomposition. i.e. a compound (HgO) is decomposed into two elements (Hg and Oxygen).

$$2HgO_{(s)} \xrightarrow{Heat} 2Hg_{(l)} + O_{2(g)}$$

Similarly, when calcium carbonate is heated, it breaks down in to calcium oxide and carbon dioxide.

It is a type of compound to compound/compound decomposition.

$$CaCO_{3(s)} \xrightarrow{Heat} CaO_{(s)} + CO_{2(g)}$$

In thermal decomposition reaction, heat is supplied to break the bonds. Such reactions, in which heat is absorbed, are called **'Endothermic reactions.**

(ii) Electrolytic Decomposition Reactions

In some of the decomposition reactions, electrical energy is used to bring about the reaction.

For example, decomposition of sodium chloride occurs on passing electric current through its aqueous solution. Sodium chloride decomposes in to metallic sodium and chlorine gas. This process is termed as 'Electrolysis'.

$$2NaCl_{(aq)} \xrightarrow{Electricity} 2Na_{(s)} + Cl_{2(g)}$$

Here, a compound (NaCl) is converted into elements (Na and chlorine). So, it is a type of compound to element/element decomposition.

(iii) Photo Decomposition Reactions

Light is another form of energy, which facilitates some of the decomposition reactions. For example, when silver bromide is exposed to light, it breaks down into silver metal and bromine gas. As the decomposition is caused by light, this kind of reaction is also called **'Photolysis'.**

$$2AgBr_{(s)} \xrightarrow{Light} 2Ag_{(s)} + Br_{2(g)}$$

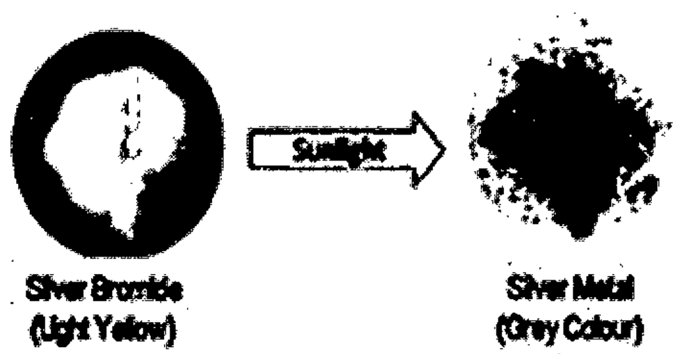
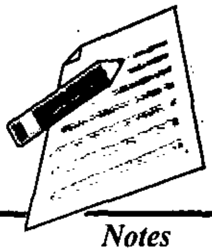


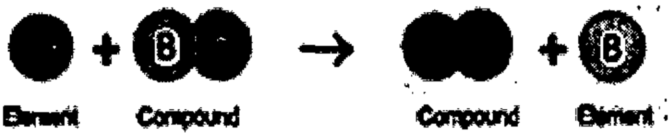
Photo decomposition of silver bromide

The yellow coloured silver bromide turns into grey coloured silver metal. It is also a compound to element/element decomposition.

(c) Single Displacement Reactions

It is a reaction between an element and a compound. When they react, one of the elements of the compound-reactant is replaced by the element-reactant to form a new compound and an element. The general schematic representation of a single displacement reaction is given as:



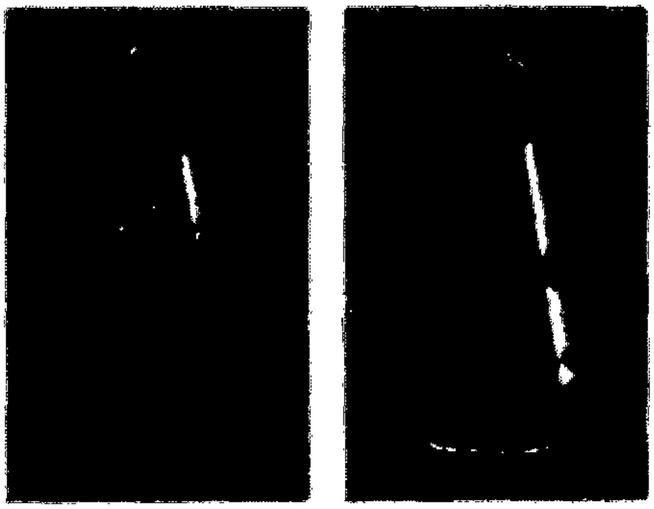


'A' displaces element 'B' from the compound 'BC' and hence a single displacement reaction occurs. If zinc metal is placed in hydrochloric acid, hydrogen gas is evolved. Here, hydrogen is displaced by zinc metal and zinc chloride is formed.

$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

$Fe_{(s)} + CuSO4_{(aq)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$

If an iron nail is placed in an aqueous solution of copper (II) sulphate as shown in Fig. 10.2, the iron displaces copper from its aqueous solution and the so formed copper deposits over the iron nail.



Displacement of copper

It is easy to propose so many reactions of this kind with different combinations of reactants. Will they all occur in practice? No. This is most easily demonstrated with halogens. Let us consider the following two reactions:

$2NaCl_{(aq)} + F_{2(g)} \rightarrow 2NaF_{(aq)} + Cl_{2(g)}$

$2NaF_{(aq)} + Cl_{2(g)} \rightarrow 2NaCl_{(aq)} + F_{2(g)}$

The first reaction involves the displacement of chlorine from NaCl, by fluorine. In the second reaction, chlorine displaces fluorine from NaF. Out of these two, the second reaction will not occur. Because, fluorine is more active than chlorine and occupies the upper position in the periodic table. So, in *displacement reactions*, the activity of the elements and their relative position in the periodic table are the key factors to determine the feasibility of the reactions. More active elements readily displace fewer active elements from their aqueous solution.

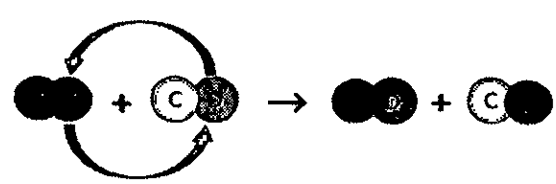
The activity series of some elements is given below:

To remember	Activity Series	
• Please	Potassium (K)	↑ Most reactive
• Send	Sodium (Na)	
• Lions	Lithium (Li)	
• Cats	Calcium (Ca)	
• Monkeys	Magnesuim (Mg)	
• And	Aluminium (Al)	
• Zebras	Zinc (Zn)	
• Into	Iron (Fe)	
• Lovely	Lead (Pb)	
• Hot	Hydrogen (H) non-metal	
• Countries	Copper (Cu)	
• Signed	Silver (Ag)	
• General	Gold (Au)	
• Penguin	Platinum (Pt)	Least reactive

By referring the activity series, try to answer the following questions: Which of the metals displaces hydrogen gas from hydrochloric acid? Silver or Zinc. Give the chemical equation of the reaction and Justify your answer

(d) Double Displacement Reactions

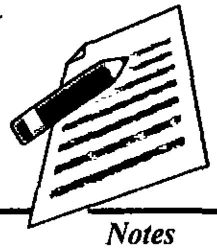
When two compounds react, if their ions are interchanged, then the reaction is called double displacement reaction. The ion of one compound is replaced by the ion of another compound. Ions of identical charges are only interchanged, i.e., a cation can be replaced by other cations. This reaction is also called '**Metathesis Reaction**'. The schematic representation of a double displacement reaction is given below:



For a double displacement reaction to take place, one of the products must be a precipitate or water. By this way, there are major classes of double displacement reactions. They are:

(i) Precipitation Reactions

(ii) Neutralization Reactions



(i) Precipitation Reactions

When aqueous solutions of two compounds are mixed, if they react to form an insoluble compound and a soluble compound, then it is called precipitation reaction. Because the insoluble compound, formed as one of the products, is a precipitate and hence the reaction is so called.

Differences between combination and decomposition reactions

COMBINATION REACTIONS	DECOMPOSITION REACTIONS
One or more reactants combine to form a single product	A single reactant is decomposed to form one or more products
Energy is released	Energy is absorbed
Elements or compounds may be the reactants	Single compound is the reactant

When the clear aqueous solutions of potassium iodide and lead (II) nitrate are mixed, a double displacement reaction takes place between them.

$Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \rightarrow PbI_{2(s)}\downarrow + 2KNO_{3(aq)}$

Potassium and lead displace or replace one other and form a yellow precipitate of lead (II) iodide as shown in Fig. 10.3.

Precipitation of PbI_2

(ii) Neutralization Reactions

In your lower classes, you have learned the reaction between an acid and a base. It is another type of displacement reaction in which the acid reacts with the base to form a salt and water. It is called 'neutralization reaction' as both acid and base neutralize each other.

Acid + Base → Salt + [illegible]

Reaction of sodium hydroxide with hydrochloric acid is a typical neutralization reaction. Here, sodium replaces hydrogen from hydrochloric acid forming sodium chloride, a neutral soluble salt.

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

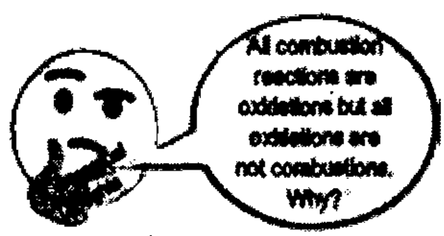
Similarly, when ammonium hydroxide reacts with nitric acid, it forms ammonium nitrate and water.

$$HNO_{3(aq)} + NH_4OH_{(aq)} \rightarrow NH_4NO_{3(aq)} + H_2O_{(l)}$$

(e) Combustion Reactions

A combustion reaction is one in which the reactant rapidly combines with oxygen to form one or more oxides and energy (heat). So, in combustion reactions, one of the reactants must be oxygen. Combustion reactions are majorly used as heat energy sources in many of our day to day activities. For instance, we use LPG gas for domestic cooking purposes. We get heat and flame from LPG gas by its combustion reaction of its constituent gases. LPG is a mixture of hydrocarbon gases like propane, butane, propylene, etc. All these hydrocarbons burn with oxygen to form carbon dioxide and water.

$$\underset{\text{Propane}}{C_3H_{8(g)}} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)} + \text{Heat}$$



Since heat is evolved, it is an exothermic reaction. As oxygen is added, it is also an oxidation. So, combustion may be called as an exothermic oxidation. If a flame is formed (as shown in Fig. 10.4), then it is called **burning**.

Combustion of LPG gas

Which of the following is a combustion?

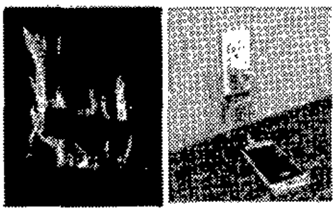
(i) Digestion of Food

(ii) Rusting of iron

Many thousands of reactions fall under these five categories and further you will learn in detail about these reactions in your higher classes.

2. **Classification based on the direction of the reaction**

You know that innumerable changes occur every day around us. Are all they permanent? For example, liquid water freezes into ice, but then ice melts into liquid water. In other words, freezing is reversed. So, it is not a permanent change. Moreover, it is a physical change. Physical changes can be reversed easily. Can chemical changes be reversed? Can the products be converted into reactants? Let us consider the burning of a wood. The carbon compounds present in the wood are burnt into carbon dioxide gas and water. Can we get back the wood immediately from carbon dioxide and water? We cannot. So, it is a permanent change. In most of the cases, we cannot. But some chemical reactions can be reversed. Our mobile phone gets energy from its lithium ion battery by chemical reactions. It is called discharging. On recharging the mobile, these chemical reactions are reversed. Thus, chemical reactions may be reversed under suitable conditions. Hence, they are grouped into two categories such as reversible and irreversible reactions.



Burning of wood and recharging of mobile battery

Reversible Reactions

A reversible reaction is a reaction that can be reversed, i.e., the products can be converted back to the reactants. A reversible reaction is represented by a double arrow with their heads in the direction opposite to each other. Thus, a reversible reaction can be represented by the following equation:

Explanation: Here, the compound 'AB' undergoes decomposition to form the products 'A' and 'B'. It is the **forward reaction**. As soon as the products are formed, they combine together to form 'AB'. It is the **backward reaction**. So, the reaction takes place in both the directions. Do you think then that no products are formed in the aforesaid reaction? If you think so, you are wrong. Because, *even though the reaction takes place in both the directions, at the initial stage the rates (speed) of these reactions are not equal.* Consider the following decomposition reaction of phosphorous pentachloride into phosphorous trichloride and chlorine.

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

The forward reaction is the decomposition of PCl_5 and the backward reaction is the combination of PCl_3 and Cl_2. Initially, the forward reaction proceeds faster than the backward reaction. After sometimes, the speed of both the reactions become equal. So, PCl_5 cannot be completely converted into the products as the reaction is reversed. It is a reversible reaction. The actual measurements of the given reaction show that the reaction is at equilibrium, but the amount of PCl_5 is more than that of PCl_3 and Cl_2.

Thus, a greater number of products can be obtained in a reversible reaction by the periodical removal of one of the products or the periodical addition of the reactants.

$$2H_2O_{2(aq)} \rightleftharpoons 2H_2O_{(l)} + O_{2(g)}$$

Irreversible Reactions

The reaction that cannot be reversed is called **irreversible reaction**. The irreversible reactions are unidirectional, i.e., they take place only in the forward direction. Consider the combustion of coal into carbon dioxide and water.

$$\underset{\text{Coal}}{C_{(s)}} + \underset{\text{Oxygen}}{O_{2(g)}} \rightarrow \underset{\text{Carbon dioxide}}{CO_{2(g)}} + \text{Heat}$$

In this reaction, solid coal burns with oxygen and gets converted into carbon dioxide gas and water. As the product is a gas, as soon as it is formed it escapes out of the reaction container. It is extremely hard to decompose a gas into a solid. Thus, the backward reaction is not possible in this case. So, it is an irreversible reaction. Table provides the main differences between a reversible and an irreversible reaction:

Differences Between Reversible and Irreversible Reactions

Reversible Reaction	Irreversible Reaction
It can be reversed under suitable conditions.	It cannot be reversed.
Both forward and backward reactions take place simultaneously.	It is unidirectional. It proceeds only in forward direction.
It attains equilibrium.	Equilibrium is not attained.
The reactants cannot be converted completely into products.	The reactants can be completely converted into products.
It is relatively slow.	It is fast.

You will learn more about these reactions in your higher classes.

Summary of the Chapter

1. **Chemical reactions-** The transformation of chemical substance into a new chemical substance by making and breaking of bonds between different atoms is known as Chemical Reaction.

2. **Signs of a chemical reaction-** These factors denote that a chemical reaction has taken place- change of state of substance, change of colour of substance, evolution of heat, absorption of heat, evolution of gas and evolution of light.

3. **Chemical Equation:** The representation of chemical reaction by means of symbols of substances in the form of formulae is called chemical equation. E.g. - $H_2 + O_2 \Rightarrow H_2O$

4. **Balanced Chemical Equation:** A balanced chemical equation has number atoms of each element equal on both left and right sides of the reaction.

***Note–** According to Law of Conservation of Mass, mass can neither be created nor destroyed in a chemical reaction. To obey this law, the total mass of elements present in reactants must be equal to the total mass of elements present in products.

Types of Chemical Reactions-

(i) **Combination-** When two elements or one element and one compound or two compounds combines to give one single product.

(ii) **Decomposition-** Splitting of a compound into two or more simple products.

(iii) **Displacement-** It takes place when a more reactive metal displaces a less reactive metal.

(iv) **Double displacement-** Reactions in which ions are exchanged between two reactants forming new compounds are called double displacement reactions.

(v) **Precipitation-** The insoluble compound called precipitate forms in this reaction.

(vi) **Exothermic-** Reactions which produce energy are called exothermic reaction. Most of the decomposition reactions are exothermic.

(vii) **Endothermic-** Reactions which absorb energy are called endothermic reaction. Most of the combination reactions are endothermic.

(viii) **Oxidation:** Gain of oxygen or removal of hydrogen or metallic element from a compound is known as oxidation.

(iv) **Reduction:** Addition of hydrogen or removal of oxygen from a compound is called reduction.

(x) **Redox-** A chemical reactions where oxidation and reduction both take place simultaneously are also known as redox reaction.

E.g. – $NaOH + HCl \Rightarrow NaCl + H_2O$

EXERCISE

Multiple Choice Questions

1. The chemical formula of lead sulphate is
   (a) Pb_2SO_4
   (b) $Pb(SO_4)_2$
   (c) $PbSO_4$
   (d) $Pb_2(SO_4)_3$
2. Which information is not conveyed by a balanced chemical equation?
   (a) Physical states of reactants and products
   (b) Symbols and formulae of all the substances involved in a particular reaction
   (c) Number of atoms/molecules of the reactants and products formed
   (d) Whether a particular reaction is actually feasible or not
3. Chemically rust is
   (a) hydrated ferrous oxide
   (b) only ferric oxide
   (c) hydrated ferric oxide
   (d) none of these
4. Both CO_2 and H_2 gases are
   (a) heavier than air
   (b) colourless
   (c) acidic in nature
   (d) soluble in water
5. Which of the following gases can be used for storage of fresh sample of an oil for a long time?
   (a) Carbon dioxide or oxygen
   (b) Nitrogen or helium
   (c) Helium or oxygen
   (d) Nitrogen or oxygen
6. The electrolytic decomposition of water gives H_2 and O_2 in the ratio of
   (a) 1 : 2 by volume
   (b) 2 : 1 by volume
   (c) 8 : 1 by mass
   (d) 1 : 2 by mass
7. In the decomposition of lead (II) nitrate to give lead (II) oxide, nitrogen dioxide and oxygen gas, the coefficient of nitrogen dioxide (in the balanced equation) is
   (a) 1
   (b) 2
   (c) 3
   (d) 4

8. Fatty foods become rancid due to the process of
(a) oxidation
(b) corrosion
(c) reduction
(d) hydrogenation

9. We store silver chloride in a dark coloured bottle because it is
(a) a white solid
(b) undergoes redox reaction
(c) to avoid action by sunlight
(d) none of the above

10. Silver article turns black when kept in the open for a few days due to formation of
(a) H_2S
(b) AgS
(c) $AgSO_4$
(d) Ag_2S

11. When crystals of lead nitrate are heated strongly in a dry test tube
(a) crystals immediately melt
(b) a brown residue is left
(c) white fumes appear in the tube
(d) a yellow residue is left

12. Dilute hydrochloric acid is added to granulated zinc taken in a test tube. The following observations are recorded. Point out the correct observation.
(a) The surface of metal becomes shining
(b) The reaction mixture turns milky
(c) Odour of a pungent smelling gas is recorded
(d) A colourless and odourless gas is evolved

13. When carbon dioxide is passed through lime water,
(a) calcium hydroxide is formed
(b) white precipitate of CaO is formed
(c) lime water turns milky
(d) colour of lime water disappears.

14. When a magnesium ribbon is burnt in air, the ash formed is
(a) black
(b) white
(c) yellow
(d) pink

15. In which of the following, heat energy will be evolved?
(a) Electrolysis of water
(b) Dissolution of NH4Cl in water
(c) Burning of L.P.G.
(d) Decomposition of AgBr in the presence of sunlight

16. Rancidity can be prevented by
    (a) adding antioxidants
    (b) storing food away from light
    (c) keeping food in refrigerator
    (d) all of these
17. The reaction of H_2 gas with oxygen gas to form water is an example of
    (a) combination reaction
    (b) redox reaction
    (c) exothermic reaction
    (d) all of these reactions
18. The reaction in which two compounds exchange their ions to form two new compounds is called
    (a) displacement reaction
    (b) combination reaction
    (c) double displacement reaction
    (d) redox reaction
19. On immersing an iron nail in $CuSO_4$ solution for few minutes, you will observe
    (a) *no reaction takes place*
    (b) the colour of solution fades away
    (c) the surface of iron nails acquires a black coating
    (d) the colour of solution changes to green
20. An element X on exposure to moist air turns reddish-brown and a new compound Y is formed. The substance X and Y are
    (a) X = Fe, Y = Fe_2O_3
    (b) X = Ag, Y = Ag_2S
    (c) X = Cu, Y = CuO
    (d) X = Al, Y = Al_2O_3

Answers

1. (c)	**2.** (d)	**3.** (c)	**4.** (b)	**5.** (b)
6. (b)	**7.** (d)	**8.** (a)	**9.** (c)	**10.** (d)
11. (b)	**12.** (d)	**13.** (c)	**14.** (b)	**15.** (c)
16. (d)	**17.** (a)	**18.** (c)	**19.** (d)	**20.** (a)

HOTS

Chemical Reactions and Equations

1. What is a redox reaction?
2. What is corrosion? Explain its advantage and disadvantage.
3. What is rancidity? How can we reduce the problem of rancidity?
4. How is corrosion different from rusting?
5. What is meant by endothermic and exothermic reactions? Give suitable example for each.
6. Define different types of chemical reaction and give examples for each.

7. Why is photosynthesis considered as an endothermic reaction?
8. In electrolysis of water, why is the volume of gas collected over one electrode double that of the other electrode?
9. What happens when water is added to solid calcium oxide taken in a container? Write a chemical formula for the same.
10. Give one use of quick lime.
11. Give three types of decomposition reaction.
12. Name the compound used for testing CO^2 gas.

CLASS–10

Science

Notes

Space for Work

Theme: Materials

Unit I: Chemical Substances-Nature and Behaviour

2 ACIDS, BASES AND SALTS

Acids, bases and salts: Their definitions in terms of furnishing of H+ and OH- ions, General properties, examples and uses, concept of pH scale (Definition relating to logarithm not required), importance of pH in everyday life; preparation and uses of Sodium Hydroxide, bleaching powder, baking soda, Washing soda and Plaster of Paris.

The main objective of this chapter is to explain about Acids, Bases and Salts Including their properties and uses.

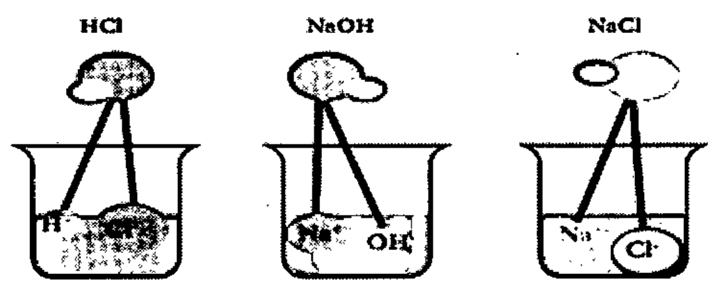
- **Acids,**
- **Bases and**
- **Salts**

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. yet play a key role in our day-to-day activities.

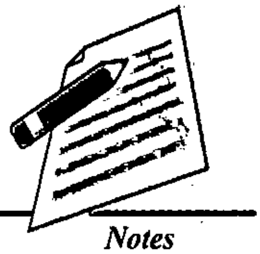
Our body metabolism is carried out by means of hydrochloric acid secreted in our stomach.



(a) Acid **(b) Base** **(c) Salt**

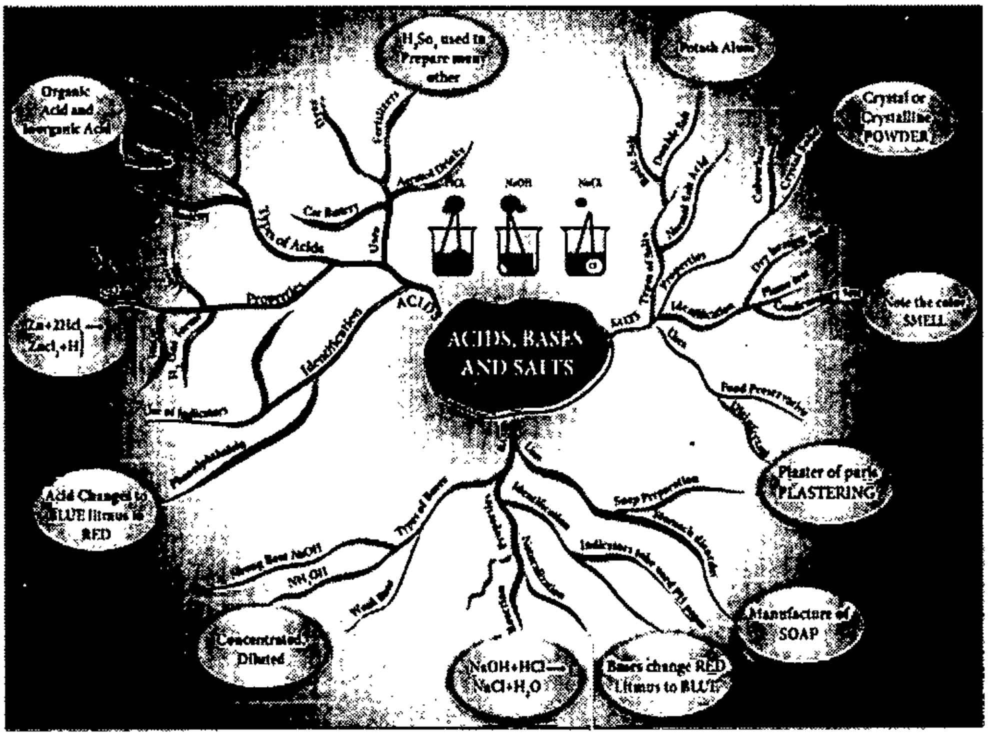
Acid, base and salt

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.



Notes

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.

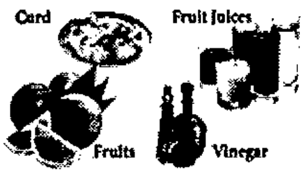


What are Acids

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.

What are Acids?

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



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.

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.

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

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

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.

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.

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.

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

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

(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.

$CaO + H_2SO_4 \rightarrow CaSO_4 + H_2O$

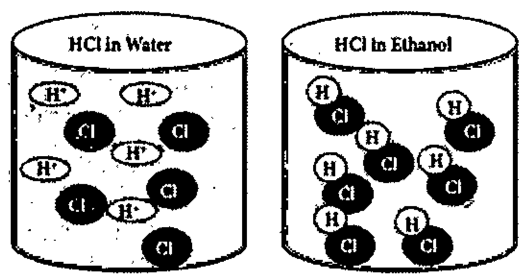
(g) Acids react with bases to give salt and water.

$HCl + NaOH \rightarrow NaCl + H_2O$

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.*



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.
4. **Aqua Regia**

   We know that metals like gold and silver are not reactive with either HCl or HNO3. But the mixture of these two acids can dissolve gold. This mixture is called Aqua Regia. 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 aqua regia is a Latin phrase meaning "King's Water". The name reflects the ability of aqua regia to dissolve the noble metals such as gold, platinum and palladium.

Uses of Aqua Regia:

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

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.

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.

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

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, $Ca(OH)_2$

2. Properties of Bases:

(a) They have bitter taste.

(b) Their aqueous solutions have soapy touch.

(c) They turn red litmus blue

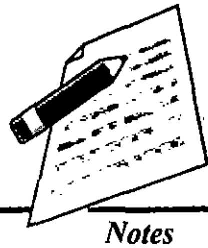
(d) Their aqueous solutions conduct electricity

(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.

$NaOH + NH_4Cl \rightarrow NaCl + H_2O + NH_3 \uparrow$

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.

3. Uses of Bases

- Sodium hydroxide is used in the manufacture of soap.
- Calcium hydroxide is used in white washing of building.
- Magnesium hydroxide is used as a medicine for stomach disorder.
- Ammonium hydroxide is used to remove grease stains from cloths.

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.

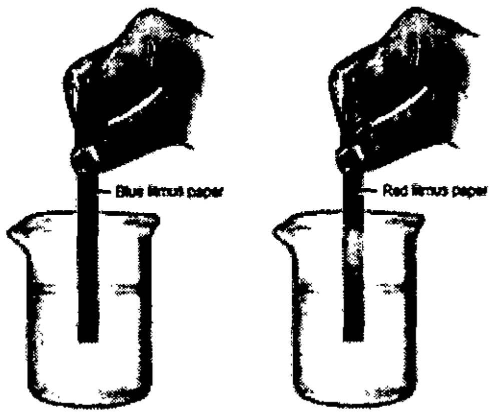
(a) Test with a litmus paper:

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.



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.

Test for acid and base using indicator

Acid base indicator

Indicator	Colour in acid	Colour in base
Litmus	Blue to Red	Red to Blue
Phenolphthalein	Colourless	Pink
Methyl orange	Pink	Yellow

How strong are Acid or Base solutions?

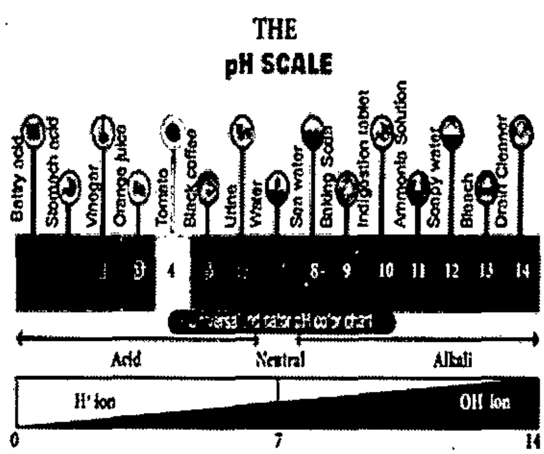
pH Scale

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

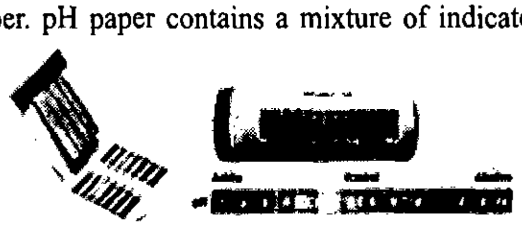
1. How can we measure the pH of a given solution?

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.



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.



Indicators and pH paper

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 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.

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

What are Salts

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.

$$\boxed{\text{Acid}} + \boxed{\text{Base}} \rightarrow \boxed{\text{Salt}} + \boxed{\text{Water}}$$

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.

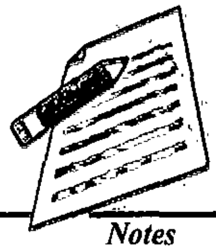
   $KAl(SO_4)_2.12H_2O$

2. **Properties of Salts**

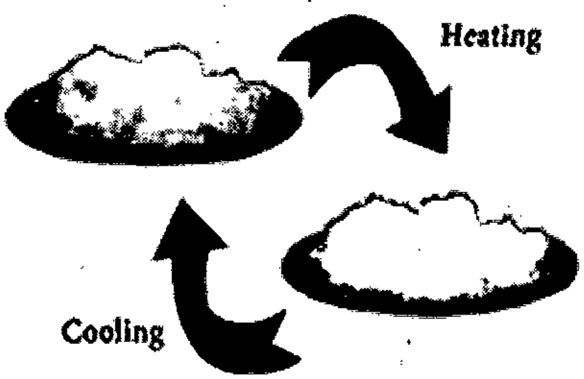
   - Salts are mostly solids which melt as well as boil at high temperature.
   - Most of the salts are soluble in water. For example, chloride salts of potassium and sodium are soluble in water. But silver chloride is insoluble in water They are odourless, mostly white, cubic crystals or crystalline powder with salty taste.
   - Salt is hygroscopic in nature.

3. **Water of Crystallisation**

   Many salts are found as crystals with water molecules they contain. ese 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 an er the dot·in its chemical formula. For example, copper sulphate crystal have ve molecules of water for each molecule of copper sulphate. It is written as $CuSO_4.5H_2O$ and named as copper sulphate pentahydrate. is water of crystallisation makes the copper sulphate blue. When it is heated, it loses its water molecules and becomes white.



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:

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.

   (ii) **Dry heating Test.**

   is test is performed by heating a small amount of salt in a dry test tube. An er 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+}

Preparation and Uses of Baking Soda

SODIUM BICARBONATE OR BAKING SODA - DEFINITION

Formula: NaHCO3

Properties:

Sodium hydrogen carbonate is a white crystalline solid having a density of about 2.2 g/ml. It has alkaline taste and is sparingly soluble in water.

The solubility of sodium hydrogen carbonate increases with the rise of temperature.

USES OF SODIUM BICARBONATE OR BAKING SODA - DEFINITION

1. As a component of baking powder.
2. In fire extinguishers.
3. In medicines as a mild antiseptic for skin diseases and to neutralize the acidity of the stomach.
4. As a reagent in laboratory.

METHODS OF PREPRATION OF BAKING SODA - DEFINITION

Sodium hydrogen carbonate (baking soda) is made by saturating a solution of sodium carbonate with carbon dioxide.

The white crystalline powder of sodium hydrogen carbonate being less soluble, gets separated out.

What is washing soda ($Na_2CO_3.10H_2O$)?

Washing soda finds its application in numerous ways, be it from household uses to a vast range of industrial applications. It is an alkaline compound with a high alkaline character which has the capability to remove adamant stains from clothes during washing. Washing soda formula is written as $Na_2CO_3.10H_2O$. The chemical name of washing soda is sodium carbonate. Chemically soda ash is a hydrated salt of sodium carbonate.

Solvay Process- Preparation of Sodium Carbonate

Steps involved in the manufacture of sodium carbonate are explained below:

- Purification of Brine
- Formation of sodium hydrogen carbonate
- Formation of sodium carbonate
- Recovery of ammonia

Step 1: Purification of Brine

Concentrated brine is obtained by the process of evaporation and impurities like calcium, magnesium, etc are removed by the precipitation process. The concentrated brine solution undergoes filtration and is mixed with ammonia in the ammonia tower and the ammonia tower gets cooled.

Step 2: Formation of sodium hydrogen carbonate

In a carbonate tower, carbon dioxide is passed through an ammoniated brine solution.

$NH_3(aq) + CO_2(g) + NaCl(aq) + H_2O \rightarrow NaHCO_3(s) + NH_4Cl(aq)$

Step 3: Formation of sodium carbonate

Sodium Bicarbonate ($\underline{NaHCO_3}$) formed is obtained from the tower and is heated at a temperature of 300°C. Hence, formations of sodium carbonate take place.

$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

Step 4: Recovery of ammonia

Ammonia can be recovered by treating the solution of NH_4Cl with Ca $(OH)_2$. This ammonia is again used in the Solvay process and $CaCl_2$ is obtained as a by-product.

$2NH_4Cl + Ca\ (OH)_2 \rightarrow 2NH_3 + CaCl_2 + H_2O$

Physical properties and chemical properties of sodium carbonate:

- It is a crystalline solid which is white.
- It exists as a monohydrated salt ($Na_2CO_3.10H_2O$), anhydrous salt (Na_2CO_3), heptahydrous salt ($Na_2CO_3.7H_2O$) and decahydrate salt ($Na_2CO_3.10H_2O$).
- Sodium carbonate is basic in nature.
- It has a melting point of 851°C.
- In the presence of heat, it loses its water to form an anhydrous salt (soda ash).

  $Na_2CO_3.10H_2O \rightarrow Na_2CO_3.H_2O \rightarrow Na_2CO_3$ (at 373 K)

Uses of Washing Soda:

- Used as a cleansing agent in industries and household.
- It finds its application in paper, textile, soap, and detergent industries.
- It is used in the process of softening of water.
- It is used in the manufacturing of glass.
- It is one of the most important agents in laundries.

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Summary of the Chapter

Acids: Acids are sour in taste, turn blue litmus to red, dissolve in water to release H^+ ions.

E.g., vinegar, hydrochloric acid and sulphuric acid.

- **Reaction with Metal**

  Acid + Metal $\rightarrow$ Salt + Hydrogen gas

  e.g., $2HCl + Zn \rightarrow ZnCl_2 + H_2$

- **Reaction with Metal carbonate**

  Acid + Metal carbonate → Salt + CO_2 + H_2O

  e.g., 2HCl + Na_2CO_3 → 2NaCl + CO_2 + H_2O

- Reaction with Metal hydrogen carbonate

  Acid + Metal hydrogen carbonate Salt + CO_2 + H_2O

  e.g. HCl + $NaHCO_3$ → NaCl + H_2O + CO_2

- **Reaction with Metallic oxide**

  Acid + Metal oxide → Salt + Water

  e.g. 2HCl + CuO → $CuCl_2$ + H_2O

- **Acids in water:**

  Acids produce H^+ ions when dissolved in water. H+ ions cannot exist alone. They combine with water molecule (H_2O) to form H_3O^+ (hydronium ions). It conducts electricity..

- Decrease in H_30+ ions concentration per unit volume results in formation of dilute acids.

- It is a highly exothermic reaction.

  Acids when dissolved in water release large amount of heat. If water is added to concentrated acid then the heat generated may cause the mixture to splash out and cause bums. Hence to avoid burns acid must be added drop wise into water with constant stirring. So that the heat generated spreads over in water.

  strong acids → release more H^+ ions → HCl

  weak acids → releases a smaller number of H^+ ions → acetic acid

  strong base → give more OH– ions → NaOH

  weak base → gives less OH– ions → CH_3COOH

Bases: Bases are bitter in taste, turns red litmus to blue and when dissolved in water releases OH– ions;

e.g., NaOH and KOH.

- **Reaction with metal**

  Base + Metal → Salt + H_2 gas

  e.g., 2NaOH + Zn → Na_2ZnO_2 + H_2

  This reaction is possible only with reactive metals like sodium and potassium.

- **Reaction with non-metallic oxide**

  Base + Non-metallic oxide → Salt + H_2O

  Bases in water → Bases produce OH– ions when dissolved in water. Bases soluble in water are called alkalis. It conducts electricity.

- Decrease in OH– ions single concentration per unit volume results in formation of dilute bases.

- It is an exothermic reaction.

  To make basic solution, base must be added drop wise into water with constant stirring, so that the heat generated spreads over in water.

Indicators: Indicators are those substances which tell us whether a substance is acidic or basic by change in colour. For e.g., litmus solution.

- Olfactory indicators: Those substances whose odour changes in acidic or basic media are called olfactory indicators. For e.g., clove, vanilla, onion.
- Natural indicators: Turmeric, litmus (obtained from lichen).
- Synthetic indicators: Methyl orange, phenolphthalein.

Indicator	**Acids**	**Bases**
1. Red litmus	remains red	turns blue
2. Blue litmus	turns red	remains blue
3. Phenolphthalein	colourless	pink
4. Methyl orange	red	yellow

EXERCISE

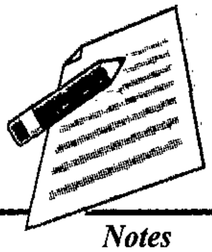
Multiple Choice Questions

1. Which one of the following is acidic?
   (a) Lemon juice
   (b) Tomatoes
   (c) Milk
   (d) All
2. Which one of the following will turn red litmus blue?
   (a) Vinegar
   (b) Baking soda solution
   (c) Lemon juice
   (d) Soft drinks
3. *Which one of the following will turn blue litmus red?*
   (a) Vinegar
   (b) Lime water
   (c) Baking soda solution
   (d) Washing soda solution
4. Methyl orange is
   (a) *Pink in acidic medium, yellow in basic medium*
   (b) Yellow in acidic medium, pink in basic medium
   (c) Colourless in acidic medium, pink in basic medium
   (d) Pink in acidic medium, colourless in basic medium.

5. Lime water is
   (a) CaO
   (b) Ca(OH)2
   (c) CaCO3
   (d) CaCl2
6. The nature of calcium phosphate is present in tooth enamel is
   (a) Basic
   (b) Amphoteric
   (c) Acidic
   (d) Neutral
7. Which of the following salts has no water of crystallization?
   (a) Blue vitriol
   (b) Washing soda
   (c) Baking soda
   (d) Gypsum
8. The function of quick lime in soda lime mixture is to
   (a) Absorb moisture present in soda lime
   (b) Increase the efficiency of soda lime
   (c) Increase the pH of soda lime
   (d) Take part in reaction with NaOH
9. The Ph of a solution of HCL is 4. This shows that the molarity of the solution is
   (a) 4.0M
   (b) 0.4M
   (c) 0.0001M
   (d) 0.001M
10. The difference of molecules of water in gypsum and PoP is
    (a) 5/2
    (b) 2b
    (c) 3/2
    (d) ½
11. Which of the following does not form an acidic salt?
    (a) Phosphoric acid
    (b) Carbonic acid
    (c) Hydrochloric acid
    (d) Sulphuric acid
12. The chemical formula of caustic potash is
    (a) NaOH
    (b) $Ca(OH)_2$
    (c) NH_4OH
    (D) KOH

ANSWERS

1. (d)	2. (b)	3. (a)	4. (a)	5. (b)	6. (a)
7. (c)	8. (a)	9. (a)	10. (c)	11. (b)	12. (d)



Notes

High Order Thinking Skills

1. Why is Plaster of Paris stored in a moisture proof container?
2. What do you mean by neutralization reaction? Give two examples.
3. Mention two uses of baking soda and washing soda.
4. Why does a milkman add a small amount of baking soda to fresh milk to shift the pH of fresh milk from 6 to slightly alkaline?
5. Why do acids not show acidic behaviour in the absence of water?
6. Rain water conducts electricity but distilled water does not. Why?
7. Why don't we keep sour substances in brass and copper vessels?
8. *What is the common name of CaOCl2?*
9. Name the compound used for softening hard water.
10. What happens when baking soda is heated?
11. Give the properties and uses of bleaching powder.
12. Give a few uses of acids, bases and salts respectively.

Space for Work

3 METALS AND NON-METALS

The main objective of this chapter is to explain Metals, Non-Metals Including their properties and uses. Apart from that the concept of The Reactivity Series Is also explained in this chapter.

Introduction

Metals, Non-Metals and Metalloids

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.

METALS, NON-METALS AND METALLOIDS

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

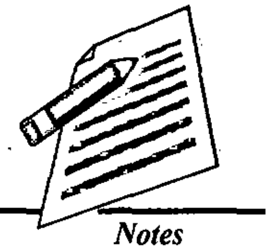
   (iv) Other Metals e.g.: Aluminium and Tin

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

3. **Metalloids**

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



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. 	Have no lustre and l.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)

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

The Reactivity Series

- The chemistry of the metals is studied by analysing their reactions with water, dilute acid and oxygen
- Based on these reactions a reactivity series of metals can be produced
- The series can be used to place a group of metals in **order of reactivity** based on the observations of their reactions with water, acid and oxygen

METAL	REACTION WITH WATER	REACTION WITH ACID	REACTION WITH OXYGEN
MOST REACTIVE			
POTASSIUM	REACTS VIOLENTLY	REACTS VIOLENTLY	REACTS QUICKLY IN AIR
SODIUM	REACTS QUICKLY	REACTS VIOLENTLY	REACTS QUICKLY IN AIR
CALCIUM	REACTS LESS STRONGLY	REACTS VIGOROUSLY	REACTS READILY
MAGNESIUM		REACTS VIGOROUSLY	REACTS READILY
ZINC		REACTS LESS STRONGLY	REACTS
IRON		REACTS LESS STRONGLY	REACTS
HYDROGEN			REACTS
COPPER			REACTS
LEAST REACTIVE			

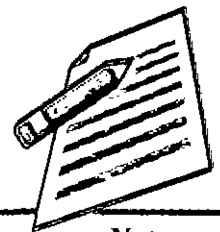
Carbon and the reactivity series mnemonic

- Carbon is an important element and has its own place on the reactivity series
- Its use in the extraction of metals from their oxides is discussed in this section but a more complete reactivity series with an accompanying mnemonic to help you memorise it is below

The reactivity series mnemonic

- "Please send lions, cats, monkeys and cute zebras into hot countries signed Gordon"

METAL	ABBREVIATION
MOST REACTIVE	
POTASSIUM	P- PLEASE
SODIUM	S- SEND
LITHIUM	L- LIONS,
CALCIUM	C- CATS,
MAGNESIUM	M- MONKEYS,
ALUMINIUM	A-AND
CARBON	C- CUTE
ZINC	Z- ZEBRAS
IRON	I-INTO



Notes

HYDROGEN	H- HOT
COPPER	C- COUNTRIES
SILVER	S- SIGNED
GOLD	G- GORDON
LEAST REACTIVE	

Extended Only

Reactions with Aqueous Ions & Oxides

- The reactivity of metals increases going up the reactivity series
- This means that a more reactive metal can displace a less reactive metal from its oxide by heating

  Example: Copper (II) Oxide
- It is possible to reduce copper (II) oxide by heating it with magnesium
- As magnesium is above copper in the reactivity series, magnesium is more reactive so can displace copper
- The reducing agent in the reaction is magnesium:

  $CuO (s) + Mg (s) \rightarrow Cu (s) + MgO (s)$

Other common reactions

MIXTURE	PRODUCTS	EQUATION FOR REACTION
IRON (III) OXIDE AND ALUMINIUM (THERMITE REACTION)	IRON AND ALUMINIUM OXIDE	$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$
SODIUM OXIDE AND MAGNESIUM	NO REACTION AS SODIUM IS ABOVE MAGNESIUM	–
SILVER OXIDE AND COPPER	SILVER AND COPPER(II) OXIDE	$Ag_2O + Cu \rightarrow 2Ag + CuO$
ZINC OXIDE AND CALCIUM	ZINC AND CALCIUM OXIDE	$ZnO + Ca \rightarrow Zn + CaO$
LEAD (II) OXIDE AND SILVER	NO REACTION AS LEAD IS MORE REACTIVE THAN SILVER	–

Displacement reactions between metals and aqueous solutions of metal salts

- Any metal will displace another metal that is **below** it in the reactivity series from a solution of one of its salts
- This is because more reactive metals lose electrons and form ions more readily than less reactive metals, making them better **reducing agents**
- The less reactive metal is a better electron acceptor than the more reactive metal, thus the less reactive metal is reduced. (OIL-RIG: reduction is gain of electrons)

  Example: Zinc and copper (II) sulphate
- As Zinc is above copper in the reactivity series, zinc is more reactive so can displace copper from copper (II) sulphate solution:

$$Zn (s) + CuSO_4 (aq) \rightarrow ZnSO_4 (aq) + Cu (s)$$

Notes

Other Common Reactions

MIXTURE	PRODUCTS	EQUATION FOR REACTION
MAGNESIUM AND IRON(II) SULFATE	MAGNESIUM SULFATE AND IRON	$Mg + FeSO_4 \rightarrow MgSO_4 + Fe$
ZINC AND SODIUM CHLORIDE	NO REACTION AS SODIUM IS ABOVE ZINC	–
LEAD AND SILVER NITRATE	LEAD (II) NITRATE AND SILVER	$Pb + 2AgNO_3 \rightarrow Pb(NO_3)_2 + 2Ag$
COPPER AND CALCIUM CHLORIDE	NO REACTION AS CALCIUM IS MORE REACTIVE THAN COPPER	–
IRON AND COPPER(II) SULFATE	IRON (II) SULFATE AND COPPER	$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

Extended Only

Heating Metal Hydroxides, Carbonates & Nitrates

Thermal decomposition reactions

- Some compounds **decompose** or **breakdown** when they are heated to sufficiently high temperatures
- These reactions are called thermal decomposition reactions
- A common example is the thermal decomposition of calcium carbonate (limestone), which occurs at temperatures above 800°C:

$$CaCO_3 \rightarrow CaO + CO_2$$

Thermal decomposition of metal hydroxides

- Most metal hydroxides undergo thermal decomposition
- **Water** and the corresponding **metal oxide** are the products formed, for example zinc hydroxide thermally decomposes as follows:

$$Zn(OH)_2 \rightarrow ZnO + H_2O$$

- Group II metal hydroxides decompose similarly but the Group I hydroxides (apart from lithium) do **not** decompose due to their having a higher thermal stability

Thermal decomposition of metal carbonates

- Most of the metal carbonates and hydrogen carbonates undergo thermal decomposition
- The **metal oxide** and **carbon dioxide** are the products formed, for example magnesium carbonate thermally decomposes as follows:

$$MgCO_3 \rightarrow MgO + CO_2$$

- Group I carbonates (again apart from lithium carbonate) do **not** decompose when heated

- This is due to the high thermal stability of reactive metals; the more reactive the metal then the more difficult it is to decompose its carbonate
- $CuCO_3$ for example is relatively easy to thermally decompose but K_2CO_3 does not decompose

Thermal decomposition of metal nitrates

- All of the metal nitrates decompose when they are heated
- Group I nitrates decompose forming the **metal nitrite** and **oxygen,** for example sodium nitrate decomposes as follows:

$$2NaNO_3 \rightarrow 2NaNO_2 + O_2$$

- Most other metal nitrates form the corresponding **metal oxide, nitrogen dioxide** and **oxygen** when heated, for example copper nitrate:

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

Aluminium and its apparent lack of reactivity

- Aluminium is a curious metal in terms of its reactivity
- It is placed **high** on the reactivity series but it doesn't react with water or acids
- This is because the surface of aluminium metal reacts with oxygen in the air forming a protective coating of **aluminium oxide**:

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

- The aluminium oxide layer is **tough, unreactive** and **resistant** to **corrosion**
- It adheres very strongly to the aluminium surface and protects it from reaction with other substances, hence making it appear unreactive

> **Exam Tip**
>
> For the thermal decomposition reactions, you will need to be able to describe how the Group I nitrates differ from the other metals.
>
> You should be able to write out the balanced symbol equations for these reactions.

Summary of the Chapter

Elements are classified into two basic categories, metals and non-metals.

Elements
↓
Metals — Non-metals

Before giving the definition of metal and non-metal, we must know some important terms:

(i) **Malleability:** Ability of an element due to which it can be beaten with hammer into thin sheets.

(ii) **Ductility:** Ability of an element due to which it can be drawn into wires.

(iii) **Sonorous:** Property of an element to produce sound when it is struck with a hard substance.

(iv) **Brittleness:** Property of an element to break easily into pieces on hammering or stretching.

HIGHER ORDER THINKING SKILLS QUESTIONS

METALS AND NON-METALS

1. A metal 'X' loses two electrons and a non-metal 'Y' gains one electron. Show the electron dot structure of compound formed between them. Is ionic or covalent? Does it have high melting point or low? Will it conduct electricity in solid state or in aqueous solution and why? Will it be soluble in water?
2. A student was given Mn, Zn, Fe and Cu metals. Identify which of them
   (a) will not displace H_2 from dil. HCl.
   (b) will react only with steam to give $H_2(g)$.
   (c) Will give H_2 with 5% HNO_3.
   Write the chemical reactions involved.
3. Compound X and aluminium are used to join railway tracks.
   (a) Identify the compound X.
   (b) Name the reaction.
   (c) Write down its reaction.
4. A metal A, which is used in thermite process, when heated with oxygen gives an oxide B, which is amphoteric in nature? Identify A and B. Write down the reactions of oxide B with HCl and NaOH.
5. A non-metal A is an important constituent of our food and forms two oxides B and C. Oxide B is toxic whereas C causes global warming.
   (a) Identify A, B and C.
   (b) To which group of periodic table does A belong?
7. An element A reacts with water to form a compound B which is used in white washing. The compound B on heating forms an oxide which on treatment with water gives back B. Identify A, B and C and give the reactions involved.
6. A non-metal A which is the largest constituent of air, when heated with H_2 in 1:3 ratio in the presence of catalyst (Fe) gives a gas B. On heating with O_2, it gives an oxide C. If this oxide is passed into water in the presence of air, it gives and acid D which act as a strong oxidising agent.
   (a) Identify A, B, C and D.
   (b) To which group of periodic table does this non-metal belong?
7. An element A burns with golden flame in air. It reacts with another element B, atomic number 17 to give a product C. An aqueous solution of product C on electrolysis gives a compound D and liberates hydrogen. Identify A, B, C and D. Also write down the equations for the reactions involved.

EXERCISE

Multiple Choice Questions

1. Which of the following metals is present in the anode mud during the electrolytic refining of copper?
   (a) Sodium
   (b) Aluminium
   (c) Gold
   (d) Iron
2. An element reacts with oxygen to give a compound with a high melting point. The compound is soluble in water. The element is likely to be
   (a) calcium
   (b) carbon
   (c) iron
   (d) silicon
3. The second most abundant metal in the earth's crust is
   (a) oxygen
   (b) silicon
   (c) aluminium
   (d) iron
4. An alloy of Zn and Cu is dissolved in dil. HC1. Hydrogen gas is evolved. In this evolution of gas
   (a) only zinc reacts with dil. HC1
   (b) only copper reacts with dil. HC1
   (c) both zinc and copper react with dil. HC1
   (d) only copper reacts with water
5. A greenish coating develops on copper utensils due to formation of
   (a) $CuCo_3$
   (b) $Cu(OH)_2$
   (c) $Cu(OH)_2.CuCO_3$
   (d) CuO
6. Rusting of iron takes place in
   (a) ordinary water
   (b) distilled water
   (c) both ordinary and distilled water
   (d) none of the above
7. The bronze medals are made up of
   (a) Cu and Zn
   (b) Zn and Ni
   (c) Cu and Sn
   (d) Cu, Zn, Tn

8. Silver articles becomes black on prolonged exposure to air. This is due to the formation of
   (a) Ag2O
   (b) Ag2S
   (c) AgCN
   (d) Ag2O and Ag2S
9. *During smelting, an additional substance is added which combines with impurities* to form a fusible product known as
   (a) slag
   (b) mud
   (c) gangue
   (d) flux
10. A student placed an iron nail in copper sulphate solution. He observed the reddish-brown coating on the iron nail which is
    (a) soft and dull
    (b) hard and flading
    (c) smooth and shining
    (d) rough and granular
11. Which among the following alloys contain non-metal as one of its constituents?
    (a) Brass
    (b) Amalgam
    (c) Gun metal
    (d) None of these
12. An aluminium strip is kept immersed in freshly prepared ferrous sulphate solution taken in a test tube, the change observed is that
    (a) Green solution slowly turns brown
    (b) Lower end of test tube become slightly warm
    (c) A colourless gas with the smell of burning sulphur is observed
    (d) Light green solution changes to blue.

Answers

1. (d)	**2.** (c)	**3.** (d)	**4.** (a)	**5.** (a)	**6.** (c)
7. (c)	**8.** (b)	**9.** (a).	**10.** (d)	**11.** (b)	**12.** (a)

Space for Work

Theme: Materials

Unit I: Chemical Substances-Nature and Behaviour

4 CARBON AND ITS COMPOUNDS

Introduction

Carbon is an inseparable chemical entity associated with living things of the earth. The food we eat, the clothes we wear, the cosmetics we use and the fuels by which we run the automobiles all contain carbon compounds. When we burn the materials like cotton, wood, paper, plastics and rubber, they burn with smoky flame and leave some amount of solid or ash at the end. This is nothing but carbon.

Carbon is one of the most important **non-metallic** elements. Antoine Lavoisier named Carbon from the Latin word **'Carbo'** meaning coal. This is because carbon is the main constituent of coal. Coal is a fossil fuel developed from prolonged decomposition of buried plants and animals. So, it is clear that all the life forms contain carbon. The earth's crust contains only 0.032% of carbon (i.e.320 parts per million by weight) in the form of minerals like carbonates, coal and petroleum and the atmosphere has only 0.03% of carbon dioxide (i.e.300 parts per million by weight). In spite of this availability of small amount of carbon in nature, carbon compounds have an immense importance in everyday life. For example, we ourselves are made of carbon compounds. About 18 % of the weight of human body is carbon.

- Carbon is present in our muscles, bones, organs, blood and other components of living matter. Carbohydrates (compounds formed primarily of carbon and hydrogen) provide fuel for living organisms, underlie the structure of plants, animals and bacteria and are essential components of DNA and RNA, the molecular blueprints of life.
- A large number of things which we use in our daily life are made up of carbon compounds.
- The most vital photochemical reaction of plants involves carbon compounds (CO_2 and Chlorophyll)

  So, without carbon, there is no possibility for the existence of plants and animals including human. Thus, **Carbon Chemistry** is also called as **Living Chemistry**.

Discovery of Carbon-Milestones

Carbon has been known since ancient times in the form of soot, charcoal, graphite and diamonds. Ancient cultures did not realize, of course, that these substances were different forms of the same element.

In 1772, French scientist **Antoine Lavoisier** pooled resources with other chemists to buy a diamond, which they placed in a closed glass jar. They focused the Sun's rays on the diamond with a remarkable giant magnifying glass and saw the diamond burn and disappear. Lavoisier noted that the overall weight of the jar was unchanged and that when it burned, the diamond had combined with oxygen to form carbon dioxide. He concluded that diamond and charcoal were made of the same element – carbon.

In 1779, Swedish scientist **Carl Scheele** *showed that graphite burned to* form carbon dioxide and so it must be another form of carbon.

In 1796, English chemist **Smithson Tennant** established that diamond is pure carbon and not a compound of carbon and it burned to form only carbon dioxide. Tennant also proved that when equal weights of charcoal and diamonds were burned, they produced the same amount of carbon dioxide.

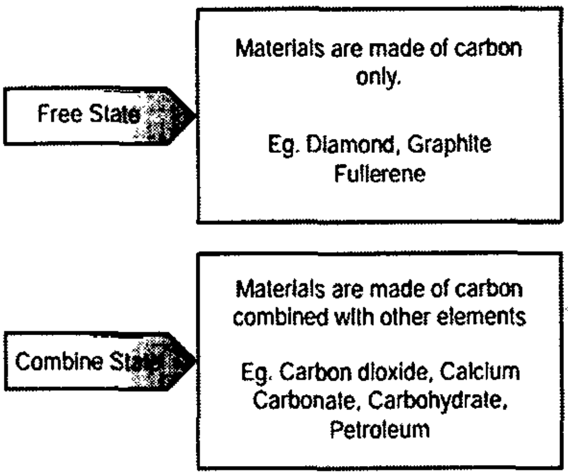
In 1855, English chemist **Benjamin Brodie** produced pure graphite from carbon, proving graphite is a form of carbon.

Although it had been previously attempted without success, in 1955 American scientist **Francis Bundy** and co-workers at 'General Electric' company finally demonstrated that graphite could be transformed into diamond at high temperature and high pressure.

In 1985, **Robert Curl, Harry Kroto and Richard Smalley** discovered fullerenes, a new form of carbon in which the atoms are arranged in soccer-ball shapes. The most recently discovered allotrope of carbon is **graphene**, which consists of a single layer of carbon atoms arranged in hexagons. Graphene's discovery was announced in 2004 by **Kostya Novoselov and Andre Geim,** who used adhesive tape to detach a single layer of atoms from graphite to produce the new allotrope. If these layers were stacked upon one other, graphite would be the result. Graphene has a thickness of just one atom.

Compounds of Carbon - Classification

Carbon is found both in free state as well as combined state in nature.



In the pre-historic period, ancients used to manufacture charcoal by burning organic materials. They used to obtain carbon compounds both from living things as well as non-living matter. Thus, in the early 19th century, Berzelius classified carbon compounds based on their source as follows:

(i) **Organic Carbon Compounds:** These are the compounds of carbon obtained from living organisms such as plants and animals. e.g. Ethanol, cellulose, Starch.

(ii) **Inorganic Carbon Compounds:** These are the compounds containing carbon but obtained from non-living matter. e.g. Calcium Carbonate, Carbon Monoxide, Carbon dioxide.

1. Organic Compounds of Carbon

There are millions of organic carbon compounds available in nature and also synthesized manually. Organic carbon compounds contain carbon connected with other elements like hydrogen, oxygen, nitrogen, sulphur etc. Thus, depending on the nature of other elements and the way in which they are connected with carbon, there are various classes of organic carbon compounds such as hydrocarbons, alcohols, aldehydes and ketones, carboxylic acids, amino acids, etc. You will study about organic carbon compounds in your higher classes.

2. Inorganic Compounds of Carbon

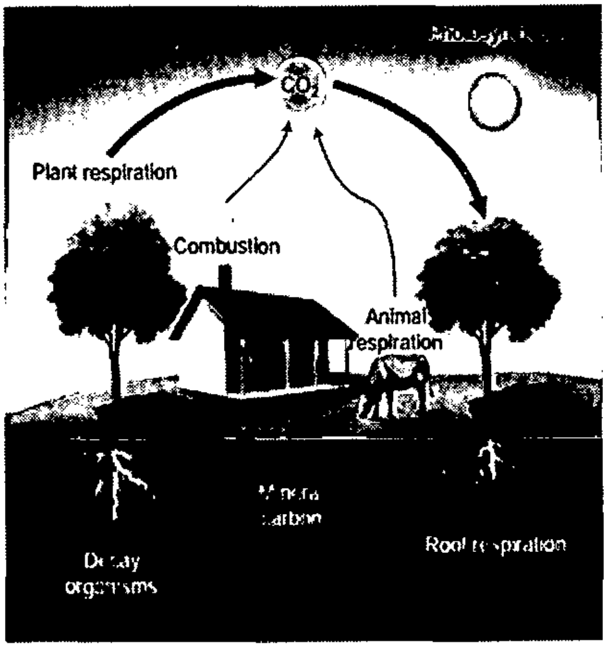
As compared to organic compounds, the number of inorganic carbon compounds are limited. Among them oxides, carbides, sulphides, cyanides, carbonates and bicarbonates are the major classes of inorganic carbon compounds. Formation, properties and uses of some of the compounds are given in Table.

Compounds	**Formation**	**Properties**	**Uses**
Carbon monoxide (CO)	Not a natural component of air. Mainly added to atmosphere due to incomplete combustion of fuels.	Colourless Odourless Highly toxic Sparingly soluble in water.	Main component of water gas ($CO+H_2$). Reducing agent.
Carbon dioxide (CO_2)	Occurs in nature as free and combined forms. Combined form is found in minerals like limestone, magnesite. Formed by complete combustion of carbon or coke.	Colourless Odourless Tasteless Stable Highly soluble in water Takes part in photosynthesis.	Fire extinguisher Preservative for fruits Making bread To manufacture urea Carbonated water Nitrogenous fertilizers Dry ice in refrigerator

Calcium Carbide (CaC_2)	Prepared by heating CaO and Coke	Greyish black solid	To manufacture graphite and hydrogen To prepare acetylene gas for welding.
Carbon disulphide (CS_2)	Directly prepared from C and S	Colourless Inflammable Highly poisonous gas	Solvent for sulphur To manufacture rayon Fungicide Insecticide
Calcium Carbonate ($CaCO_3$)	Prepared by passing CO_2 into the solution of slaked lime	Crystalline solid Insoluble in water	Antacid
Sodium bicarbonate ($NaHCO_3$)	Formed by NaOH with carbonic acid (H_2CO_3)	White Crystalline substance Sparingly soluble in water	Preparation of sodium carbonate. Backing powder Antacid

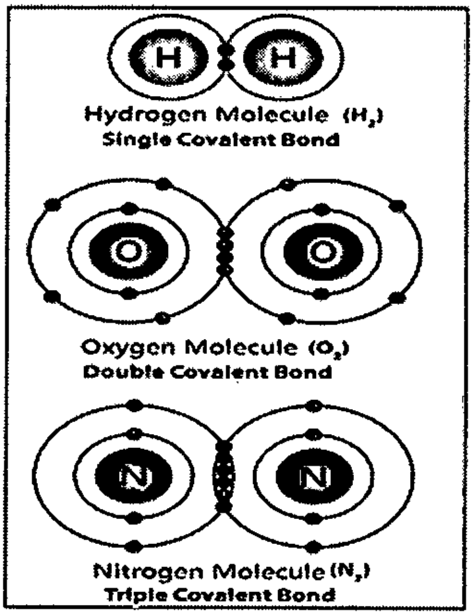
Carbon cycle

The carbon cycle is the biogeochemical cycle by which carbon is exchanged among the biosphere, geosphere, hydrosphere and atmosphere of the Earth. Carbon is the main component of biological compounds as well as a major component of many minerals such as limestone. Along with the nitrogen cycle and the water cycle, the carbon cycle comprises a sequence of events that are key to make Earth capable of sustaining life.



Covalent bonds:

Do you know all elements (except noble gases) occurs either as compounds or as polyatomic molecules? Let us consider hydrogen gas in which two hydrogen atoms bind to give a dihydrogen molecule. Each hydrogen atom has one electron and it requires one more electron to attain the electronic configuration of the nearest noble gas helium. Lewis suggested that both hydrogen atoms will attain the stable configuration by mutually sharing the electrons available with them. Similarly, in the case of oxygen molecule, both the oxygen atoms share two electron pairs between them and in nitrogen molecule three electron pairs are shared between two nitrogen atoms. ***This type of mutual sharing of one or more pairs of electrons between two combining atoms results in the formation of a chemical bond called a covalent bond.*** If two atoms share just one pair of electrons a single covalent bond is formed as in the case of hydrogen molecule. If two or three electron pairs are shared between the two combining atoms, then the covalent bond is called a double bond or a triple bond, respectively.



Representation of Lewis Structures of covalent bonds

Representing a covalent bond - Lewis structure (Lewis dot structure)

Lewis structure (Lewis dot structure) is a pictorial representation of covalent bonding between the combining atoms. In this structure the shared valence electrons are represented as a pair of dots between the combining atoms and the unshared electrons of the atoms are represented as a pair of dots (lone pair) on the respective individual atoms.

The Lewis dot structure for a given compound can be written by following the steps given below. Let us understand these steps by writing the Lewis structure for water.

1. **Draw the skeletal structure of the molecule**. In general, the most electronegative atom is placed at the centre. Hydrogen and fluorine atoms should be placed at the terminal positions. For water, the skeletal structure is

$$\boxed{\mathrm{H} \quad \mathrm{O} \quad \mathrm{H}}$$

2. **Calculate the total number of valence electrons of all the atoms in the molecule**. In case of polyatomic ions the charge on ion should also be considered during the calculation of the total number of valence electrons. In case of anions the number of negative charges should be added to the number of valence electrons. For positive ions the total number of positive charges should be subtracted from the total number of valence electrons.

   In water, total number of valence electron = [2×1 (valence electron of hydrogen)] + [1 × 6 (valence electrons of oxygen)] = 2 + 6 = 8.

3. **Draw a single bond between the atoms in the skeletal structure of the molecule**. Each bond will account for two valence electrons (a bond pair). For water, we can draw two bonds accounting for four valence electrons as follows.

$$\boxed{\mathrm{H}—\mathrm{O}—\mathrm{H}}$$

4. **Distribute the remaining valence electrons as pairs (lone pair), giving octet (only duet for hydrogen) to the atoms in the molecule**. The distribution of lone pairs starts with the most electronegative atoms followed by other atoms.

   In case of water, the remaining four electrons (two lone pairs) are placed on the most electronegative central oxygen, giving octet.

5. **Verify whether all the atoms satisfy the octet rule (for hydrogen duet).** If not, use the lone pairs of electrons to form additional bond to satisfy the octet rule.

   In case of water, oxygen has octet and the hydrogens have duets, hence there is no need for shifting the lone pairs. The Lewis structure of water is as follows

Lewis structure of water

CLASS–10

Science

Notes

Let us draw the Lewis structure for nitric acid.

1. Skeletal structure

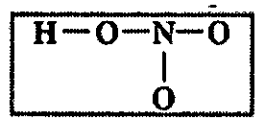
H	**O**	**N**	**O**
		O	

2. Total number of valence electrons in HNO_3

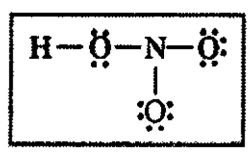
   = [1 × 1(hydrogen)] + [1 × 5(nitrogen)] + [3× 6(oxygen)]

   = 1+ 5 + 18 = 24

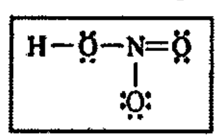
3. Draw single bonds between atoms. Four bonds can be drawn as shown in the figure for HNO_3 which account for eight electrons (4 bond pairs).



4. Distribute the remaining sixteen (24 - 8= 16) electrons as eight lone pairs starting from most electronegative atom, the oxygen. Six lone pairs are distributed to the two terminal oxygens (three each) to satisfy their octet and two pairs are distributed to the oxygen that is connected to hydrogen to satisfy its octet.

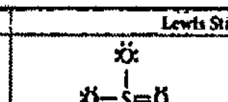
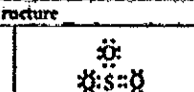
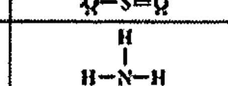
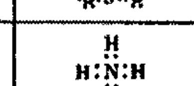
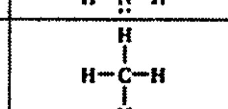
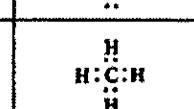
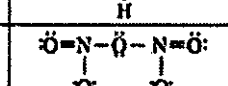
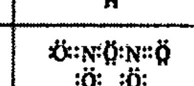


5. Verify weather all the atoms have octet configuration. In the above distribution, the nitrogen has one pair short for octet. Therefore, move one of the lone pair from the terminal oxygen to form another bond with nitrogen. The Lewis structure of nitric acid is given as



Lewis structure of Nitric acid

The Lewis dot structures for some molecules

S. No	Molecule	Lewis Structure	
1.	Sulphur trioxide (SO_3)		
2.	Ammonia (NH_3)		
3.	Methane		
4.	Dinitrogen Pentoxide (N_2O_5)		

Formal charge:

Let us draw the Lewis structure for carbon dioxide.

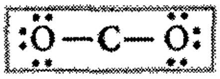
1. Skeletal structure

$$\boxed{O \quad C \quad O}$$

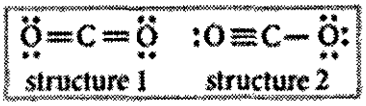
2. Total number of valence electrons in CO_2
   $= [1 \times 4(\text{carbon})] + [2 \times 6(\text{oxygen})] = 4 + 12 = 16$
3. Draw single bonds between atoms. Two bonds can be drawn as shown in the figure for CO_2 which accounts for four electrons (2 bond pairs).

$$\boxed{O - C - O}$$

4. Distribute the remaining twelve electrons (16 - 4= 12) as six lone pairs starting from most electronegative atom, the oxygen. Six lone pairs are distributed to the two terminal oxygens (three each) to satisfy their octet.



5. Verify weather all the atoms have octet configuration. In the above distribution, the central carbon has two pair short for octet. Therefore, to satisfy the octet rule two lone pairs from one oxygen or one pair from each oxygen can be moved to form multiple bonds, leading the formation of two possible structures for carbon dioxide as shown below



two possible structures for carbon dioxide

Similarly, the Lewis structure for many molecules drawn using the above steps gives more than one acceptable structure. Let us consider the above mentioned two structures of carbon dioxide.

Which one the above forms represent the best distribution of electrons in the molecule. To find an answer, we need to know the formal charge of each atom in the Lewis structures. Formal charge of an atom in a molecule, is the electrical charge difference between the valence electron in an isolated atom and the number of electrons assigned to that atom in the Lewis structure.

$$\text{Formal charge of an atom} = N_v - \left(N_l + \frac{N_b}{2}\right)$$

Where,

N_v- Number of valence electron of atom in its isolated state.

N_l - Number of electrons present as lone pairs around the atom in the Lewis structure

N_b - Number of electrons present in bonds around the atom (bond pairs) in the Lewis structure]

Now let us calculate the formal charge on all atoms in both structures,

For Structure 1,

$$\text{Formal charge on carbon} = N_v - \left(N_l + \frac{N_b}{2}\right)$$

$$= 4 - \left(0 + \frac{8}{2}\right) = 0$$

$$\text{Formal charge on oxygen} = 6 - \left(4 + \frac{4}{2}\right)$$

$$= 0 \text{ (for both oxygens)}$$

For structure 2

Formal charge on carbon

$$= N_v - \left(N_l + \frac{N_b}{2}\right)$$

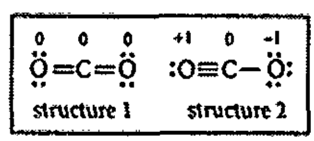
$$= 4 - \left(0 + \frac{8}{2}\right) = 0$$

Formal charge on singly bonded oxygen

$$= 6 - \left(6 + \frac{2}{2}\right) = -1$$

Formal charge on triply bonded oxygen

$$= 6 - \left(2 + \frac{6}{2}\right) = +1$$



two possible structures for carbon dioxide (with formal charges)

After calculating the formal charges, the best representation of Lewis structure can be selected by using following guidelines.

1. A structure in which all formal charges are zero preferred over the one with charges.
2. A structure with small formal charges is preferred over the one with higher formal charges.
3. A structure in which negative formal charges are placed on the most electronegative atom is preferred.

   In case of CO_2 structures, the structure one is preferred over the structure 2 as it has zero formal charges for all atoms.

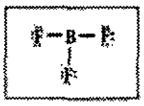
Lewis structures for exceptions to octet rule

The octet rule is useful for writing Lewis structures for molecules with second period element as central atoms. In some molecules, the central atoms have less than eight electrons around them while some others have more than eight electrons. Exception to the octet rule can be categorized into following three types.

1. Molecules with electron deficient central atoms
2. Molecules containing odd electrons
3. Molecules with expanded valence shells

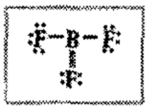
1. Molecules with electron deficient central atoms

Let us consider boron trifluoride, as an example. The central atom boron has three valence electron and each fluorine has seven valence electrons. The Lewis structure is



Lewis structure of BF_3

In the above structure, only six electrons around boron atom. Moving a lone pair from one of the fluorine to form additional bond as shown below.

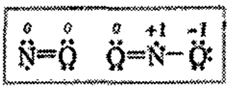


Lewis structure of BF_3

However, the above structure is unfavourable as the most electronegative atom fluorine shows positive formal charge and hence the structure with incomplete octet is the favourable one. Molecules such as BCl_3, $BeCl_2$, etc... also have incomplete octets.

2. Molecules containing odd electrons

Few molecules have a central atom with an odd number of valence electrons. For example, in nitrogen dioxide and nitric oxide all the atoms does not have octet configuration. The Lewis structure of the above molecules are shown in the figure.

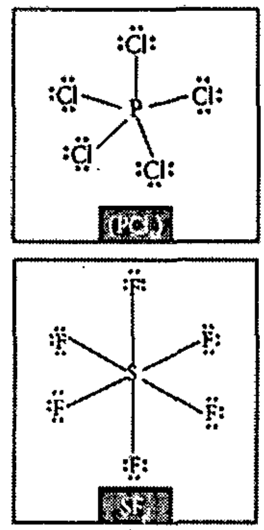


Lewis structures of Nitric oxide and Nitrogen dioxide (with formal charges)

3. Molecules with expanded valence shells

In molecules such as sulphur hexafluoride (SF_6), phosphorous pentachloride (PCl_5) the central atom has more than eight valence electrons around them.

Here the central atom can accommodate additional electron pairs by using outer vacant d orbitals. In SF_6 the central atom sulphur is surrounded by six bonding pair of electrons or twelve electrons.



Lewis structures for SF_6 and PCl_5

Versatile nature of carbon

Organic compounds are made up of carbon, oxygen, hydrogen, and few other elements. However, the number of organic compounds is far bigger than inorganic compounds that do not form bonds.

The distinct nature of carbon atom and its capacity to form bonds with other atoms leads to such huge number of organic compounds.

The versatile nature of carbon can be best understood with its features such as, tetravalency and catenation. In this section let us learn more about versatility of carbon.

Carbon is a versatile element and is found in many different chemical compounds, including those found in space. Carbon is versatile because it can form single, double, and triple bonds. It can also form chains, branched chains, and rings when connected to other carbon atoms.

The two characteristic features seen in carbon, that is, *tetravalency* and *catenation*, put together give rise to a large number of compounds. Many have the same non-carbon atom or group of atoms attached to different carbon chains.

Catenation: The property of forming long chains by self-linking with other carbon atoms to form long chains, rings, double or triple bonds is called catenation.

Isomerism: Compounds with same molecular formula but different structural formula are called isomers. An isomerism commonly seen is due to difference in the arrangement of atoms or groups of atoms & is called structural isomerism. The 4 types of structural isomerism are:

- Chain isomerism
- Position
- Functional
- Metamerism

Tetravalency: Carbon has 4 electrons in its valence shell. Energy considerations do not allow it to gain or lose 4 electrons; therefore, it forms covalent bonds with other elements to complete its octet. This accounts for its tetravalency and explains its ability to form a variety of compounds.

Hydrocarbons

These are organic compounds containing only carbon and hydrogen and are represented by the general formula C x H y where x and y are whole numbers. Other organic compounds are derived from these parent compounds by replacement of one or more hydrogen atoms, e.g. the addition of one -CH□ group can result in the formation of a new compound.

Homologous series of compounds is a family of carbon compounds which:

- Have the same general formula.
- Show a difference of 14 u in their molecular mass..
- Show gradation in the physical properties.
- Show similarity in the chemical properties.
- Are characterised by the same functional group.
- Differ from the previous member by a –CH□ group.

  Example, CH_3OH, C_2H_5OH etc.

Rules to name carbon compounds:

- Choose the longest unbranched carbon chain.
- Determine the functional group present.
- Number the carbon atoms such that the C atom to which the functional group is present gets the smallest number.
- If the same substituent occurs more than once, the location of each point on which the substituent occurs is given & the number of times the substituent group is indicated by a prefix (di, tri, tetra etc.).

Summary of the Chapter

What are carbon compounds?

Carbon compounds are compounds which contain the element **carbon.**

These compounds contain carbon and hydrogen only or **carbon** and **hydrogen** in combination with a few other elements such as **oxygen, sulphur, nitrogen, halogens** and **phosphorus.**

Organic compounds

Carbon compounds can be classified into two groups:

(a) **Organic compounds**

(b) **Inorganic compounds**

Chemists define **organic compounds** as **carbon- containing compounds.** However, some exceptions to this definition are

(a) **oxides of carbon** such as carbon monoxide, CO and carbon dioxide, CO_2

(b) **carbonates** such as calcium carbonate, $CaCO_3$

(c) **hydrogen carbonates** such as sodium hydrogen carbonate, $NaHCO_3$

(d) **cyanides** such as potassium cyanide, KCN

(e) **metallic carbides** such as aluminium carbide, Al_4C_3

Inorganic compounds include all **non-carbon-containing compounds** and the few carbon- containing compounds just mentioned.

Table shows examples of organic and inorganic compounds found in nature.

***Table** Examples of organic and inorganic compounds and their elements*

Organic compound	Inorganic compound
Protein (C, H, O, N)	Silica (Si, O)
Carbohydrate (C, H, O)	Marble (Ca, C, O)
Alcohol (C, H, O)	Bauxite (Al, O)
Chloroform (C, H, Cl)	Galena (Pb, O)
Polystyrene (C, H)	Ammonia (N, H)

Most organic compounds contain the elements **carbon** and **hydrogen.** Hence, **complete combustion** of organic compounds produces **carbon dioxide** and **water.**

The following equation shows the complete combustion of glucose, $C_6H_{12}O_6$.

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

EXERCISE

Multiple Choice Questions

1. The isomeric pair is
   (a) ethane and propane
   (b) propane and butane
   (c) ethane and ethane
   (d) butane and 2-methyl propane

2. Which of the following is used to oxidise ethanol to ethanoic acid?
   (a) Alkaline $KMnO_4$
   (b) Conc. H_2SO_4
   (c) Acidified $K_2Cr_2O_7$
   (d) All of above

3. Which is denatured spirit?
   (a) ethanol only
   (b) ethanol and methanol (50%)
   (c) ethanol and methanol (5%)
   (d) methanol only
4. Tertiary butane gets oxidised with oxidising agents like alkaline $KMNO_4$ to
   (a) Isobutane
   (b) Ter-butyl alcohol
   (c) Secondary-propyl alcohol
   (d) All of above
5. The substance not responsible for the hardness of water is
   (a) Sodium nitrate
   (b) calcium hydrogen carbonate
   (c) calcium carbonate
   (d) magnesium carbonate
6. The by-product of soap is
   (a) isoprene
   (b) glycerol
   (c) butene
   (d) ethylene glycol
7. Covalent compounds
   (a) (a) have high melting and boiling point
   (b) are mostly soluble in water
   (c) are formed between atoms of metals and non-metals
   (d) are formed by the sharing of electrons in the bonding atoms.
8. Vinegar is a solution of
   (a) 30% 40% acetic acid in alcohol
   (b) 5% 8% acetic acid in alcohol
   (c) 5% 8% acetic acid in water
   (d) 15% 20% acetic acid in water
9. Which of the following can be used for the denaturation of ethyl alcohol?
   (a) Methyl alcohol
   (b) Pyridines
   (c) Copper sulphate
   (d) All of above
10. Soaps are formed by saponification of
    (a) alcohols
    (b) glycosides
    (c) simple esters
    (d) carboxylic acids

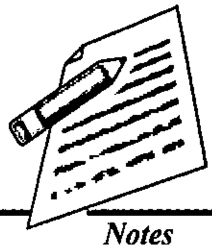
Answers

1. (d)	**2.** (d)	**3.** (c)	**4.** (b)	**5.** (a)
6. (b)	**7.** (d)	**8.** (c)	**9.** (d)	**10.** (c)

Hots for Carbon and its Compounds

1. Name two allotropes of carbon.
2. Why covalent compounds have low melting and boiling points?
3. Give two properties of ethanol.
4. What are heteroatoms?
5. Define catalyst.
6. Name the peculiar/specific chemical property exclusive in case of saturated hydrocarbons and unsaturated hydrocarbons.
7. Why does carbon forms large number of compounds?
8. Write the structural formula for brompentane and ethanoic acid.
9. How does ethanoic acid react with carbonates and hydrogen carbonates? Show it with the equation.
10. Draw the structures of two isomers of butane.
11. Differentiate between saturated and unsaturated hydrocarbons. Give one example for each.
12. Diamond and graphite show different physical properties although they are made up of carbon and shows same chemical properties. What is the property called?
13. What is denatured alcohol?
14. What is esterification and give its uses?
15. Give difference between soap and detergent.

Space for Work



Theme: Materials

Unit I: Chemical Substances-Nature and Behaviour

5 PERIODIC CLASSIFICATION OF ELEMENTS

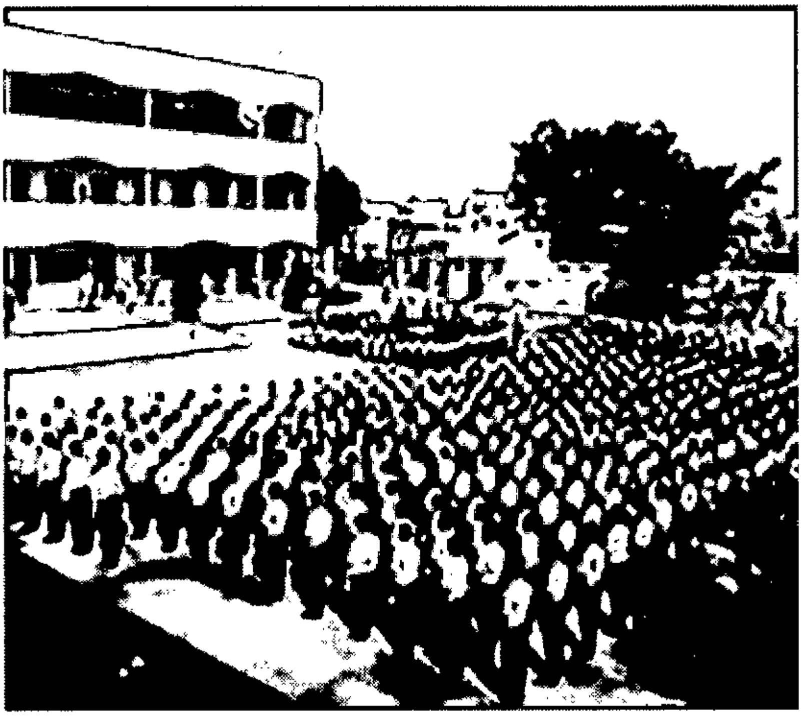
Periodic classification of elements: Need for classification, early attempts at classification of elements (Dobereiner's Triads, Newland's Law of Octaves, Mendeleev's Periodic Table), Modern periodic table, gradation in properties, valency, atomic number, metallic and non-metallic properties.

Objective of the Chapter

The main objective of the unit is to make student understand about the Periodic classification of elements including its early attempts and Modern periodic table.

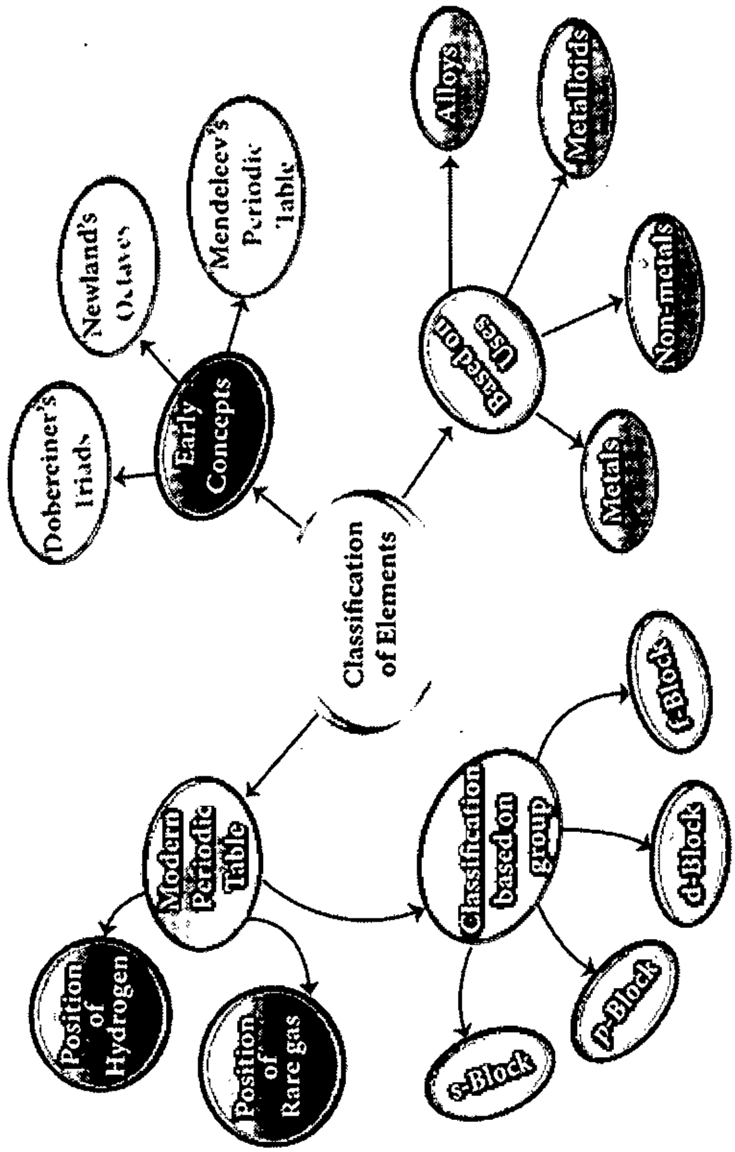
Introduction

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.

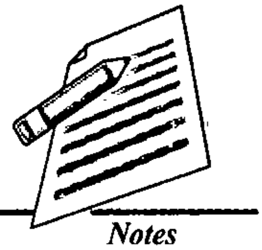


The vendor in a medical store could locate the medicines we seek in a flash of time with the use of a pattern they are arranged. We can easily identify the books in the library as quickly as possible.

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.



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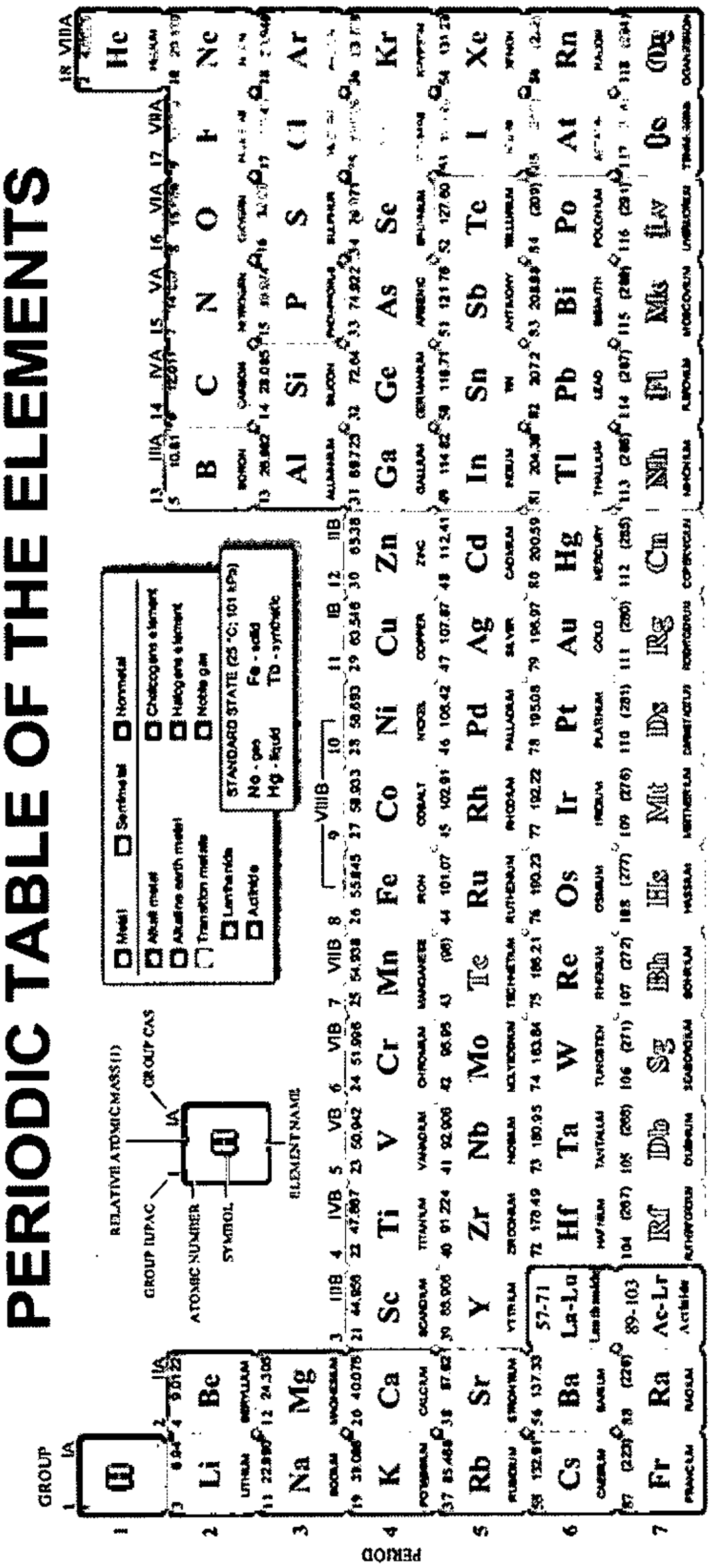


Early Concepts of Classification of Elements

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.

Table 4.1 Dobereiner's law of triads

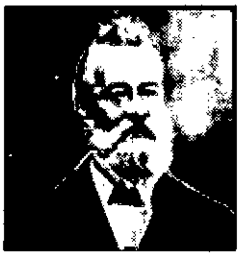
Triad Group (1)		Triad Group (2)		Triad Group (3)	
Element	Atomic Mass	Element	Atomic Mass	Element	Atomic Mass
Li	6.9	Cl	35.5	Ca	40.1
Na	23	Br	79.9	Sr	87.6
K	39.1	I	126.9	Ba	137.3

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.

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.

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

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.
- 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. E.g.: Neon between Fluorine and Sodium.

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. E.g.: The atomic mass of beryllium was known to be 14.Mendeleev reassessed it as 9 and assigned beryllium a proper place.
- Columns were le vacant for elements which were not known at that time and their properties also were predicted.is gave motivation to experiment in Chemistry. E.g.: Mendeleev gave names Eka Aluminium 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 4.3 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	

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. E.g.: Hard metals like copper (Cu) and silver (Ag) were included along with so 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. E.g. Co & Ni, Te & I
- No place for isotopes in the periodic table

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.

1. Features of Modern Periodic Table

All the elements are arranged in the increasing order of their atomic number

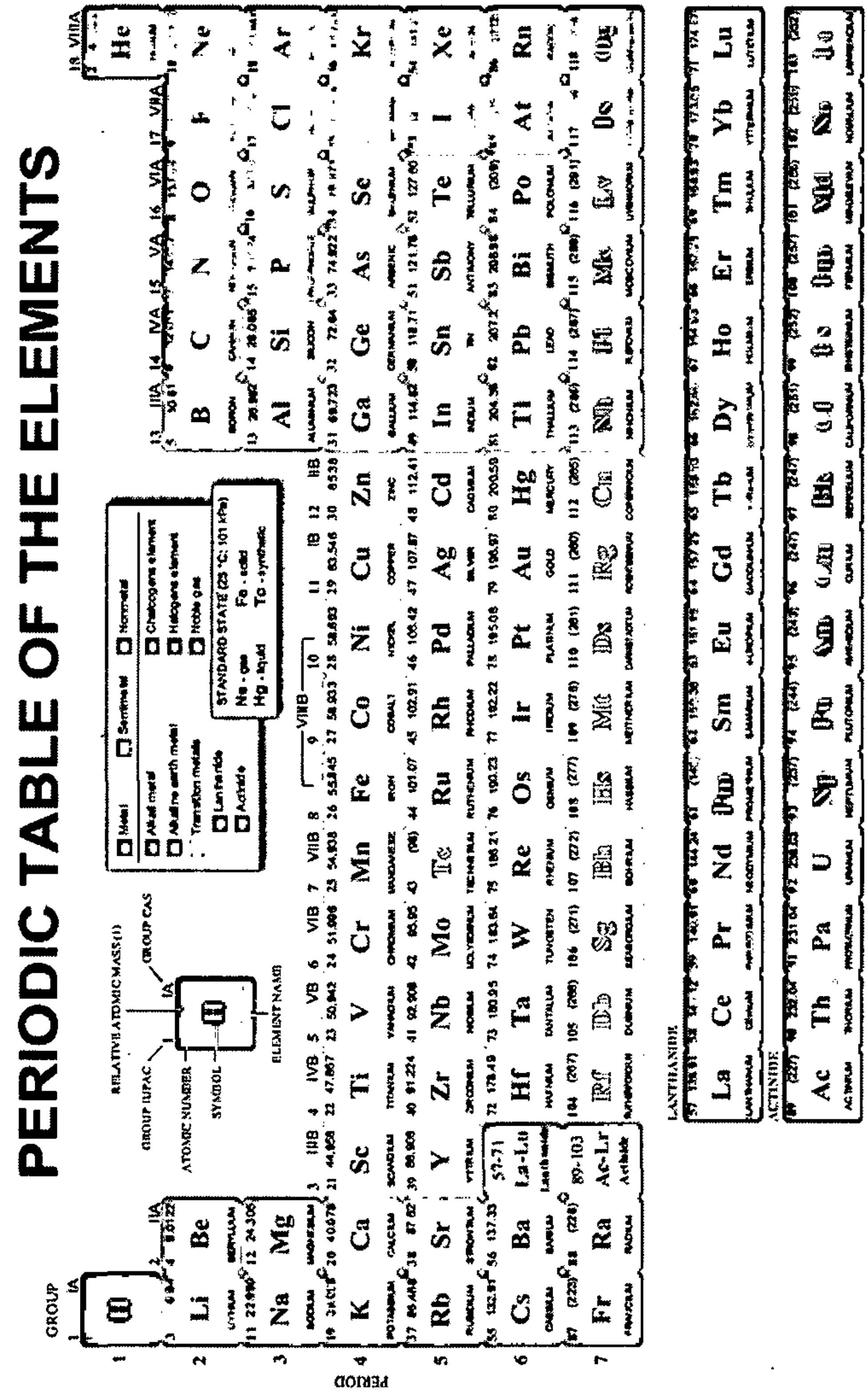
The horizontal rows are called periods.

There are seven periods in the periodic table.

The elements are placed in periods based on the number of shells in their atoms

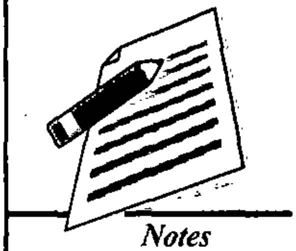
Vertical columns in the periodic table starting from top to bottom are called groups. There are 18 groups in the periodic table

Based on the physical and chemical properties of elements, they are grouped into various families.



2. 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 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.

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

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

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			

(1) s-Block Elements

While arranging the electrons of elements of group 1 and 2, the last electron is added to s subshell. ese 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. ese 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 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. ese 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

elements of group 3 to 12 have their valence electrons in their outermost d subshells. ese 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".

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.

5. Position of Hydrogen in the periodic table:

Hydrogen is the lightest, smallest and first element of the periodic table. Its electronic configuration (1s) 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.

- Hydrogen can lose its only electron to form a hydrogen ion (H^+) like alkali metals.
- It can also gain one electron to form the hydride ion (H^-) like halogens.
- 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.

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 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.

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

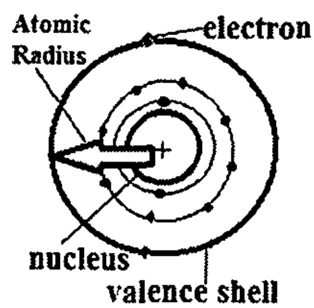
Notes

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

Trends in the Modern Periodic Table - Valency, Atomic Size, Metallic Character

DEFINE ATOMIC SIZE (ATOMIC RADIUS) - DEFINITION



Atomic Size (Atomic Radius) is the distance between the nucleus and valence shell.

METALLIC AND NON-METALLIC PROPERTIES - DEFINITION

The tendency of an element to lose electrons and form positive ions (cations) is called electropositive or metallic character. The tendency of an element to accept electrons to form an anion is called its non-metallic or electronegative character. In each period, metallic character of elements decreases as we move to the right. Elements to the left of the periodic table have a pronounced metallic character while those to the right have a non-metallic character. Conversely, non-metallic character increases from left to right.

As we move down the group the number of shells increases. This causes the effective nuclear charge to decrease due to the outer shells being further away: in effect the atomic size increases. The electrons of the outermost shell experience less nuclear attraction and so can lose electrons easily thus showing increased metallic character.

DIFFERENT ATOMIC RADIUS DEFINITIONS - DEFINITION

In a practical way, it is difficult to measure the size of an individual atom. But we can estimate the radii of the atom by the bonds it forms. But still, there is no fixed radius of an atom.

We can understand atomic radius by three definitions:

- Covalent Radius: If an element is non-metallic
- Metallic Radius: If an element is metallic
- van der Waals Radius: If an element is a noble gas.

FACTORS AFFECTING METALLIC OR NONMETALLIC CHARACTER - EXAMPLE

Metals are highly electropositive in nature and non-metals are more electronegative in nature. As the electro positively increases metallic character increases and as the electronegativity increases non-metallic character increases.

TREND OF METALLIC AND NON-METALLIC PROPERTIES IN MODERN PERIODIC TABLE - EXAMPLE

In modern periodic table metallic character increases down the group and decreases from left to right across the period.

METALLIC CHARACTER TREND ACROSS THE PERIOD - DEFINITION

Metallic character decreases as you move across a period from left to right. Metallic character depends on how quick electron can lose from an atom. As the tendency to lose electrons decreases across the period, metallic character decreases.

SIZE OF ATOMS AND MOLECULES - DEFINITION

Most molecules and atoms are far too small to be seen with the naked eye, but there are exceptions. DNA, a macromolecule, can reach macroscopic sizes, as can molecules of many polymers. Molecules commonly used as building blocks for organic synthesis have a dimension of a few angstroms (A^{o}) to several dozen , or around one billionth of a meter.

METALLIC AND NONMETALLIC CHARACTER - DEFINITION

The tendency of an atom to lose electrons is known as metallic character.

The tendency of an atom to gain electrons is known as non-metallic character.

ATOMIC SIZE OR ATOMIC RADIUS - DEFINITION

The atomic radius of an element is a measure of the size of its atoms. It represents the mean distance from the nucleus to the outermost boundary of the surrounding cloud of electrons. Atomic radii vary in a predictable manner across the periodic table.

FACTORS WHICH AFFECT ATOMIC SIZE - EXAMPLE

Factors affecting atomic size are:

(a) Screening effect- caused by mutual repulsion between electrons in the inner shell with those in the outer shell.

(b) Nuclear charge- more the number of protons in the nucleus. More will be the pull-on electrons closer to the nucleus which causes the atomic size to decrease

Summary of the Chapter

- Doberiener's Triads – When elements are arranged in a group of three in increasing order of their atomic masses, the atomic mass of the middle element is found to be approximately equal to the arithmetic mean of the atomic masses of the other two elements.
- Newland's Law of octaves – The properties of every eighth element was similar to the first.

Mendeleev's Periodic Law states that the physical and chemical properties of elements are periodic function of their atomic masses.

Limitations

- Anomalous position of hydrogen
- Position of isotopes
- Atomic masses do not increase in a regular manner.
- Uncertainty in prediction of new elements.

Modern Periodic Law

The physical and chemical properties of elements are periodic function of their atomic numbers.

Modern periodic table

- It contains 7 periods and 18 groups.
- All the limitations of Mendeleev's periodic table had been removed except one i.e., anomalous position of hydrogen.

PERIODIC CLASSIFICATION OF ELEMENTS

Periodicity in Properties		
Properties	**Across a period**	**Down the group**
(a) Valency	First increases from 1 to 4 than decreases from 4 to zero	Remains same
(b) Atomic size	Decreases	Increases
(c) Metallic character	Decreases	Increases
(d) Non-metallic character	Increases	Decreases

EXERCISE

Multiple Choice Questions

1. 14 elements after actinium is called
   (a) Lanthanides
   (b) Actinides
   (c) D-block elements
   (d) P block elements

2. An element has an atomic number of 15 with which of the following elements will it show similar chemical properties.
   (a) Be (4)
   (b) Ne (10)
   (c) N(7)
   (d) O (8)
3. The group number and period number respectively of an element with atomic number 8 is.
   (a) 6,2
   (b) 16,2
   (c) 6,8
   (d) 16,4
4. An element belongs to period 2 and group 2 the number of valence electrons in the atoms of this element is.
   (a) 2
   (b) 4
   (c) 3
   (d) 1
5. In the third period of the periodic table the element having smallest size is
   (a) Na
   (b) Ar
   (c) Cl
   (d) Si
6. Electronic configuration of Al+3 is
   (a) 2,8,3
   (b) 2,8,8
   (c) 2,8
   (d) 2,8,8,3
7. Identify the group which is not a Dobereiner triad
   (a) Li, Na, K
   (b) Be, Mg, Cr
   (c) Ca, Sr, Ba
   (d) Cl, Br, I
8. Which is not true about the noble gases?
   (a) They are non-metallic in nature
   (b) They exist in atomic form
   (c) They are radioactive in nature
   (d) Xenon is the most reactive among these
9. Identify the wrong sequence of the elements in a group
   (a) Ca, Br, Ba
   (b) Cu, Au, Ag
   (c) N,P, As
   (d) Cl, Br, I

10. An element with atomic number will form a basic oxide_______
    (a) 7
    (b) 17
    (c) 14
    (d) 11

ANSWERS

1. (B)	**2.** (C)	**3.** (A)	**4.** (A)	**5.** (B)
6. (C)	**7.** (B)	**8.** (C)	**9.** (B)	**10.** (D)

HOTS

1. On what basis did Mendeleev classified the element?
2. Define 'groups and period'?
3. What is common among all the elements present in one period?
4. Name two alkali metals present in Group 1.
5. An element X belongs to II group and 2nd period. Write atomic number and name of element.
6. The electronic configuration of an atom is 2,8,7. Give its atomic number, nature of oxide.
7. Why are noble gases placed in a separate group?
8. Lithium, sodium potassium belongs to same group called alkali metals. Why?
9. Give characteristics of period.
10. State three points of difference between Mendeleev's Periodic Table and Modern Periodic Table.

Space for Notes

Theme: The World of the Living
Unit II: World of Living (50 Periods)

6 LIFE PROCESSES

Life processes: 'Living Being'. Basic concept of nutrition, respiration, transport and excretion in plants and animals.

Objective of the Chapter

The main objective of the chapter is to make student understand about the basic concepts of Life processes in 'Living Being' by explaining the concepts of nutrition, respiration, transport and excretion

Introduction

- All the plants and animals are alive or living things.
- The most important criterion to decide whether something is alive or not is the movement.
- The movements in animals are fast and can be observed easily but the movements in plants are slow and observed with difficulty.
- Animals can move from one place to another or they can move their body parts.
- The plants can only move parts of their body such as leaves, flowers, roots and shoots.

Life Processes

The basic functions performed by living organisms to maintain their life on this earth are called life processes.

Basic life processes common to all living organisms are:

Basic life processes	Function
Nutrition	Taking of food inside the body and converting it into smaller molecules which can be absorbed by the body.
Respiration	The process which releases energy from the food absorbed by the body.
Transport	The process in which a substance absorbed or made in one part of the body is moved to other parts of the body.
Excretion	The process in which the waste materials produced in the cells of the body are removed from the body.

Control and coordination	A process which helps the living organisms to survive in the changing environment around them.
Growth	The process involves the changes from a smaller organism to a big organism.
Movement	The organism either moves from one place to another or moves its body parts.
Reproduction	The process involves the making of more organisms form the existing once.

All the living organisms need energy to perform various life processes. They get this energy from food. Food is a kind of fuel which provides energy to all the living organisms.

Nutrition

- Food is an organic substance. The simplest food is glucose also called simple sugar.
- A more complex food is starch. It is made from glucose.
- The general name of substances like glucose and starch is 'carbohydrates.

Nutrient: A nutrient can be defined as a substance which an organism obtains from its surroundings and uses it as a source of energy or for the biosynthesis of its body constituents.

Example: carbohydrates and fats are the nutrients which are used by the organism mainly as a source of energy.

Proteins and mineral salts are nutrients used by organism for the biosynthesis of its body constituents like skin, blood, etc.

Nutrition:

Nutrition is the process of intake of nutrients (like carbohydrates, fats, proteins, minerals, vitamins and water) by an organism as well as the utilization of these nutrients by the organism.

Mode of Nutrition:

Mode of nutrition means method of obtaining food by an organism. There are mainly two modes of nutrition:

1. Autotrophic mode of nutrition
2. Heterotrophic mode of nutrition

Autotrophic mode of nutrition: ('auto' means 'self' and 'trophe' means 'nutrition')

- Autotrophic nutrition is that mode of nutrition in which an organism makes (or synthesizes) its own food from the simple inorganic materials like carbon dioxide and water present in the surroundings (with the help of sunlight energy).

- Those organisms which can make their own food from carbon dioxide and water are called **autotrophs.**
- Example: all green plants, autotrophic bacteria.
- Autotrophs make their food by photosynthesis.

Heterotrophic mode of nutrition: ('heteros' means 'others' and 'trophe' means 'nutrition')

- Heterotrophic nutrition is that mode of nutrition in which an organism cannot make (or synthesizes) its own food from simple inorganic materials like carbon dioxide and water, and depends on other organisms for its food.
- Those organisms which cannot make their own food from inorganic substances like carbon dioxide and water, and depends on other organisms for their food are called **heterotrophs.**
- **Example:** all the animals (man, dog, cat, lion, etc.), most bacteria and fungi.

Types of Heterotrophic Nutrition:

Heterotrophic mode of nutrition is of three types

1. Saprotrophic (saprophytic) nutrition
2. Parasitic nutrition
3. Holozoic nutrition

Saprotrophic nutrition:

- Saprotrophic nutrition is that nutrition in which an organism obtains its food from decaying organic matter of dead plants, dead animals and rotten bread, etc.
- The organisms having saprotrophic mode of nutrition are called saprophytes.
- **Saprophytes** are the organisms which obtain food from dead plants (like rotten leaves), dead and decaying animal bodies, and other decaying organic matter.
- Example: Fungi (liker bread moulds, mushrooms), and many bacteria.

Parasitic nutrition:

- The parasitic nutrition is that nutrition in which an organism derives its food from the body of another living organisms without killing it.
- A **parasite** is an organism (plant or animal) which feed on another living organism called its host.
- Example: some animals like Plasmodium and roundworms, a few plants like Cuscuta (amarbel) and several fungi and bacteria.

Holozoic nutrition:

- The holozoic nutrition is that nutrition in which an organism takes the complex organic food materials into its body by the process of ingestion, the ingested food is digested and then absorbed into the body cells of the organism.
- **Example:** human beings and most of the animal.

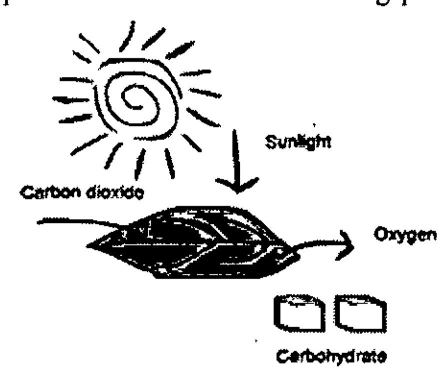
Plant Nutrition

Green plants prepare their own food. They make food in the presence of sunlight. Sunlight provides energy. carbon dioxide and water are the raw materials. Chloroplast is the site where food is made.

Photosynthesis: The process by which green plants prepare food is called photosynthesis. During this process; the solar energy is converted into chemical energy and carbohydrates are formed. Green leaves are the main sites of photosynthesis. The green portion of the plant contains a pigment chloroplast; which contains chlorophyll. The whole process of photosynthesis can be shown by following equation:

Steps of Photosynthesis:

- Sunlight activates chlorophyll; which leads to splitting of water molecule.
- The hydrogen; released by splitting of water molecule is utilized for reduction of carbon dioxide to produce carbohydrates.
- Oxygen is the by-product of photosynthesis.
- Carbohydrate is subsequently converted into starch and is stored in leaves and other storage parts.
- The splitting of water molecules is part of the light reaction.
- Other steps are part of the dark reaction during photosynthesis.



How do raw materials for photosynthesis become available to the plant?

- Water comes from soil; through the xylem tissue in roots and stems.
- Carbon dioxide comes in the leaves through stomata.

Animal Nutrition

Heterotrophic Nutrition: When an organism takes food from another organism, it is called heterotrophic nutrition. Different heterotrophic organisms follow different methods to take and utilize food. Based on this, heterotrophic nutrition can be divided into two types:

a. **Saprophytic Nutrition:** In saprophytic nutrition, the digestion of food takes place before ingestion of food. This type of nutrition is usually seen in fungi and some other microorganisms. The organism secretes digestive enzymes on the food and then ingests the simple substances. Saprophytes feed on dead materials and thus help in decomposition dead remains of plants and animals.

b. **Holozoic Nutrition:** In holozoic nutrition, the digestion of food follows after the ingestion of food. Thus, digestion takes place inside the body of the organism. Holozoic nutrition happens in five steps, viz. ingestion, digestion, absorption, assimilation and egestion.

Steps of Holozoic Nutrition

1. **Ingestion:** The process of taking in the food is called ingestion.
2. **Digestion:** The process of breaking complex food substances into simple molecules is called digestion. Simple molecules; thus obtained; can be absorbed by the body.
3. **Absorption:** The process of absorption of digested food is called absorption.
4. **Assimilation:** The process of utilization of digested food; for energy and for growth and repair is called assimilation.
5. **Egestion:** The process of removing undigested food from the body is called egestion.

Nutrition in Amoeba:

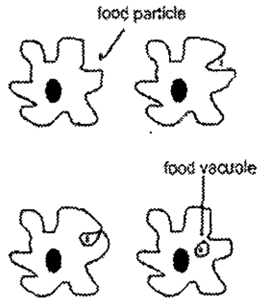


Fig: Nutrition in Amoeba

Amoeba is a unicellular animal which follows holozoic mode of nutrition. The cell membrane of amoeba keeps on protruding into pseudopodia. Amoeba surrounds a food particle with pseudopodia and makes a food vacuole. The food vacuole contains the food particle and water. Digestive enzymes are secreted in the food vacuole and digestion takes place. After that, digested food is absorbed from the food vacuole. Finally, the food vacuole moves near the cell membrane and undigested food is expelled out.

Nutrition in Humans

Human beings are complex animals; which have a complex digestive system. The human digestive system is composed of an alimentary canal and some accessory glands. The alimentary canal is divided into several parts, viz. oesophagus, stomach, small intestine, large intestine, rectum and anus. Salivary gland, liver and pancreas are the accessory glands which lie outside the alimentary canal.

Structure of the Human Digestive System:

Mouth or Buccal Cavity: The mouth has teeth and tongue. Salivary glands are also present in the mouth. The tongue has gustatory receptors which perceive the sense of taste. Tongue helps in turning over the food, so that saliva can be properly mixed in it. Teeth help in breaking down the food into smaller particles so that swallowing of food becomes easier. There are four types of teeth in human beings. The incisor teeth are used for cutting the food. The canine teeth are used for tearing the food and for cracking hard substances. The premolars are used for coarse grinding of food. The molars are used for fine grinding of food. Salivary glands secrete saliva. Saliva makes the food slippery which makes it easy to swallow the food. Saliva also contains the enzyme salivary amylase or ptyalin. Salivary amylase digests starch and converts it into sucrose.

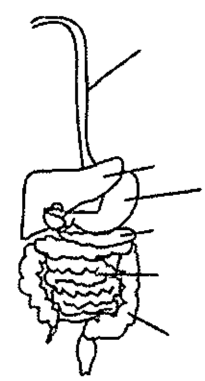


Fig: Human Digestive System

Stomach: Stomach is a bag-like organ. Highly muscular walls of the stomach help in churning the food. The walls of stomach secrete hydrochloric acid. Hydrochloric acid kills the germs which may be present in food. Moreover, it makes the medium inside stomach as acidic. The acidic medium is necessary for gastric enzymes to work. The enzyme pepsin; secreted in stomach; does partial digestion of protein. The mucus; secreted by the walls of the stomach saves the inner lining of stomach from getting damaged from hydrochloric acid.

Small Intestine: It is a highly coiled tube-like structure. The small intestine is longer than the large intestine but its lumen is smaller than that of the large intestine. The small intestine is divided into three parts, viz. duodenum, jejunum and ileum.

Liver: Liver is the largest organ in the human body. Liver manufactures bile; which gets stored in gall bladder. From the gall bladder, bile is released as and when required.

Pancreas: Pancreas is situated below the stomach. It secretes pancreatic juice which contains many digestive enzymes.

Bile and pancreatic juice go to the duodenum through a hepato-pancreatic duct. Bile breaks down fat into smaller particles. This process is called emulsification of fat. After that, the enzyme lipase digests fat into fatty acids and glycerol. Trypsin and chymotrypsin are enzymes which digest protein into amino acids. Complex carbohydrates are digested into glucose. The major part of digestion takes place in the duodenum.

No digestion takes place in jejunum. The inner wall in the ileum is projected into numerous finger-like structures; called villi. Villi increase the surface area inside the ileum so that optimum absorption can take place. Moreover, villi also reduce the lumen of the ileum so that food can stay for longer duration in it; for optimum absorption. Digested food is absorbed by villi.

Large Intestine: Large intestine is smaller than small intestine. Undigested food goes into the large intestine. Some water and salt are absorbed by the walls of the large intestine. After that, the undigested food goes to the rectum; from where it is expelled out through the anus.

Respiration

The process by which a living being utilizes the food to get energy is called respiration. Respiration is an oxidation reaction in which carbohydrate is oxidized to produce energy. Mitochondrion is the site of respiration and the energy released is stored in the form of ATP (Adenosine triphosphate). ATP is stored in mitochondria and is released as per need.

Steps of Respiration:

a. **Breaking down glucose into pyruvate:** This step happens in the cytoplasm. Glucose molecule is broken down into pyruvic acid. Glucose molecule is composed of 6 carbon atoms, while pyruvic acid is composed of 3 carbon atoms.

b. **Fate of Pyruvic Acid:** Further breaking down of pyruvic acid takes place in mitochondria and the molecules formed depend on the type of respiration in a particular organism. Respiration is of two types, viz. aerobic respiration and anaerobic respiration.

Types of Respiration:

a. **Aerobic Respiration:** This type of respiration happens in the presence of oxygen. Pyruvic acid is converted into carbon dioxide. Energy is released and water molecule is also formed at the end of this process.

b. **Anaerobic Respiration:** This type of respiration happens in the absence of oxygen. Pyruvic acid is either converted into ethyl alcohol or lactic acid. Ethyl alcohol is usually formed in case of anaerobic respiration in microbes; like yeast or bacteria. Lactic acid is formed in some microbes as well as in the muscle cells.

Glucose (6 carbon molecule) ⇨ Pyruvate (3 carbon molecule) + Energy

Pyruvate (In yeast; lack of O_2*) ⇨ Ethyl alcohol + Carbon dioxide + Energy*

Pyruvate (In muscles; lack of O_2*) ⇨ Lactic Acid + Energy*

Pyruvate (In mitochondria; presence of O_2 *) ⇨ Carbon dioxide + Water + Energy*

The equations for above reactions can be written as follows:

$$C_6H_{12}O_6 \Rightarrow 6CO_2 + 6H_2O + Energy$$

$$C_6H_{12}O_6 \Rightarrow C_2H_5OH + CO_2$$

$$C_6H_{12}O_6 \Rightarrow CH_3CHOHCOOH$$

Pain in Leg Muscles on Running: When someone runs too fast, he may experience a throbbing pain the leg muscles. This happens because of anaerobic respiration taking place in the muscles. During running, the energy demand from the muscle cells increases. This is compensated by anaerobic respiration and lactic acid is formed in the process. The deposition of lactic acid causes the pain the leg muscles. The pain subsides after taking rest for some time.

Exchange of Gases: For aerobic respiration; organisms need a continuous supply of oxygen, and carbon dioxide produced during the process needs to be removed from the body. Different organisms use different methods for intake of oxygen and expulsion of carbon dioxide. Diffusion is the method which is utilized by unicellular and some simple organisms for this purpose. In plants also, diffusion is utilized for exchange of gases. In complex animals, respiratory system does the job of exchange of gases. Gills are the respiratory organs for fishes. Fishes take in oxygen; which is dissolved in water; through gills. Since availability of oxygen is less in the aquatic environment so the breathing rate of aquatic organisms is faster. Insects have a system of spiracles and tracheae which is used for taking in oxygen.

Terrestrial organisms have developed lungs for exchange of gases. Availability of oxygen is not a problem in the terrestrial environment so breathing rate is slower compared to what it is in fishes.

Human Respiratory System:

The human respiratory system is composed of a pair of lungs. These are attached to a system of tubes which open on the outside through the nostrils. Following are the main structures in the human respiratory system:

Nostrils: There two nostrils which converge to form a nasal passage. The inner lining of the nostrils is lined by hairs and remains wet due to mucus secretion. The mucus and the hairs help in filtering the dust particles out from inhaled air. Further, air is warmed up when it enters the nasal passage.

Pharynx: It is a tube-like structure which continues after the nasal passage.

Larynx: This part comes after the pharynx. This is also called the voice box.

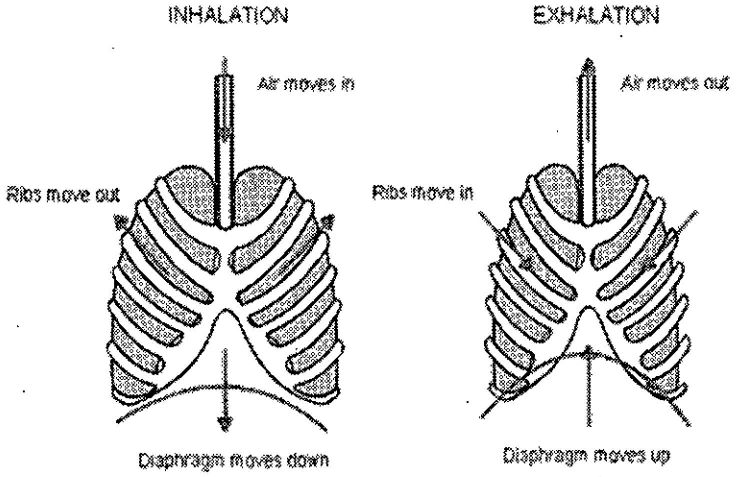
Trachea: This is composed of rings of cartilage. Cartilaginous rings prevent the collapse of trachea in the absence of air.

Bronchi: A pair of bronchi comes out from the trachea; with one bronchus going to each lung.

Bronchioles: A bronchus divides into branches and sub-branches; inside the lung.

Alveoli: These are air-sacs at the end of bronchioles. Alveolus is composed of a very thin membrane and is the place where blood capillaries open. This is alveolus; where oxygen mixes with the blood and carbon dioxide exits from the blood. The exchange of gases; in alveoli; takes place due to pressure differential.

Breathing Mechanism: The breathing mechanism of lungs is controlled by the diaphragm and the intercostalis muscles. Diaphragm is a membrane which separates the thoracic chamber from the abdominal cavity. When diaphragm moves down, the lungs expand and air is inhaled. When diaphragm moves up, the lungs contract and air is exhaled.



Transportation in Animals

Circulatory System: The circulatory system is responsible for transport of various substances in human beings. It is composed of the heart, arteries, veins and blood capillaries. Blood plays the role of the carrier of substances.

Heart: Heart is a muscular organ; which is composed of cardiac muscles. It is so small that it can fit inside and adult's fist. The heart is a pumping organ which pumps the blood. The human heart is composed of four chambers, viz. right auricle, right ventricle, left auricle and left ventricle.

Systole: Contraction of cardiac muscles is called systole.

Diastole: Relaxation of cardiac muscles is called diastole.

Arteries: These are thick-walled blood vessels which carry oxygenated blood from the heart to different organs. Pulmonary arteries are exceptions because they carry deoxygenated blood from the heart to lungs; where oxygenation of blood takes place.

Veins: These are thin-walled blood vessels which carry deoxygenated blood from different organs to the heart. Pulmonary veins are exceptions because they carry oxygenated blood from lungs to the heart. Valves are present in veins to prevent backflow of blood.

Capillaries: These are the blood vessels which have single-celled walls.

Blood: Blood is a connective tissue which plays the role of the carrier for various substances in the body. Blood is composed of plasma, blood cells and platelets.

Blood Plasma: Blood plasma is a pale coloured liquid which is mostly composed of water. Blood plasma forms the matrix of blood.

Blood Cells: There are two types of blood cells, viz. Red Blood Cells (RBCs) and White Blood Cells (WBCs).

Red Blood Corpuscles (RBCs): These are of red colour because of the presence of haemoglobin which is a pigment. Haemoglobin readily combines with oxygen and carbon dioxide. The transport of oxygen happens through haemoglobin. Some part of carbon dioxide is also transported through haemoglobin.

White Blood Corpuscles (WBCs): These are of pale white colour. They play important role in the immunity.

Platelets: Platelets are responsible for blood coagulation. Blood coagulation is a defence mechanism which prevents excess loss of blood; in case of an injury.

Lymph: Lymph is similar to blood but RBCs are absent in lymph. Lymph is formed from the fluid which leaks from blood capillaries and goes to the intercellular spaces in the tissues. This fluid is collected through lymph vessels and finally returns to the blood capillaries. Lymph also plays an important role in the immune system.

Double Circulation: In the human heart, blood passes through the heart twice in one cardiac cycle. This type of circulation is called double circulation. One complete heart beat in which all the chambers of the heart contract and relax once is called cardiac cycle. The heart beats about 72 times per minute in a normal adult. In one cardiac cycle, the heart pumps out 70 mL blood and thus about 4900 mL blood in a minute. Double circulation ensures complete segregation of oxygenated and deoxygenated blood which is necessary for optimum energy production in warm-blooded animals.

Circulation of Blood through the heart:

Systemic Vein ⇨ Sinus Venosus ⇨ Right Auricle ⇨ Right Ventricle ⇨ Pulmonary Artery ⇨ Lungs ⇨ Pulmonary Vein ⇨ Left Auricle ⇨ Left Ventricle ⇨ Trunchus Arteriosus ⇨ Systemic Circulation

Excretion

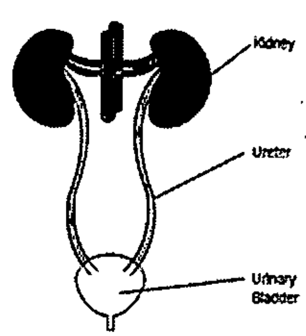


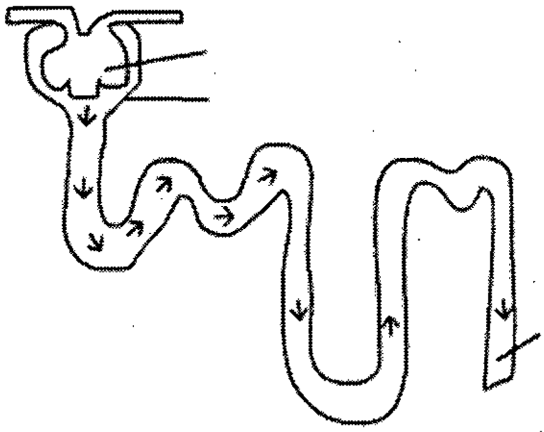
Fig: Human Excretory System

Removal of harmful waste from the body is called excretion. Many wastes are produced during various metabolic activities. These need to be removed in time because their accumulation in the body can be harmful and even lethal for an organism.

Human Excretory System

The human excretory system is composed of a pair of kidneys. A tube; called ureter; comes out of each kidney and goes to the urinary bladder. Urine is collected in the urinary bladder, from where it is expelled out through urethra as and when required.

Kidney: Kidney is a bean-shaped organ which lies near the vertebral column in the abdominal cavity. The kidney is composed of many filtering units; called nephrons. Nephron is called the functional unit of kidney.



Nephron: It is composed of a tangled mess of tubes and a filtering part; called glomerulus. Glomerulus is a network of blood capillaries to which renal artery is attached. The artery which takes blood to the glomerulus is called afferent arteriole and the one receiving blood from the glomerulus is called efferent arteriole. Glomerulus is enclosed in a capsule like portion; called Bowman's capsule. The Bowman's capsule extends into a fine tube which is highly coiled. Tubes from various nephrons converge into collecting duct; which finally goes to the ureter.

Filtration in Glomerulus: Filtration happens because of very high pressure inside the glomerulus. The lumen of efferent arteriole is smaller than that of afferent arteriole. Due to this, the blood entering the glomerulus experiences very high pressure and due to this, the waste products are filtered out through the thin membrane of capillaries in the glomerulus. The filtered blood is sent to the systemic circulation through efferent arteriole and the filtrate goes to the Bowman's capsule. That is how urine is formed inside the kidneys. Reabsorption of water and some other filtrates takes place in the tubular part of the nephron. This increases the concentration of urine. The human urine is mainly composed of water and urea.

Summary of the Chapter

Life Process

The processes which maintain the body functions and are required for the survival of living being are called life processes. Some of the important life processes are nutrition, respiration, transportation, excretion etc.

Nutrition in Human Beings

The alimentary canal is a long tube extending from the mouth to the anus. The nutrition in human being is divided into five steps:

- **Ingestion:**
- **Digestion:**
- **Absorption**
- **Assimilation:**
- **Excretion**

Transportation

Transportation in Human Beings

- Blood consists of fluid medium called plasma in which the cells are suspended. Plasma transports food, CO_2 & nitrogenous wastes in dissolved form. Oxygen is carried by RBC.
- Heart: Heart is the muscular organ made up of cardiac muscles and is as big as our fist. It is composed of four chambers (2 atria & 2 ventricles) to prevent the mixing of oxygenated & deoxygenated blood.
- Ventricles are thick wailed as they have to pump the blood to various organs of the body. In addition, valves are also present in heart and veins to prevent the backflow of the blood.

Circulation of blood: Oxygenated blood is carried out from lungs to the left atrium with the help of pulmonary' veins.

- Left atrium contracts to release blood into the left ventricle which relaxes while collecting it. It then pumped out the blood to whole body via aorta.

  a Deoxygenated blood from whole body then enters the right atrium via vena cava vein.

- Right atrium contracts to pump the blood in right ventricle. It then pumps the blood towards lungs via pulmonary' artery for oxygenation.

Oxygenation of blood: Invertebrates such as birds, mammals etc which constantly use energy to maintain their body temperature, blood goes through heart twice during each cycle which is known as double circulation.

- In contrast, animals like amphibians or many reptiles have three-chambered hearts as they can tolerate some mixing of the oxygenated & de-oxygenated blood streams. They do not use energy for thermoregulation and body temperature depends on the temperature in the environment.

- Fishes, on other hand, have only two chambered heart. Blood is pumped to the gills for oxygenation and passes directly to the rest of the body.

Transportation in Plants

There are two main pathways present in plants: xylem pathway- moves water & minerals from the soil & phloem transports products of photosynthesis from leaves (where they are synthesized) to other parts of the plant.

EXERCISE

Multiple Choice Questions

1. The chlorophyll in photosynthesis is used for
   (a) Absorbing light
   (b) Breaking down water molecule
   (c) No function
   (d) Reduction of CO_2
2. Proteins after digestion are converted into
   (a) Carbohydrates
   (b) Small globules
   (c) Amino acids
   (d) starch
3. Carbohydrates in the plants are stored in the form of
   (a) Glycogen
   (b) Starch
   (c) Glucose
   (d) Maltose
4. Main site of photosynthesis
   (a) Leaf
   (b) Stem
   (c) Chloroplast
   (d) Guard cells
5. The small pores present of leaf's surface are called
   (a) Stomata
   (b) Chlorophyll
   (c) Guard cells
   (d) None of these
6. Photosynthesis is a
   (a) Catabolic process
   (b) Parabolic process
   (c) Amphibolic process
   (d) Photochemical process

7. Opening and closing of pores is a function performed by
   (a) Stomata
   (b) Chlorophyll
   (c) Chloroplast
   (d) Guard cells
8. Which element is used in the synthesis of proteins?
   (a) Hydrogen
   (b) Oxygen
   (c) Nitrogen
   (d) Carbon dioxide
9. Temporary finger like extensions on amoeba are called
   (a) Cell membrane
   (b) Cell wall
   (c) Pseudopodia
   (d) Cilia
10. Bile juice is secreted by
    (a) Stomach
    (b) Pancreas
    (c) Small intestine
    (d) Liver
11. Which of these juices is secreted by pancreas?
    (a) Trypsin
    (b) Pepsin
    (c) Bile juice
    (d) Both I and II
12. Lipase acts on
    (a) Amino acids
    (b) Fats
    (c) Carbohydrates
    (d) All of these

ANSWERS

1. (a)	**2.** (c)	**3.** (b)	**4.** (c)	**5.** (a)
6. (d)	**7.** (d)	**8.** (c)	**9.** (c)	**10.** (d)
11. (d)	**12.** (b)			

Review Questions

1. How is 'respiration' different from 'breathing'? Explain the process of aerobic and anaerobic respiration.
2. (i) Name the blood vessel that brings oxygenated blood to the human heart.
   (ii) Which chamber of the heart received oxygenated blood?
   (iii) Explain how is the oxygenated blood from this particular chamber sent to all the body parts?

3. Explain the schematic representation of gaseous exchange in tissues.
4. Compare the functioning of alveoli in the lungs and nephrons in the kidneys with respect to their structures and functioning?
5. What is the significance of emulsification of fats?
6. Why is the small intestine in herbivores larger than in carnivores?
7. What is the advantage if a four chambered heart?

   Reproduction: Reproduction in animals and plants (asexual and sexual) reproductive health-need and methods of family planning. Safe sex vs HIV / AIDS. Child bearing and women's health.

Space for Notes

Theme: The World of the Living
Unit II: World of Living (50 Periods)

7 REPRODUCTION IN PLANTS AND ANIMALS

Objective of the Chapter

The main objective of the unit is to make student understand about:

- Reproduction in animals
- Reproduction in plants

Introduction

"Living organisms cannot survive for an indefinite period on earth. All living organisms have the ability to produce more of its own kind by the process called reproduction.

Reproduction is the unfolding of life forms where new individuals are formed. It ensures continuity and survival of the species. This process is to preserve individual species and it is called as self-perpetuation.

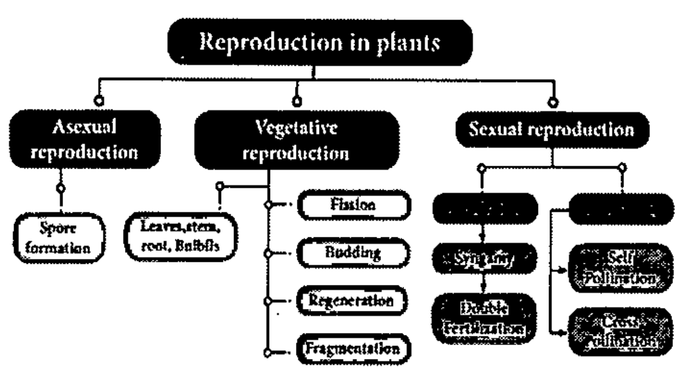
The time required to reproduce also varies from organism to organism. You may find great variations in period of reproduction in yeast, bacteria, rat, cow, elephant and humans. In sexual reproduction offspring are produced by the union of male and female gametes (sperm and egg).

The male and female gametes contain the genetic material or genes present on the chromosomes which transmit the characteristic traits to the next generation. There are three types of reproduction in plants namely

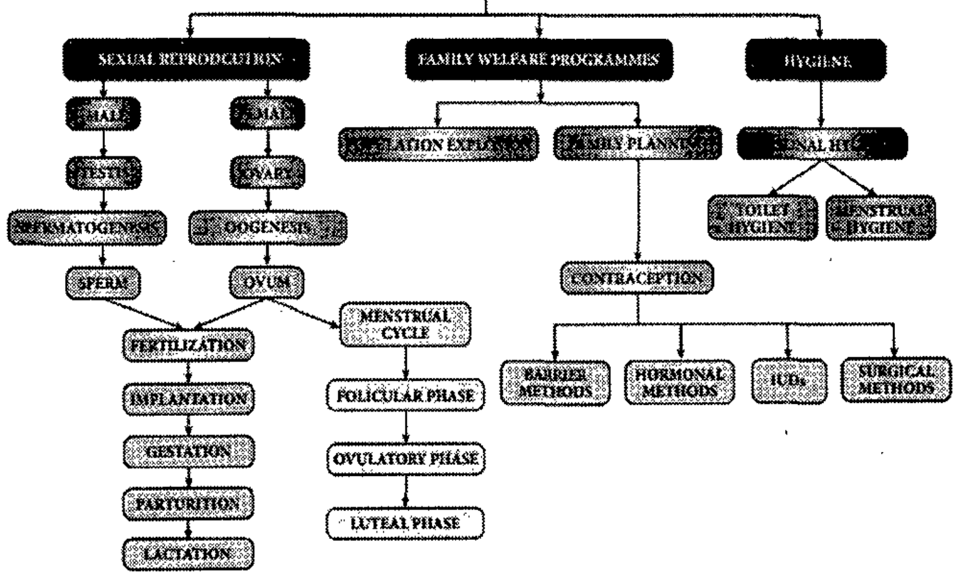
(i) Vegetative (ii) Asexual and

(iii) Sexual reproduction. In this unit you will know more about the types and the process of asexual and sexual reproduction in plants, animals and human.

Concept Map



SEXUAL REPRODUCTION IN HUMAN



Vegetative Reproduction

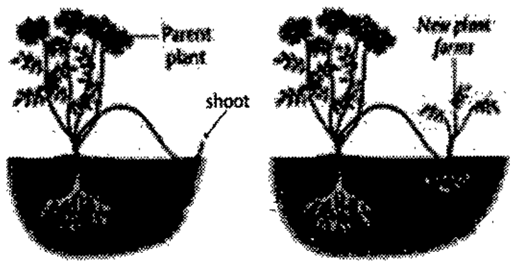
In this type, new plantlets are formed from vegetative (somatic) cells, buds or organs of plant. The vegetative part of plant (root, stem, leaf or bud) gets detached from the parent body and grows into an independent daughter plant. It has only mitotic division, no gametic fusion and daughter plants are genetically similar to the parent plant.

Vegetative reproduction may take place through

(i) **Leaves:** In Bryophyllum small plants grow at the leaf notches

Vegetative reproduction by leaf

(ii) **Stems:** In strawberry aerial weak stems touch the ground and give off adventitious roots and buds. When the connections with the parent plant is broken, the offspring becomes independent.

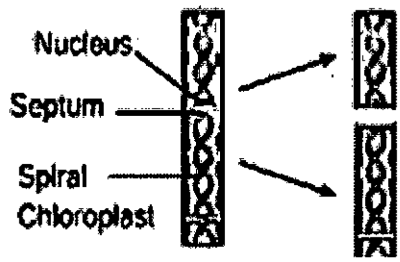


Vegetative reproduction by stem

(iii) **Root:** Tuberous roots (Asparagus and Sweet potato) can be used for vegetative propagation.

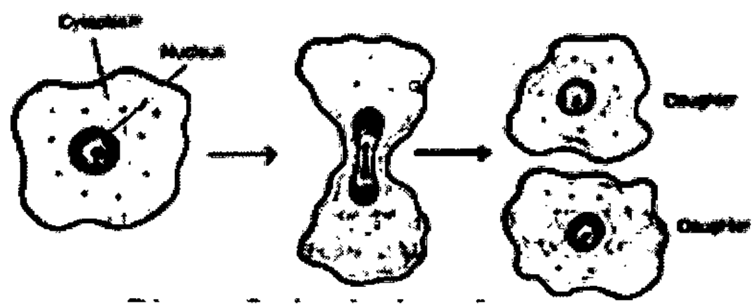
(iv) **Bulbils:** In some plants the flower bud modifies into globose bulb which are called as bulbils, when these falls on the ground they grow into new plants, e.g. Agave.

Fragmentation: In filamentous algae, breaking of the filament into many fragments is called fragmentation. Each fragment having at least one cell, may give rise to a new filament of the algae by cell division e.g. Spirogyra.



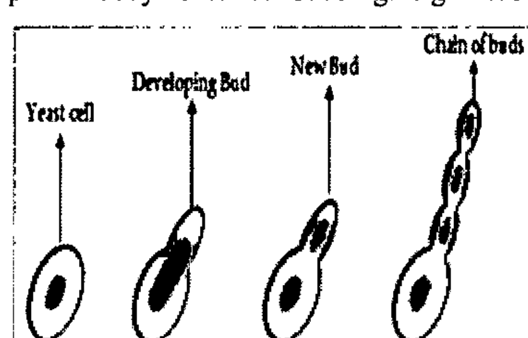
Fragmentation in Spirogyra

Fission: In this type the parent cell divides into two daughter cells and each cell develops into a new adult organism e.g. Amoeba.



Fission in Amoeba

Budding: Formation of a daughter individual from a small projection, the bud, arising on the parent body is called budding. e.g. Yeast.



Budding in Yeast

Regeneration: The ability of the lost body parts of an individual organism to give rise to a whole new organism is called regeneration. It takes place by specialized mass of cells e.g. *Hydra* and *Planaria*.

Asexual Reproduction

Production of an offspring by a single parent without the formation and fusion of gametes is called asexual reproduction. It involves only mitotic cell divisions and meiosis does not occur. Offspring produced by asexual reproduction are not only identical to parents but are also exact copies of their parent.

Asexual reproduction occurs by **spore formation.** This is the most common method of asexual reproduction in fungi and bacteria

During spore formation a structure called **sporangium** develops from the **fungal hypha**. The nucleus divides several times within the sporangium and each nucleus with small amount of cytoplasm develops into a spore. The spores are liberated and they develop into new hypha after reaching the ground or substratum.

Sexual Reproduction in Plants

Sexual reproduction is the process in which two gametes (male and female) are fused to produce offspring of their own kind. In such cases both sexes, male and female sex organs are needed to produce gametes. You have already learnt that the flower is a reproductive organ of a flowering plant. To understand this further we need to study the structure of a flower.

1. Parts of a Typical Flower

A flower is a modified shoot with limited growth to carry out sexual reproduction. A flower consists of four whorls borne on a thalamus. These whorls are from outside

(a) Calyx – consisting of sepals

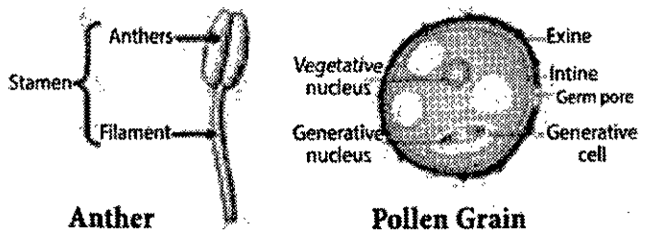
(b) Corolla – consisting of petals

(c) Androecium – consisting of stamens

(d) Gynoecium or pistil – consisting of carpels

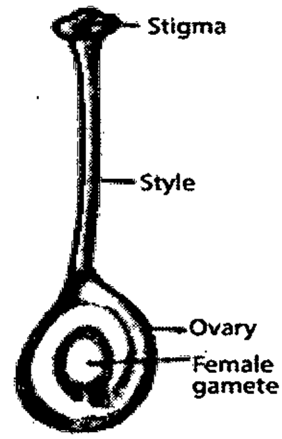
The **two outermost whorls calyx** and **corolla** are **non–essential** or **accessory whorls** as they do not directly take part in the reproduction. The other two whorls **androecium** and **gynoecium** are known as the **essential whorls,** because both take part directly in reproduction.

Androecium: Androecium, the **male part** of flower is composed of **stamens.** Each stamen consists of a stalk called the **filament** and a small bag like structure called **anther** at the tip. The pollen grains are produced in the anther within the pollen sac.



Structure of Anther and Pollen grain

Pollen grain: Pollen grains are usually spherical in shape. It has two layered walls. The hard-outer layer is known as **exine**. It has prominent apertures called germ pore. The inner thin layer is known as **intine**. It is a thin and continuous layer made up of cellulose and pectin. Mature pollen grains contain two cells, the **vegetative** and the **generative cell**. Vegetative cell contains a large nucleus. The generative cell divides mitotically to form two male gametes.



Gynoecium

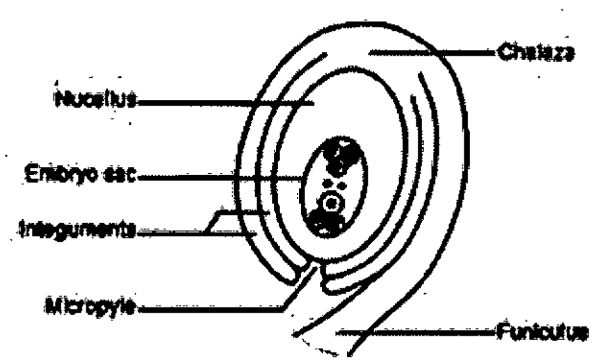
Gynoecium: Gynoecium is the female part of the flower and is made up of carpels. It has three parts:

1. Ovary
2. Style
3. Stigma

The ovary contains the ovules.

2. Structure of the Ovule

The main part of the ovule is the **nucellus** which is enclosed by two integuments leaving an opening called as **micropyle**. The ovule is attached to the ovary wall by a stalk known as **funiculus**. **Chalaza** is the basal part.



Structure of the Ovule

The embryo sac contains seven cells and the eighth nuclei located within the **nucellus**. Three cells at the **micropylar** end form the egg apparatus and the three cells at the **chalaza** end are the antipodal cells. The remaining two nuclei are called **polar nuclei** found in the centre. In the egg apparatus one is the egg cell (female gamete) and the remaining two cells are the **synergids**.

Process of sexual reproduction in flowering plants. It involves:

1. Pollination
2. Fertilization

Pollination

The transfer of pollen grains from anther to stigma of a flower is called as pollination

Importance of Pollination

1. It results in fertilization which leads to the formation of fruits and seed.
2. New varieties of plants are formed through new combination of genes in case of cross pollination.

1. Types of Pollination

1. Self-pollination
2. Cross pollination

Self-pollination (Autogamy)

Self-pollination is also known as autogamy. The transfer of pollen grains from the anther to the stigma of same flower or another flower borne on the same plant is known as self-pollination. e.g. *Hibiscus*.

Advantages of self-pollination

- Self-pollination is possible in certain bisexual flowers.
- Flowers do not depend on agents for pollination.
- There is no wastage of pollen grains.

Disadvantages of self-pollination

- The seeds are less in numbers.
- The endosperm is minute. Therefore, the seeds produce weak plants.
- New varieties of plants cannot be produced

Cross pollination

Cross-pollination is the transfer of pollen from the anthers of a flower to the stigma of a flower on another plant of the same species e.g. apples, grapes, plum, etc.

Advantages of cross pollination

- The seeds produced as a result of cross pollination, develop and germinate properly and grow into better plants, i.e. cross pollination leads to the production of new varieties.
- More viable seeds are produced.

Disadvantages of cross-pollination

- Pollination may fail due to distance barrier.
- More wastage of pollen grains
- It may introduce some unwanted characters
- Flowers depend on the external agencies for pollination

Agents of Cross Pollination

In order to bring about cross pollination, it is necessary that the pollen should be carried from one flower to another of a different plant. This takes place through the agency of animals, insects, wind and water.

1. **Pollination by wind**

   The pollination with the help of wind is called **anemophily**. The anemophilous flowers produce enormous amount of pollen grains. The pollen grains are small, smooth, dry and light in weight. Pollen of such plants are blown off at a distance of more than 1,000 km. The stigmas are comparatively large, protruding and sometimes hairy to trap the pollen grains. e.g. Grasses and some cacti.

2. **Pollination by insects**

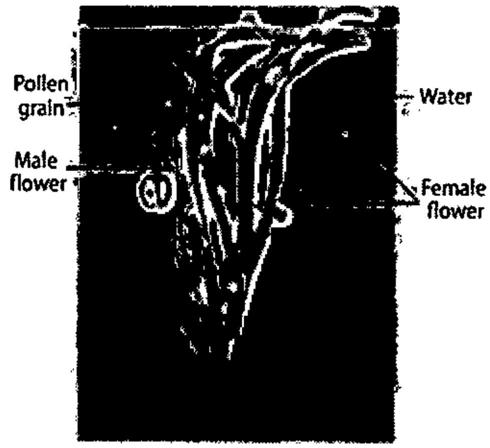
   Pollination with the help of insects like honey bees, flies are called **entomophily**. To attract insects these flowers are brightly coloured, have smell and nectar. The pollen grains are larger in size, the exine is pitted, spiny etc., so they can be adhered firmly on the sticky stigma. Approximately, 80% of the pollination done by the insects is carried by honey bees.

3. **Pollination by water**

   The pollination with the help of water is called **hydrophily**. This takes place in aquatic plants.

   (i) Pollen grains are produced in large numbers.

   (ii) Pollen grains float on surface of water till they land on the stigma of female flowers e.g. *Hydrilla, Vallisneria.*



Hydrophily

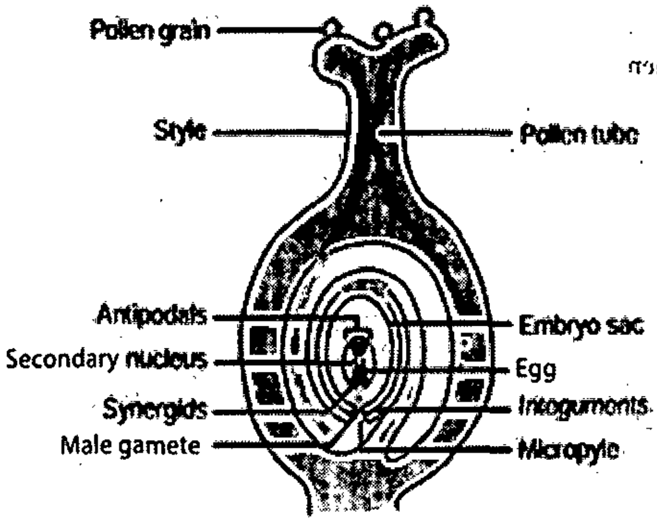
4. **Pollination by Animals**

   When pollination takes place with the help of animals, it is called **Zoophily**. Flowers of such plants attract animals by their bright colour, size, scent etc. e.g. sun bird pollinates flowers of *Canna, Gladioli* etc., Squirrels pollinate flowers of silk cotton tree.

Fertilization in Plants

Pollen grain forms a small tube-like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube.

Fertilization in Plants



Process of Fertilization

- Pollen grains reach the right stigma and begin to germinate.
- Pollen grain forms a small tube-like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube.
- Pollen tube grows through the tissues of the stigma and style and finally reaches the ovule through the micropyle.
- Vegetative cell degenerates and the generative cell divides to form two sperms (or male gametes).
- Tip of pollen tube bursts and the two sperms enter the embryo sac.
- One sperm fuse with the egg (syngamy) and forms a diploid zygote. The other sperm fuses with the secondary nucleus (Triple fusion) to form the primary endosperm nucleus which is triploid in nature. Since two types of fusion syngamy and triple fusion take place in an embryo sac the process is termed as **double fertilization**.
- After triple fusion, primary endosperm nucleus develops into an endosperm.
- Endosperm provides food to the developing embryo.
- Later the synergids and antipodal cells degenerate.

Significance of Fertilization

(i) It stimulates the ovary to develop into fruit.

(ii) It helps in development of new characters from two different individuals.

Post fertilization changes:

1. The ovule develops into a seed.
2. The integuments of the ovule develop into the seed coat.
3. The ovary enlarges and develops into a fruit.

The seed contains the future plant or embryo which develops into a seedling under appropriate conditions.

Sexual Reproduction in Human

You have studied the structural details of the male and female reproductive system in 9th standard. In human beings the male and female reproductive organs differ anatomically and physiologically. New individuals develop by the fusion of gametes. Sexual reproduction involves the fusion of two haploid gametes (male and the female gametes) to form a diploid individual (zygote).

- Organs of the reproductive system are divided into primary and secondary (accessory) sex organs. Primary reproductive organs include the gonads (Testes in male and Ovaries in female).
- Accessory sex organs

Male: Vas deferens, epididymis, seminal vesicle, prostate gland and penis.

Female: Fallopian tubes, uterus, cervix and vagina.

The secondary (accessory) sex organs include those structures which are involved in the

- Process of ovulation
- Fusion of the male and female gametes (fertilization)
- Division of the fertilized egg up to the formation of embryo
- Pregnancy
- Development of foetus

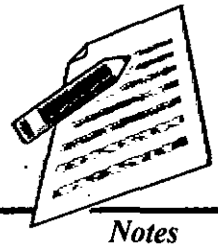
Child birth.

Now let's see the cells of the primary reproductive organs in human male and female and their role in reproduction.

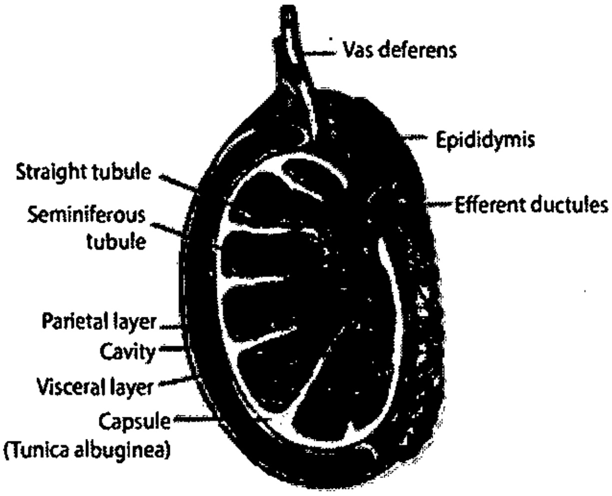
1. **Male Reproductive Organ - Structure of Testes**

   Testes are the reproductive glands of the male that are oval shaped organs which lie outside the abdominal cavity of a man in a sac like structure called **scrotum**. Now we shall study the various cells which are present in the testes.

   Each testes is covered with a layer of fibrous tissue called **tunica albuginea**. Many septa from this layer divide the testes into pyramidal lobules, in which lie seminiferous tubules, cells of Sertoli, and the Leydig cells (interstitial cells).



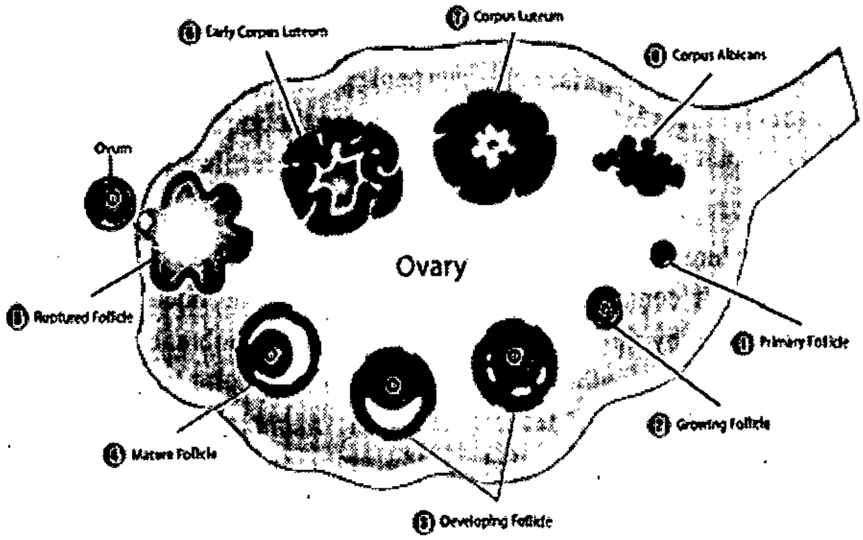
The process of **spermatogenesis** takes place in the **seminiferous tubules**. The **Sertoli cells** are the supporting cells and provide **nutrients** to the developing sperms. The **Leydig cells** are polyhedral in shape and lie between the seminiferous tubules and secrete **testosterone**. It initiates the process of **spermatogenesis.**



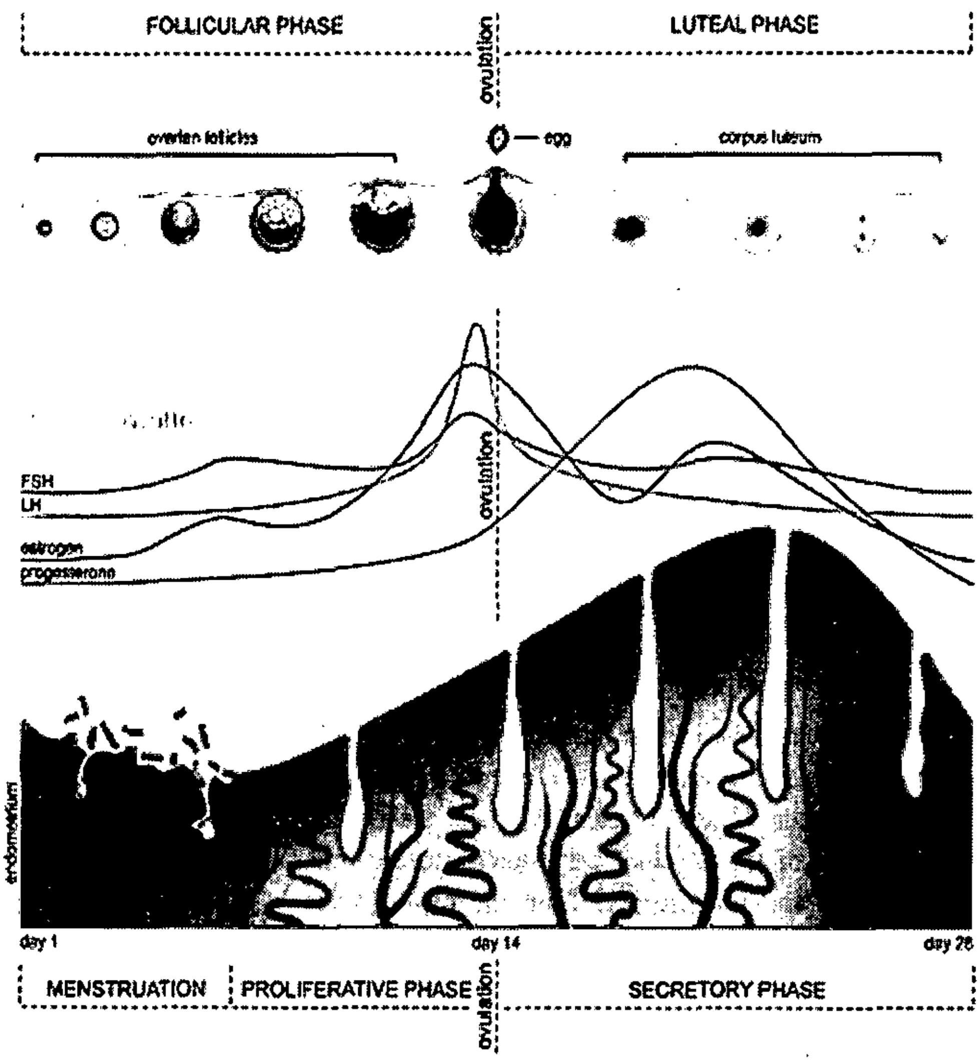
Cross section of human tests

2. **Female Reproductive Organ - Structure of Ovary**

The ovaries are located on either side of the lower abdomen composed of two almond shaped bodies, each lying near the lateral end of fallopian tube. Each ovary is a compact structure consisting of an outer cortex and an inner medulla. The cortex is composed of a network of connective tissue called as stroma and is lined by the **germinal epithelium**. The epithelial cells called the **granulosa cells** surround each ovum in the ovary together forming the primary follicle. As the egg grows larger, the follicle also enlarges and gets filled with the fluid and is called the **Graafian follicle**.



Cross secton of human ovary



Menstrual cycle

These phases show simultaneous synchrony of events in both ovary and uterus. Changes in the ovary and the uterus are induced by the pituitary hormones (LH and FSH) and ovarian hormones (estrogen and progesterone).

Events of Menstrual Cycle and the Role of Hormones

Phase	Days	Changes in Ovary	Changes in Uterus	Hormonal Changes
Menstrual phase	4-5 days	Development of primary follicles	Breakdown of uterine endometrial lining leads to bleeding	Decrease in progesterone and oestrogen
Follicular phase	6th-13th day	Primary follicles grow to become a fully mature Graafian follicle	Endometrium regenerates through proliferation	FSH and oestrogen increase

Ovulatory phase	14th day	The Graafian follicle ruptures, and releases the ovum(egg)	Increase in endometrial thickness	LHpeak
Luteal phase	15th-28th day	Emptied Graafian follicle develops into corpus luteum	Endometrium is prepared for implantation if fertilization of egg takes place, if fertilization does not occur corpus luteum degenerates, uterine wall ruptures, bleeding starts and unfertilized egg is expelled	LH and FSH decrease, Corpus luteum produces progesterone and its level increases followed by a decline, if menstrual bleeding occurs

Fertilization to Foetal Development

Fertilization

Fertilization in human is internal and occurs in the oviduct of the female genital tract. It takes place usually in the ampulla of the fallopian tube. An oocyte is alive for about 24 hours after it is released from the follicle. Fertilisation must take place within 24 hours. The sperm enters into the ovum and fuses with it, resulting in the formation of a '**zygote**'. This process is called fertilization. The zygote is a **fertilized ovum**.

Cleavage and Formation of Blastula

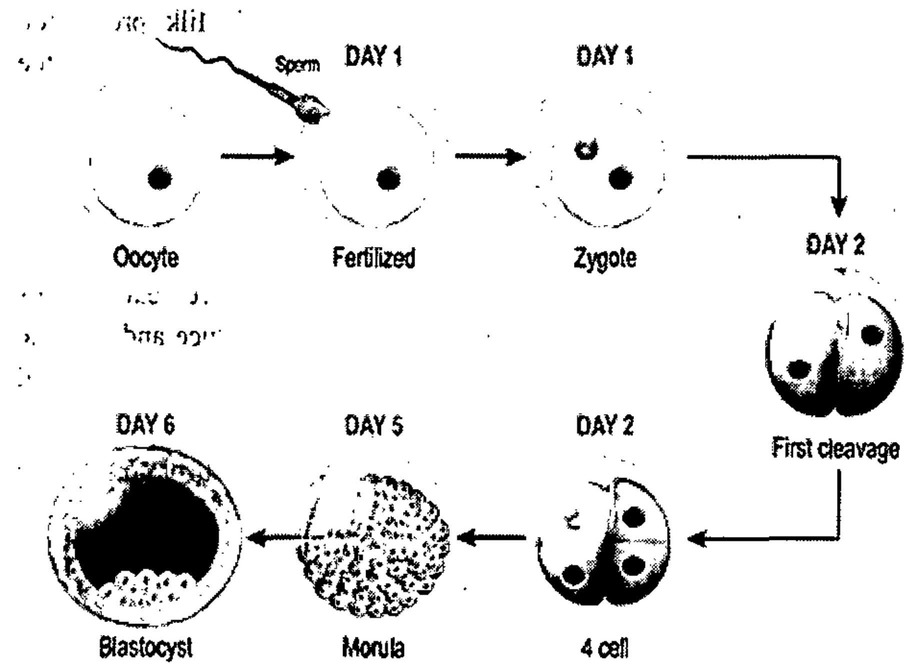
The first cleavage takes place about 30 hours after fertilization. Cleavage is a series of rapid mitotic divisions of the zygote to form many celled blastula (**Blastocyst**) which comprises an outer layer of smaller cells and inner mass of larger cells.

Implantation

The blastocyst (fertilized egg) reaches the uterus and gets implanted in the uterus. The process of attachment of the blastocyst to the uterine wall (**endometrium**) is called implantation. The fertilized egg becomes implanted in about 6 to 7 days after fertilization.

Gastrulation

The transformation of blastula into gastrula and the formation of **primary germ layers** (ectoderm, mesoderm and endoderm) by rearrangement of the cells is called gastrulation. This takes place after the process of implantation.



Developmental Stages of zygote from cleavage to blastocyst formation

Organogenesis

The establishment of the germ layers namely ectoderm, mesoderm and endoderm initiates the final phase of embryonic development. During organogenesis the various organs of the foetus are established from the different germ layers attaining a functional state.

Formation of Placenta

The placenta is a disc shaped structure attached to the uterine wall and is a temporary association between the developing embryo and maternal tissues. It allows the exchange of food materials, diffusion of oxygen, excretion of nitrogenous wastes and elimination of carbon dioxide. A cord containing blood vessels that connects the placenta with the foetus is called the **umbilical cord.**

Pregnancy (Gestation)

It is the time period during which the embryo attains its development in the uterus. Normally gestation period of human last for about 280 days. During pregnancy the uterus expands up to 500 times of its normal size.

Parturition (Child Birth)

Parturition is the **expulsion** of young one from the mother's uterus at the end of gestation. **Oxytocin** from the posterior pituitary stimulates the **uterine contractions** and provides force to expel the baby from the uterus, causing birth.

Lactation

The process of milk production after child birth from mammary glands of the mother is called lactation. The first fluid which is released from the mammary gland after child birth is called as **colostrum.** Milk production from alveoli of mammary glands is stimulated by **prolactin** secreted from the anterior pituitary.

The **ejection of milk** is stimulated by posterior pituitary hormone **oxytocin**.

Reproductive Health

According to World Health Organization (WHO) reproductive health means a total wellbeing in all aspects of reproduction, ability to reproduce and regulate fertility, women's ability to undergo pregnancy and safe child birth, maternal and infant survival and wellbeing.

Several measures were undertaken by the government to improve the reproductive health of the people by launching **National Health Programmes** such as the

(i) Family Welfare Programme

(ii) Reproductive and Child Health Care (RCH) Programme

Family welfare programme: The National Family Welfare Programme is a comprehensive scheme which includes:

- Maternal and child health care (MCH)
- Immunization of mothers, infants and children.
- Nutritional supplement to pregnant women and children.
- Contraception with health education, to motivate couples to accept contraceptive methods and to have small family norms, which improve economic status, living status and the quality of life.

Reproductive and Child Health Care (RCH) Programme: It has integrated all services which include

- Pregnancy and child birth
- Postnatal care of the mother and child
- Importance of breast feeding
- Prevention of reproductive tract infections and sexually transmitted diseases

Population Explosion and Family Planning

Population explosion defined as the sudden and rapid rise in the size of population, especially human population. Realizing the dangers inherent in population growth, the Government of India has taken several measures to check population growth and introduced family planning. **India** has been one of the **first country in the world to launch the nation-wide family planning programme in 1952**.

Family planning is a way of living that is adopted voluntarily by couples on the basis of knowledge and responsible decisions to promote the health and welfare of the family group and society. The WHO (World Health Organisation) has also stressed the importance of family planning as global strategy health for all.

- Male sex hormone is testosterone and female sex hormones are progesterone and estrogen.
- Puberty is attained at the age of 13 – 14 years in males and 10 – 12 years in females.
- The zygote formed after fertilization develops into embryo which gets implanted in uterus.
- Placenta (a disc-like special tissue) develops between uterine wall and embryo for nourishment of the embryo.
- Gestation period in humans is 280 days.

Reproductive Health

- Birth control prevents unwanted pregnancies.
  - (a) Barrier methods
  - (b) Chemical methods
  - (c) Intrauterine contraceptive device
  - (d) Surgical method
- Sexually transmitted diseases (STD) are caused by bacteria, protozoa and viruses.
- AIDS is an incurable viral disease.

EXERCISE

HOW DO ORGANISMS REPRODUCE?

Multiple Choice Questions

1. The two oviducts in a human female unite into an elastic bag like is known as
   (a) Vagina
   (b) Uterus
   (c) Fallopian tube
   (d) Cervix
2. Which of the following disease is transmitted sexually?
   (a) Kala azar
   (b) Jaundice
   (c) Cholera
   (d) Syphilis
3. Which of the following is a contraceptive?
   (a) Copper t
   (b) Condom
   (c) Diaphragm
   (d) All of these

4. When an animal is cut into pieces and each piece grows into a complex organism. What is the process?

(a) Budding

(b) Fragmentation

(c) Spore formation

(d) Regeneration

5. Which is the portion on which grafting is done it provides the roots?

(a) Stock

(b) Scion

(c) Both a and b

(d) None of these

6. Where does fertilization occur in human females?

(a) Uterus

(b) Cervix

(c) Oviduct

(d) None of these

7. Growing foetus derive nutrition from mothers' blood through

(a) Uterus

(b) Fallopian tube

(c) placenta

(d) cervix

8. What is the puberty age in human males?

(a) 8-10

(b) 10-12

(c) 12-14

(d) 14-16

9. Fruits are formed from

(a) Stamen

(b) Stigma

(c) Ovary

(d) Ovule

10. IUCD is for

(a) Vegetative propagation

(b) Contraception

(c) Increasing fertility

(d) Avoiding miscarriage

ANSWERS

1. (b)	**2.** (d)	**3.** (d)	**4.** (d)	**5.** (a)
6. (d)	**7.** (c)	**8.** (c)	**9.** (c)	**10.** (b)

HOTS

1. What are different methods of reproduction?
2. Name two plants that are bisexual.
3. What is pollination/.
4. When does DNA copying occur?
5. How does the embryo get nourishment?
6. What is STD? Name two STDs.
7. Explain process of sexual reproduction in plants.
8. With the help of diagrams explain process of budding in Hydra.
9. Name the one unisexual plant.
10. Name on organism that grows by multiple fission.

Space for Notes

Theme: The World of the Living
Unit II: World of Living (50 Periods)

8 HEREDITY AND EVOLUTION

Objective of the Chapter

The main objective of the unit is to make student understand about:

- *Mendel's contribution*
- Sex determination

Introduction

"Like Begets Like" is an important and universal phenomenon of life as the living beings produce offspring of their own kind. Colour of eye, colour of hair, shape of nose, type of earlobe, etc, are inheritable traits.

Have you ever wondered, how do we inherit traits and characteristics from our father and mother? Some of our characteristics might have been inherited from our grandparents. How do we inherit characters from one generation to another? It is because of the genes we inherit from our parents.

These genes are responsible for the physical outlook and biological functions. The branch of biology that deals with the genes, genetic variation and heredity of living organisms is called genetics.

Heredity is transmission of characters, from one generation to the next generation, while variation refers to the differences shown by the individuals of the same species and also by the offspring of the same parents.

All these can happen only due to chromosomes. Now let's see what chromosomes are and how they are composed with DNA, that form the genetic material.

Gregor Johann Mendel - Father of Genetics

Mendel (1822-1884) was an Austrian monk who discovered the basic principles of heredity through his experiments. His experiments are the foundation for modern genetics. He was born in 1822 to a family of farmers in Silesian of Czechoslovakia. After finishing his high school at the age of 18, he entered the Augustinian Monastery at Brunn as a priest. From there he went to the University of Vienna for training in physics, mathematics and natural science. Mendel returned to the monastery in 1854 and continued to work as a priest and teach in high school. In his leisure time he started his famous experiments on the garden pea plant. He conducted his experiments in the monastery for about nine years from 1856 to 1865. He had worked on nearly 10000 pea plants of 34 different varieties. Mendel noted that they differ from one another in many ways.

Thus Mendel had chosen 7 pairs of contrasting characters for his study as shown in the table.

Constrasting characters of pea plant used by Mendel

Characteristic studied	Dominant character	Recessive character
Seed shape	Round	Wrinkled
Seed colour	Yellow	Green
Seed-coat colour	Coloured	White
Pod shape	Inflated	Constricted
Pod colour	Green	Yellow
Flower Position	Axillary	Terminal
Stem length	Long	Short

Reasons for Mendel's success

He chose the pea plant as it was advantageous for experimental work in many aspects

(a) It is naturally self-pollinating and so is very easy to raise pure breeding individuals.

(b) It has a short life span as it is an annual and so it was possible to follow several generations.

(c) It is easy to cross-pollinate.

(d) It has deeply defined contrasting characters.

(e) The flowers are bisexual.

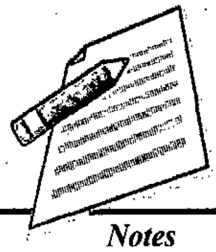
Monohybrid Cross - Inheritance of One Gene

Crosses involving **inheritance of only one pair of contrasting characters** are called monohybrid crosses. For example, it is a cross between two forms of a single trait like a cross between tall and dwarf plant.

Mendel's Explanation of Monohybrid Cross

Parental generation: Pure breeding tall plant and a pure breeding dwarf plant.

F_1 generation: Plants raised from the seeds of pure breeding parental cross in F_1 generation were tall and monohybrids.



F_2 generation: Selfing of the F_1 monohybrids resulted in tall and dwarf plants respectively in the ratio of 3:1. The actual number of tall and dwarf plants obtained by Mendel was 787 tall and 277 dwarfs. External expression of a particular trait is known as phenotype. So the phenotypic ratio is 3:1.

In the F_2 generation 3 different types were obtained:

Tall Homozygous – TT (Pure) – 1

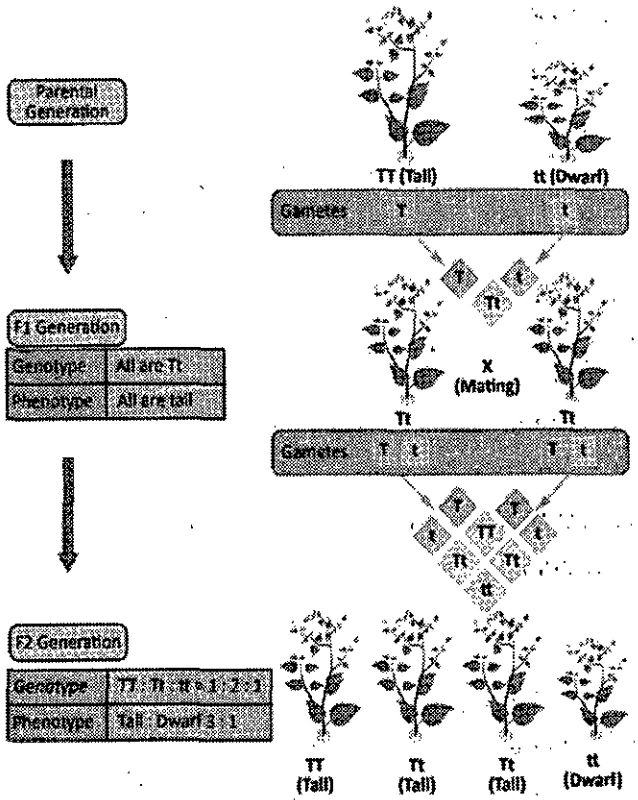
Tall Heterozygous – Tt – 2

Dwarf Homozygous – tt – 1

So the **genotypic ratio 1:2:1**. A genotype is the genetic expression of an organism

Mendel's Interpretation on Monohybrid cross

Based on these observations it was confirmed by Mendel that 'factors' are passed on from one generation to another, **now referred to as genes** . Tallness and Dwarfness are determined by a pair of contrasting factors tall plant possess a pair of factors (represented by T- taking the first letter of the dominant character) and a plant is dwarf because it possess factors for dwarfness (represented as t- recessive character).



Monohybrid cross

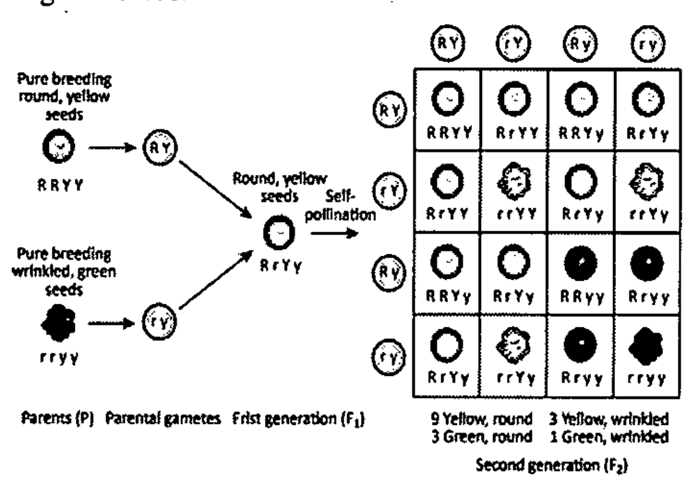
These factors occur in pairs and may be alike as in pure breeding tall plants (TT) and dwarf plants (tt). This is referred to as **homozygous**. If they are unlike (Tt) they are referred to as **heterozygous**.

1. Two factors making up a pair of contrasting characters are called **alleles** or **allelomorphs**. One member of each pair is contributed by one parent.
2. When two factors for alternative expression of a trait are brought together by fertilization only one expresses itself, (tallness) masking the expression of the other (dwarfness). The **character which expresses itself** is called **dominant** condition and that which is **masked** is called **recessive condition.**
3. The factors are always pure and when gametes are formed, the unit factors segregate so that each gamete gets one of the two alternative factors. It means that factors for tallness(T) and dwarfness(t) are separate entities and in a gamete either T or t is present. When F_1 hybrids are self-crossed the two entities separate and then unite independently, forming tall and dwarf plants

Dihybrid Cross-Inheritance Two Genes and Law of Independent Assortment

Dihybrid cross involves the **inheritance of two pairs of contrasting characteristics** (or contrasting traits) at the same time. The two pairs of contrasting characteristics chosen by Mendel were **shape and colour of seeds: round-yellow seeds and wrinkled-green seeds.**

1. Mendel crossed pea plants having round-yellow seeds with pea plants having wrinkled-green seeds. Mendel made the following observations: Mendel first crossed pure breeding pea plants having round-yellow seeds with pure breeding pea plants having wrinkled-green seeds and found that only round-yellow seeds were produced in the first generation (F_1). No wrinkled-green seeds were obtained in the F_1 generation. From this it was concluded that **round shape and yellow colour of the seeds were dominant traits over the wrinkled shape and green colour of the seeds.**
2. When the hybrids of F_1 generation pea plants having round-yellow seeds were cross-bred by self-pollination, then four types of seeds having different combinations of shape and colour were obtained in second generation or F_2 generation. They were round yellow, round-green, wrinkled yellow and wrinkled-green seeds.



Dihybrid Cross

The ratio of each phenotype (or appearance) of seeds in the F_2 **generation is 9:3:3:1**. This is known as the **Dihybrid ratio**.

From the above results it can be concluded that the factors for each character or trait remain independent and maintain their identity in the gametes. The factors are independent to each other and pass to the offspring's (through gametes).

Results of a Dihybrid Cross:

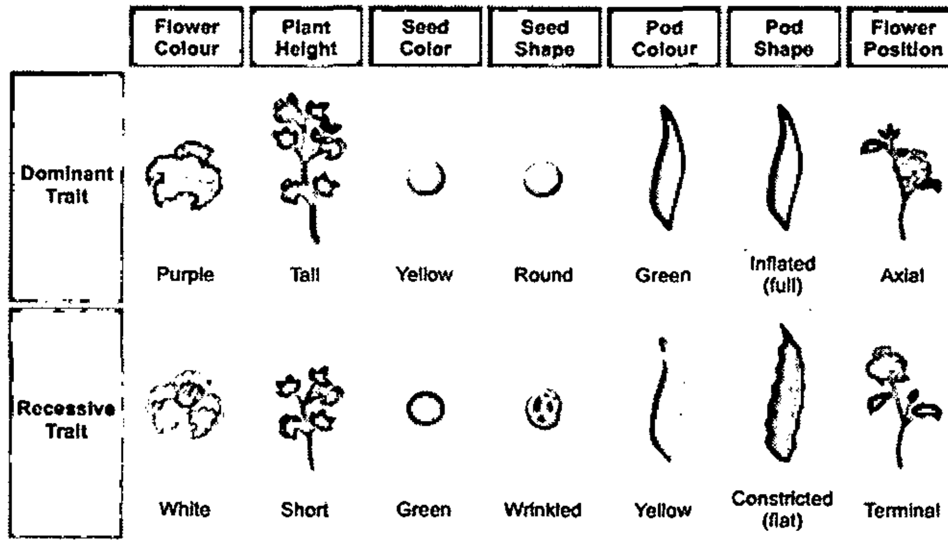
Mendel got the following results from his dihybrid cross

1. **Four Types of Plants:** A dihybrid cross produced four types of F_2 offspring in the ratio of 9 with two dominant traits, 3 with one dominant trait and one recessive trait, 3 with another dominant trait and another recessive trait and 1 with two recessive traits.
2. **New Combination:** *Two new combinations of traits with round green* and wrinkled yellow had appeared in the dihybrid cross (F_2 generation).

Mendel's Experiment and Laws

- In the 1860's, an Austrian monk named Gregor Mendel introduced a new theory of inheritance based on his experimental work with pea plants.
- Mendel believed that heredity is the result of discrete units of inheritance, and every single unit (or gene) was independent in its actions in an individual's genome.
- According to this Mendelian concept, inheritance of a trait depended on the passing-on of these units.
- For any given trait, an individual inherits one gene from each parent so that the individual has a pairing of two genes. We now understand the alternate forms of these units as 'alleles.
- If the two alleles that form the pair for a trait are identical, then the individual is said to be homozygous and if the two genes are different, then the individual is heterozygous for the trait.
- The breeding experiments of the monk in the mid□1800s laid the groundwork for the science of genetics.
- He studied peas plant for 7 years and published his results in 1866 which was ignored until the 1900 when three separate botanists, who also were theorizing about heredity in plants, independently cited the work.
- In appreciation of his work he was considered as the "Father of Genetics".
- A new stream of genetics was established after his name as Mendelian genetics which involves the study of heredity of both qualitative (monogenic) and quantitative (polygenic) traits and the influence of environment on their expressions.
- Mendelian inheritance while is a type of biological inheritance that follows the laws originally proposed by Gregor Mendel in 1865 and 1866 and re-discovered in 1900.

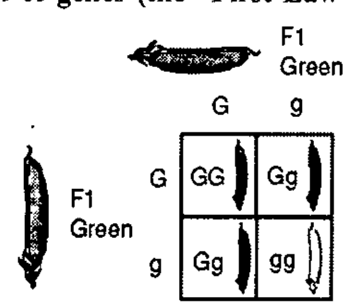
Mendel's Experiment



Mendel carried out breeding experiments in his monastery's garden to test inheritance patterns. He selectively cross-bred common pea plants (*Pisum sativum*) with selected traits over several generations. After crossing two plants which differed in a single trait (tall stems vs. short stems, round peas vs. wrinkled peas, purple flowers vs. white flowers, etc), Mendel discovered that the next generation, the "F1" (first filial generation), was comprised entirely of individuals exhibiting only one of the traits. However, when this generation was interbred, its offspring, the "F2" (second filial generation), showed a 3:1 ratio- three individuals had the same trait as one parent and one individual had the other parent's trait.

Mendel's Laws

(i) Law of Segregation of genes (the "First Law")

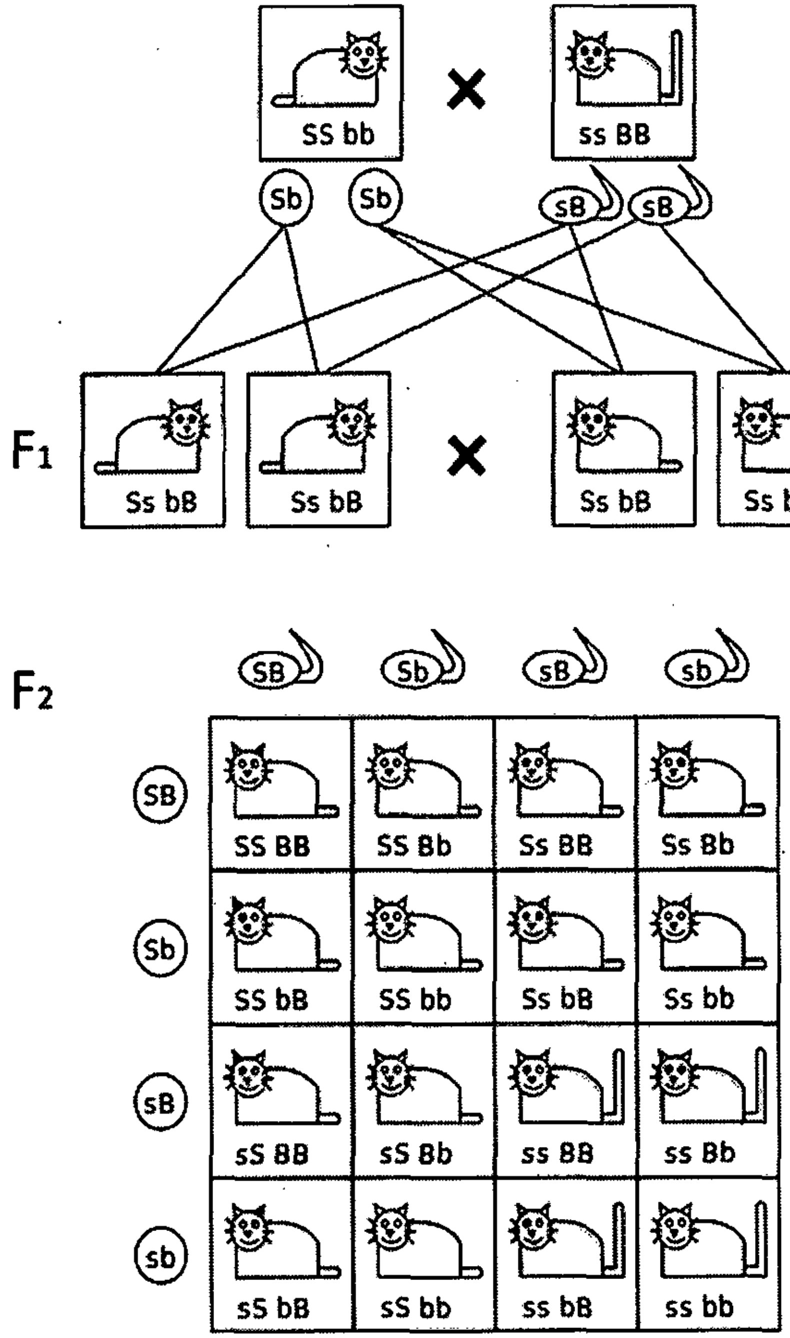


The Law of Segregation states that every individual organism contains two alleles for each trait, and that these alleles segregate (separate) during meiosis such that each gamete contains only one of the alleles.

An offspring thus receives a pair of alleles for a trait by inheriting homologous chromosomes from the parent organisms: one allele for each trait from each parent.

Hence, according to the law, two members of a gene pair segregate from each other during meiosis; each gamete has an equal probability of obtaining either member of the gene.

(ii) **Law of Independent Assortment (the "Second Law")**



Mendel's second law. The law of independent assortment; unlinked or distantly linked segregating genes pairs behave independently.

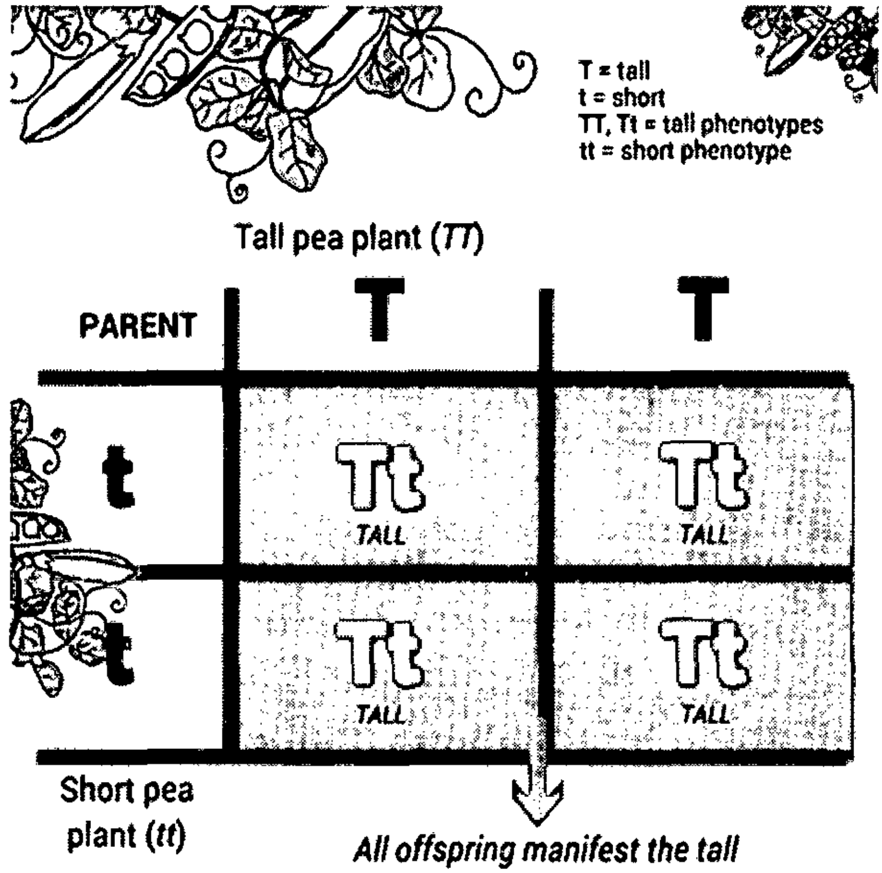
The Law of Independent Assortment states that alleles for separate traits are passed independently of one another.

That is, the biological selection of an allele for one trait has nothing to do with the selection of an allele for any other trait.

Mendel found support for this law in his dihybrid cross experiments. In his monohybrid crosses, an idealized 3:1 ratio between dominant and recessive phenotypes resulted. In dihybrid crosses, however, he found a 9:3:3:1 ratio.

his shows that each of the two alleles is inherited independently from the other, with a 3:1 phenotypic ratio for each.

(iii) Law of Dominance (the "Third Law")



All offspring manifest the tall phenotype with genotype Tt.

The genotype of an individual is made up of the many alleles it possesses.

An individual's physical appearance, or phenotype, is determined by its alleles as well as by its environment.

The presence of an allele does not mean that the trait will be expressed in the individual that possesses it.

If the two alleles of an inherited pair differ (the heterozygous condition), then one determines the organism's appearance and is called the dominant allele; the other has no noticeable effect on the organism's appearance and is called the recessive allele.

Thus, the dominant allele will hide the phenotypic effects of the recessive allele.

This is known as the Law of Dominance but it is not a transmission law: it concerns the expression of the genotype.

The upper-case letters are used to represent dominant alleles whereas the lowercase letters are used to represent recessive alleles.

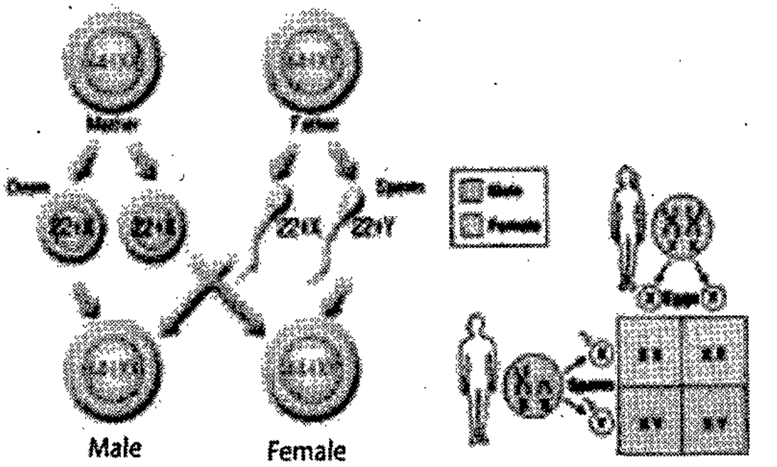
Sex Determination

The formation of zygote into male or female sex during development is called sex determination. Sex is determined by the chromosomes of an individual.

1. **Sex Determination in Human**

   Recall that human beings have 23 pairs of chromosomes out of which 22 pairs are autosomes and one pair (23rd pair) is the sex chromosome. The female gametes or the eggs formed are similar in their chromosome type (22+XX) . Therefore, human females are **homogametic**.

   The male gametes or sperms produced are of two types. They are produced in equal proportions. The sperm bearing **(22+X)** chromosomes and the sperm bearing **(22+Y)** chromosomes. The human males are called **heterogametic.**



Sex determination in human

   It is a chance of probability as to which category of sperm fuses with the egg. If the egg (X) is fused by the X-bearing sperm an **individual (female)** is produced. If the egg (X) is fused by the Y-bearing sperm an **XY individual (male)** is produced. The sperm, produced by the father, determines the sex of the child. The mother is not responsible in determining the sex of the child.

   Now let's see how the chromosomes take part in this formation. Fertilization of the egg (22+X) with a sperm (22+X) will produce a female child (44+XX). while fertilization of the egg (22+X) with a sperm (22+Y) will give rise to a male child (44+XY).

2. **Mutation**

   The term mutation was introduced by **Hugo De Vries** in 1901 when he observed phenotypic changes in the evening primrose plant, *Oenothera lamarckiana*. Mutation is an inheritable sudden change in the genetic material (DNA) of an organism. Mutations are classified into two main types, namely chromosomal mutation and gene mutation.

1. **Chromosomal mutation**

The **sudden change** in the **structure** or **number of chromosomes** is called chromosomal mutation. This may result in

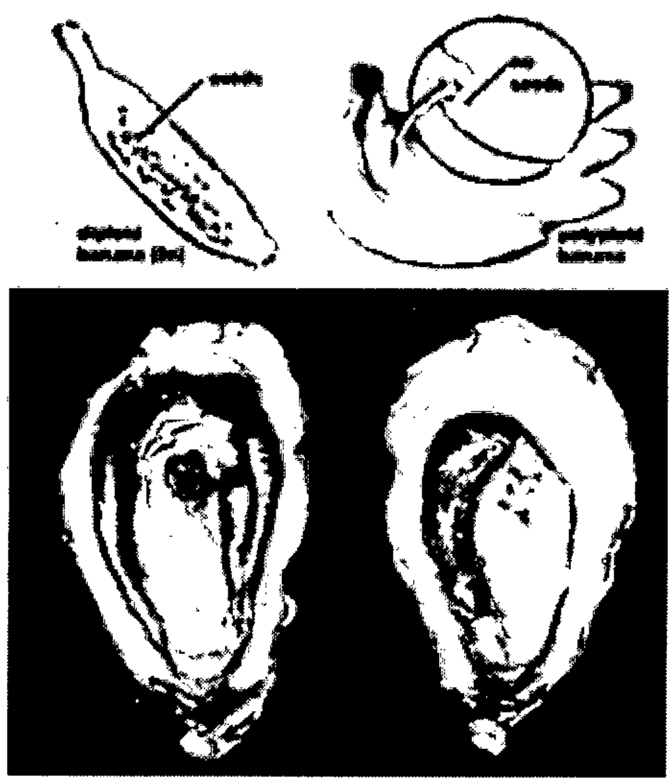
(i) **Changes in the structure of chromosomes:** Structural changes in the chromosomes usually occurs due to errors in cell division. Changes in the number and arrangement of genes takes place as a result of deletion, duplication, inversion and translocation in chromosomes.

(ii) **Changes in the number of chromosomes:** They involve addition or deletion in the number of chromosomes present in a cell. This is called **ploidy**. There are two types of ploidy

(a) Euploidy

(b) Aneuploidy.

Euploidy: It is the condition in which the individual bears **more than the usual number** of diploid (2n) chromosomes. If an individual has three haploid sets of chromosomes, the condition is called **triploidy** (3n). Triploid plants and animals are typically sterile. If it has four haploid sets of chromosomes, the condition is called **tetraploidy** (4n). Tetraploid plants are advantageous as they often result in increased fruit and flower size.



Triploid Oyster **Diploid Oyster**

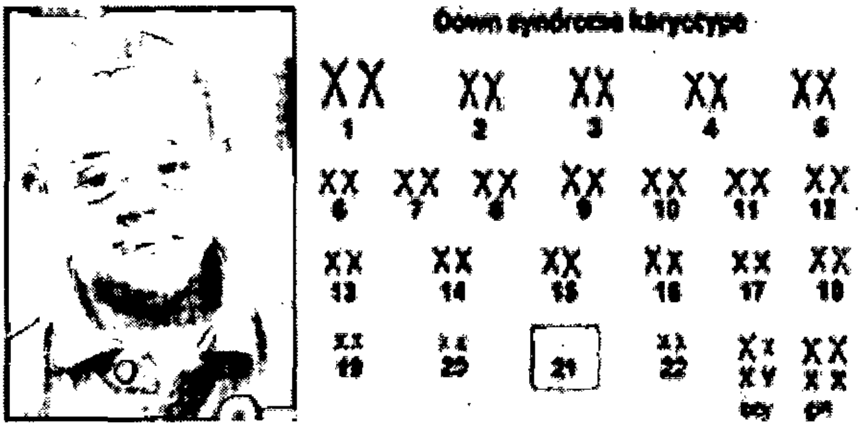
Euploidy

Aneuploidy: It is the **loss** or **gain** of **one** or **more chromosomes** in a set. It is of three types. **Monosomy** (2n-1), **Trisomy** (2n+1)and **Nullisomy** (2n-2). *In man, Down's syndrome is one of the commonly known aneuploid* condition.

Down's syndrome

This condition was first identified by a doctor named **Langdon Down** in1866.

It is a genetic condition in which there is an extra copy of **chromosome 21 (Trisomy 21)**. It is associated with mental retardation, delayed development, behavioural problems, weak muscle tone, vision and hearing disability are some of the conditions seen in these children.



Aneuploidy

2. Gene or point mutation

Gene mutation is the **changes** occurring in **nucleotide sequence of a gene**. It involves substitution, deletion, insertion or inversion of a single or more than one nitrogenous base. Gene alteration results in abnormal protein formation in an organism.

EXERCISE

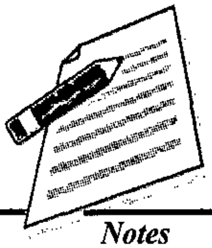
Multiple Choice Questions

1. Which of the following is totally impossible outcome of Mendel's Experiment?
   (a) 3 tall 1 short plant
   (b) 24 tall and 8 short plants
   (c) 8 tall and 0 short plants
   (d) 4 tall plants and 1 medium height plant.
2. Which of the following is not a direct conclusion that can be drawn from Mendel's Experiment?
   (a) Only one parental trait is expressed
   (b) Two copies of each trait is inherited in sexually reproducing organism
   (c) For recessive trait to be expressed, both copies should be identical
   (d) Natural selection can alter frequency of an inherited trait.

3. Which one is a possible progeny in F2 generation of pure-bred tall plant with round seed and short plant with wrinkled seeds?
   (a) Tall plant with round seeds
   (b) Tall plant with wrinkled seeds
   (c) Short plant with round seed
   (d) All of the above
4. Which section of DNA provides information for one protein
   (a) Nucleus
   (b) Chromosomes
   (c) Trait
   (d) Gene
5. Which of the following is not controlled by genes?
   1. Weight of a person
   2. Height of a person
   (a) only 1
   (b) only 2
   (c) both 1 and 2
   (d) sometimes 1 and sometimes 2
6. What is the probability that the male progeny will be a boy?
   (a) 50%
   (b) 56%
   (c) 47.43%
   (d) It varies
7. Who have a perfect pair of sex chromosomes?
   (a) Girls only
   (b) Boys only
   (c) Both girls and boys
   (d) It depends on many other factors
8. With whom you can associate theory of evolution?
   (a) Charles Darwin
   (b) Mendel
   (c) Stanley miller
   (d) Harold Urey
9. Which of the following can be called a characteristic?
   (a) Plants can photosynthesis
   (b) We have 2 eyes
   (c) Mango tree is multicellular
   (d) All of these

CLASS–10

Science



Notes

10. Homologous organ have
    (a) Same structure, same function
    (b) Different structure, different function
    (c) Same structure, different function
    (d) different structure, same function

ANSWERS

1. (d)	**2.** (d)	**3.** (d)	**4.** (d)	**5.** (b)
6. (a)	**7.** (a)	**8.** (a)	**9.** (d)	**10.** (c)

HOTS

1. Green and red coloured seeds are recessive and dominant trait respectively. Out of F1 and F2 in which generation will the green seed appear, if both parents are not hybrid.
2. *Species A shared ten characteristics with species B, species C share fifteen* characteristics with D which of the two pairs share closer relation.
3. Dead remains of two species A and B were buried. Later only as body was found to be a fossil but not Bs given reason.
4. After the death of two insects, one of the insects was buried in hot mud and the other *is usually found mud. Which of the two is more likely to be preserved better* and why?
5. With the help of an example explain how genes control characteristics or trait
6. Male has 23 pairs of chromosomes and female has 23 pairs of chromosomes.
   Then why don't an offspring have 46 pairs of chromosomes which is obtained by the fusion of these two eggs.
7. What is a genetic drift?
8. What are the uses of fossils?
9. What term did Mendel use for genes? Where are the genes located?
10. What is the effect of DNA copying which is not perfectly accurate on the reproduction process?

Space for Notes

Theme: Natural Phenomena
Unit III: Natural Phenomena

9 LIGHT

Reflection of light by curved surfaces; Images formed by spherical mirrors, centre of curvature, principal axis, principal focus, focal length, mirror formula (Derivation not required), magnification.

Refraction; Laws of refraction, refractive index.

Refraction of light by spherical lens; Image formed by spherical lenses; Lens formula (Derivation not required); Magnification. Power of a lens.

Refraction of light through a prism, dispersion of light, scattering of light, applications in daily life.

Objective of the unit

The main objective of the unit is to make student understand about:

- Reflection of light by curved surfaces
- Refraction; Laws of refraction
- Magnification. Power of a lens
- Refraction of light through a prism

INTRODUCTION

Introduction to Light

Light is a form of energy due to which we are able to see the objects which emits light for example objects like sun, lamp, candle emits light of their own and thus they are known as *luminous objects.*

There are objects like table, chair etc. which are not luminous objects and still we are able to see them and this happens because they reflects lights which falls on them from a luminous object like sun, lamp etc. and when this reflected light reaches our eyes, we are able to see such non luminous objects.

Light rays basically consist of electromagnetic waves which do not require any material medium (like solid, liquid or gas) for their propagation.

Wavelength of visible light waves is very small and is of the order of $4\times10-7m4\times10-7m$ to $8\times10-7m8\times10-7m$.

Speed of light waves depends on the medium through which they pass as speed of light in air is slightly less than the speed of light in vacuum $8\times108m/s8\times108m/s$ same way speed of light in water and glass is much less than that in air.

When light falls on the surface of an object it can either be

1. Absorbed: - If an object absorbs all the light falling on it , then it will *appear perfectly black for example a blackboard*
2. Transmitted: - An object is said to transmit light if it allows light to pass through itself and such objects are transparent.
3. Reflected: - If an object sends back light rays falling on its surface then it is said to have reflected the light

Reflection of Light

- The process of sending back light rays which falls on the surface of an object is called *REFLECTION* of light
- Silver metal is one of the best reflectors of light.
- Mirrors we use on our dressing tables in our home are plane mirrors.
- A *ray of light* is the straight line along which the light travelled and a bundle of light rays is called a *beam of light.*

Laws of Reflection of light

1. The angle of incidence is equal to the angle of reflection, and
2. The incident ray, the reflected ray and the normal to the mirror at the point of incidence all lie in the same plane.

- These laws of reflection are applicable to all types of reflecting surfaces including spherical surfaces

Real and Virtual images

- An image is formed when the light rays coming from an object meet at a point after reflection from a mirror (or refraction from lens).
- The images are of two types
  1. *Real Images:* - Real images are formed when rays of light that comes from an object (or source) meets at a point after reflection from a mirror (or refraction from a lens). Real images can be formed on a screen and can be seen with the eyes.
  2. *Virtual images:* - Virtual image is an image in which the outgoing rays from an object do not meet at a point. It will appear to meet at a point in or behind the optical device (i.e., a mirror) but they do not actually meet after reflection from a mirror (or refraction from a lens). A plane mirror always forms virtual images.

Characteristics of images formed by mirrors: -

- (a) Images formed by mirrors are always virtual and erect
  (b) Size of image is always equal to the size of the object and the image is laterally inverted.
  (c) The images formed by the plane mirror are as far behind the mirror as the object in front of the mirror.

- *Lateral inversion:* - If an object is placed in front of the mirror, then the right side of the object appears to be the left side and left side of the object appears to be the right side of this image. This change of sides of an object and its mirror image is called lateral inversion.

Spherical Mirrors

The reflecting surface of a spherical mirror may be curved inwards or outwards.

Spherical mirrors are of two types

1. **Concave mirror:** In a concave mirror reflection of light takes place at the concave surface or bent-in surface as shown below in the figure.

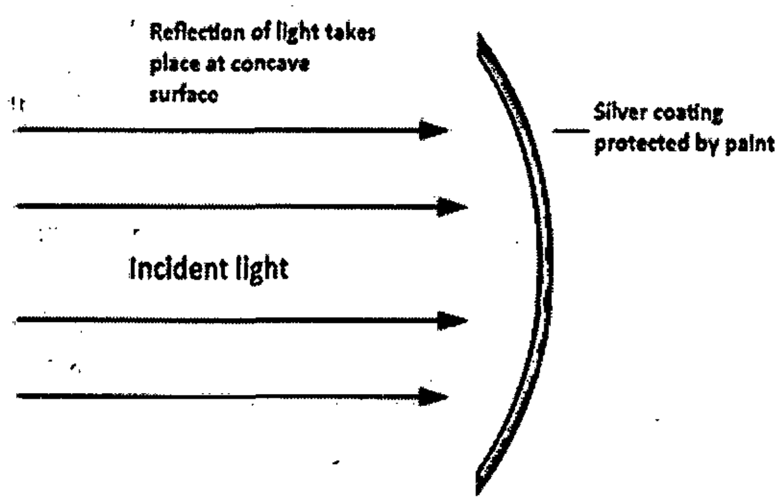


Figure 1a :- A concave mirror

2. **Convex mirror:** In a convex mirror reflection of light takes place at the convex surface or bent out surface as shown below in the figure

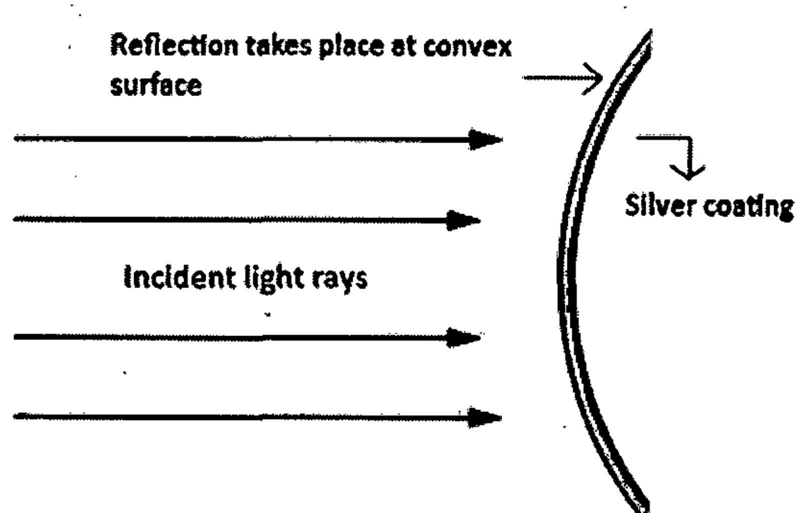


Figure 1b :- A convex mirror

Commonly used terms about Spherical mirrors: -

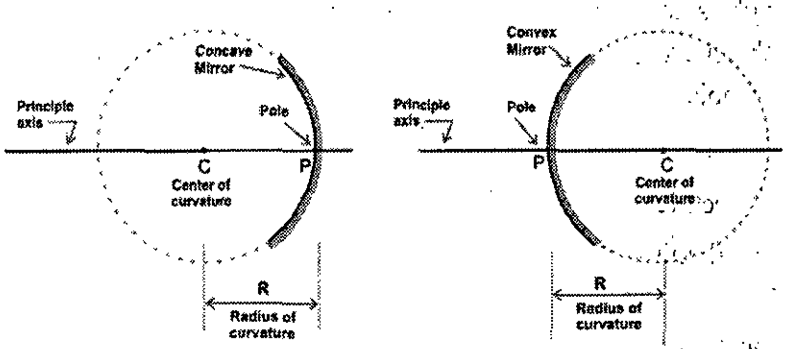


Figure 2. Concave and convex mirrors shown as part of complete hollow sphere

1. Center of curvature: - The reflecting surface of a spherical mirror forms a part of a sphere. This sphere has a center. This point is called the center of curvature of the spherical mirror. It is represented by the letter C. Please note that the center of curvature is not a part of the mirror. It lies outside its reflecting surface. The center of curvature of a concave mirror lies in front of it. However, it lies behind the mirror in case of a convex mirror as shown above in the figure 2.
2. Radius of curvature: - The radius of the sphere of which the reflecting surface of a spherical mirror forms a part, is called the radius of curvature of the mirror. It is represented by the letter R.
    1. Pole: The center of a spherical mirror is called its pole and is represented by letter P as can be seen in figure 2.
    2. Principle axis: - Straight line passing through the pole and the center of curvature of a spherical mirror is called principle axis of the mirror.
    3. Aperture of the mirror: - Portion of the mirror from which reflection of light actually takes place is called the aperture of the mirror. Aperture of the mirror actually represents the size of the mirror.

Principle focus and focal length of a Spherical Mirrors

For understanding about principle focus and focus length of a spherical mirror first consider the figure given below

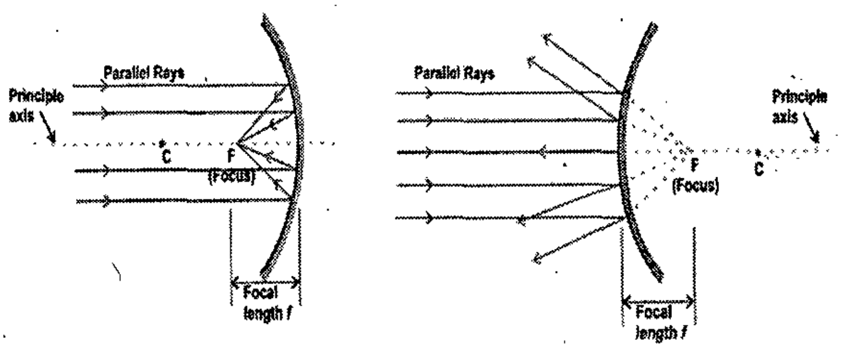


Figure 3a. Concave Mirror

Figure 3b. Convex Mirror

From figure 3a we see that a number of rays parallel to the principal axis are falling on a concave mirror. If we now observe the reflected rays, we see that they are all intersecting at a point F on the principal axis of the mirror. This point is called the principal focus of the concave mirror.

In case of convex mirror rays get reflected at the reflecting surface of the mirror and these reflected rays appear to come from point F on the principle axis and this point F is called principle focus of convex mirror.

The distance between the pole and the principal focus of a spherical mirror is called the focal length. It is represented by the letter f.

There is a relationship between the radius of curvature R, and focal length f, of a spherical mirror and is given by R=2f which means that that the principal focus of a spherical mirror lies midway between the pole and centre of curvature.

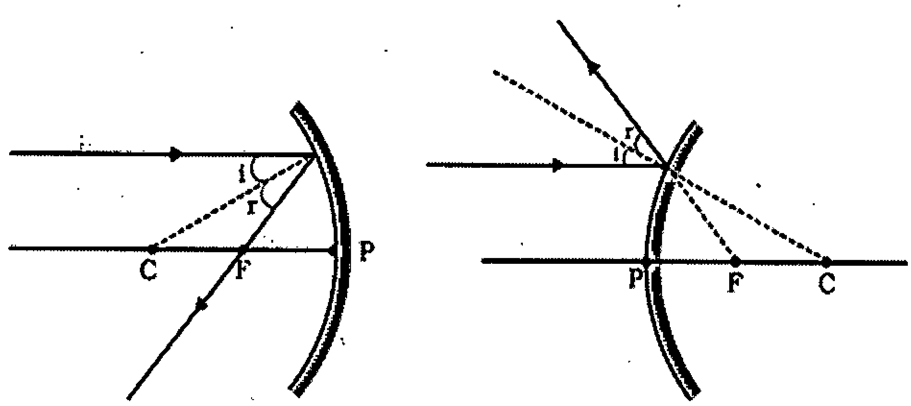
Image Formation by Spherical mirrors

- The nature, position and size of the image formed by a concave mirror depend on the position of the object in relation to points P, F and C.
- The image formed can be real as well as virtual depending on the positions of the object.
- The image is either magnified, reduced or has the same size, depending on the position of the object.

Rules for obtaining images formed by spherical mirrors

(1) **Rule 1**

A ray of light which is parallel to the principle axis of the mirror passes through its focus after reflection from the mirror as shown below in the figure

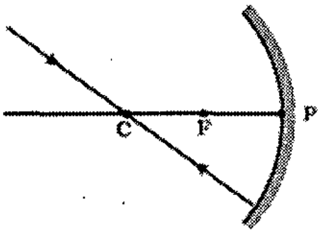


(a) concave mirror **(b) convex mirror**

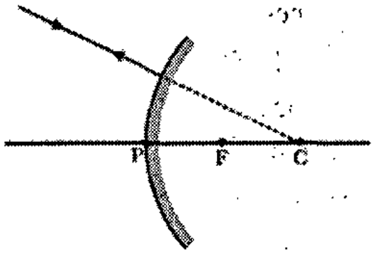
From the figure given above it can be clearly seen that the light rays pass through principle focus in case of concave mirrors and appears to diverge from principle focus in case of concave mirror.

(2) Rule 2

A ray of light passing through the center of curvature of the curvature of the concave mirror or directed in the direction of the center of curvature of a convex mirror, is reflected back along the same path as shown below in the figure



(a) concave mirror

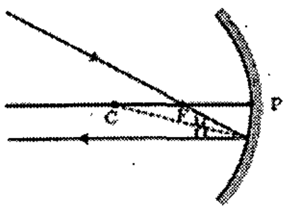


(b) convex mirror

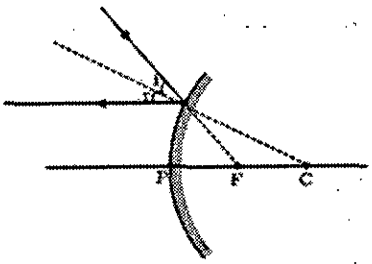
This happens because the incident rays fall on the mirror along the normal to the reflecting surface.

(3) Rule 3

A ray passing through principle focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror, becomes parallel to the principle axis after reflection and is shown below in the figure



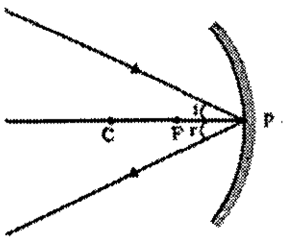
(a) concave mirror



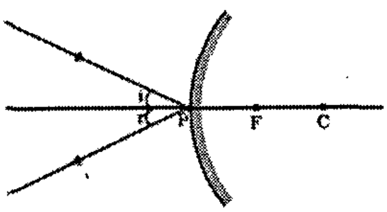
(b) convex mirror

(4) Rule 4

A ray incident obliquely to the principal axis, towards a point P (pole of the mirror), on the concave mirror or a convex mirror, is reflected obliquely. The incident and reflected rays follow the laws of reflection at the point of incidence (point P), making equal angles with the principal axis and is shown below in the figure



(a) concave mirror



(b) convex mirror

Image formation by spherical mirrors

Image formation by concave mirror

- The type of image formed by a concave mirror depends on the position of the object kept in front of the mirror. We can place the object at following places
  1. Between pole P and focus F
  2. At the focus
  3. Between focus F and center of curvature C
  4. At the center of curvature
  5. Beyond center of curvature
  6. At far off distances called infinity and cannot be shown in the figures

Image formation by a concave mirror for different positions of the object is shown below in the table

At infinity	At focus F	Highly diminished, point sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

- Concave mirrors are used as shaving mirrors, reflectors in car headlights, hand torch and table lamps.
- Large concave mirrors are used in field of solar energy to focus sun rays on objects to be heated.

Image formation by convex mirrors

In order to construct a ray diagram to find out the position, nature and size of image formed by convex mirror we should remember following path of rays of light.

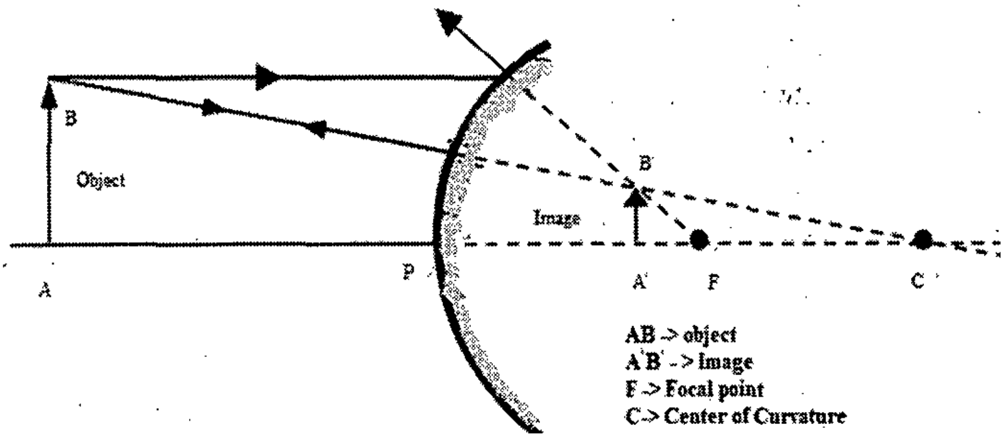
A ray of light parallel to the principle axis of a convex mirror appears to be coming from its focus after reflection from the mirror.

A ray of light going towards the center of curvature of convex mirror is reflected back along its own path.

Convex mirrors have its focus and center of curvature behind it and no light can go behind the convex mirror and all the rays that we show behind the convex mirror are virtual and no ray actually passes through the focus and center of curvature of the convex mirror.

Whatever be the position of object in front of convex mirror, the image formed by a convex mirror is always behind the mirror, virtual, erect and smaller than the object.

Nature, position and relative size of the image formed by a convex mirror is given below in the table



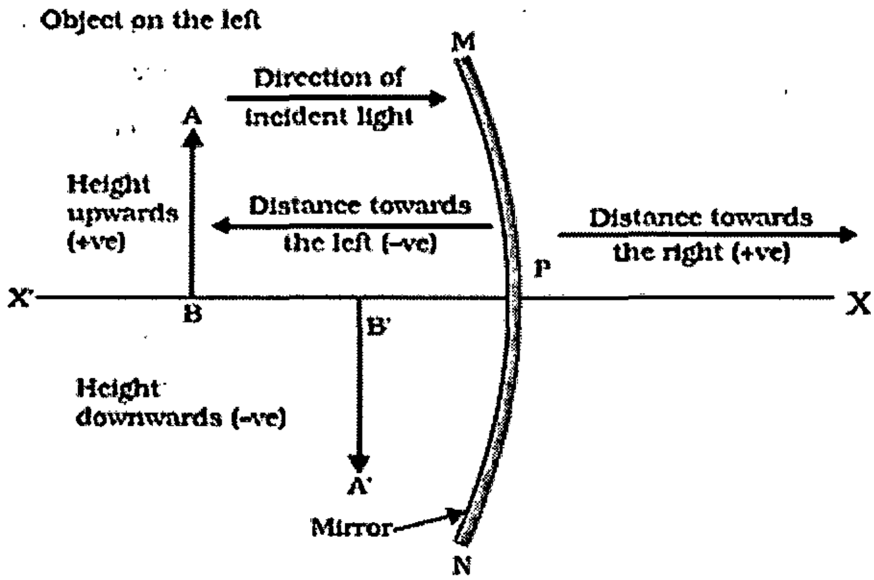
Convex mirrors are used as rear-view mirrors in automobiles to see the traffic at back side as they give erect images and also highly diminished one giving the wide field view of traffic behind.

Sign convention for reflection by spherical mirrors

Reflection of light by spherical mirrors follow a set of sign conventions called the New Cartesian Sign Convention. In this convention, the pole (P) of the mirror is taken as the origin. The principal axis of the mirror is taken as the x-axis (X'X) of the coordinate system. The conventions are as follows –

- The object is always placed to the left of the mirror. This implies that the light from the object falls on the mirror from the left-hand side.
- All distances parallel to the principal axis are measured from the pole of the mirror.
- All the distances measured to the right of the origin (along + x-axis) are taken as positive while those measured to the left of the origin (along - x-axis) are taken as negative.
- Distances measured perpendicular to and above the principal axis (along + y-axis) are taken as positive.
- Distances measured perpendicular to and below the principal axis (along -y-axis) are taken as negative.

These new Cartesian sign convention for spherical mirrors are shown below



Mirror formula and magnification

Mirror formula:

It gives the relationship between image distance *(v)* , object distance *(u)* and the focal length *(f)* of the mirror and is written as

1v+1u=1f1v+1u=1f

Where *v* is the distance of image from the mirror, *u* is the distance of object from the mirror and *f* is the focal length of the mirror. This formula is valid in all situations for all spherical mirrors for all positions of the object.

Magnification

Magnification produced by a spherical mirror gives the relative extent to which the image of an object is magnified with respect to the object size. It is expressed as the ratio of the height of the image to the height of the object. It is usually represented by the letter *m*. So, $magnification\, m = \frac{hight\ of\ image(h_1)}{hight\ of\ object(h_2)}$

or,

m=h1h2m=h1h2

The magnification *m* is also related to the object distance *(u)* and image distance *(v)* and is given as

m=h1h2=–vum=h1h2=–vu

Refraction of light

We know about light and also know that light travels in a straight-line path in a medium or two different mediums with same density.

Now a question arises what happens when light travels from one medium to another with different densities for example from air to glass.

When light ray is made to travel from one medium to another say from air to glass medium then light rays bend at the boundary between the two mediums.

So, the bending of light when it passes from one medium to another is called *Refraction of light.*

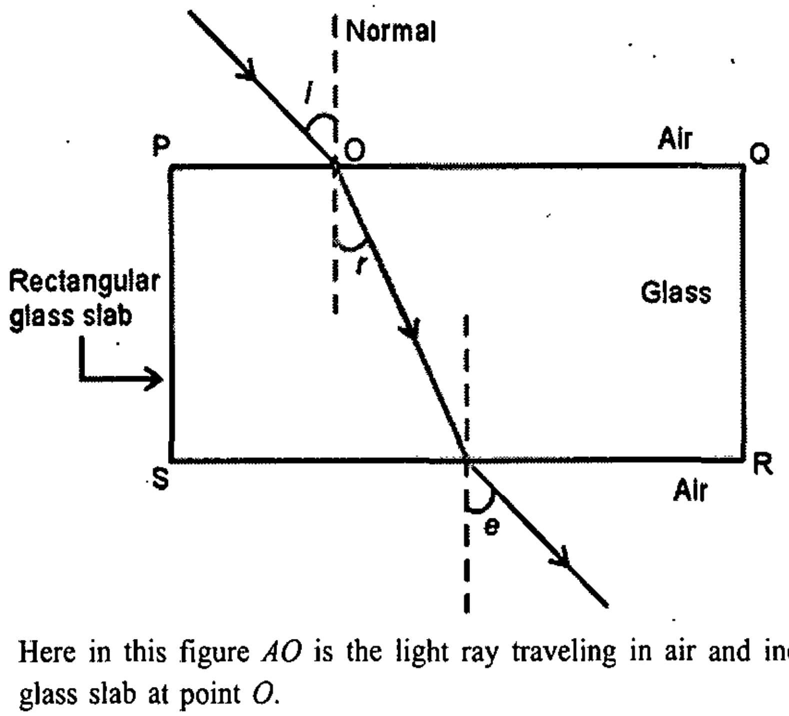
The refraction of light takes place on going from one medium to another because the speed of light is different in two media.

Medium in which speed of light is more is called *optically rarer medium* and medium in which speed of light is less is known as *optically denser medium. For example, glass is an optically denser medium* than air and water.

NOTE: - When light goes from rarer medium to denser medium it bends towards the normal and when it goes from denser medium to rarer medium it bends away from the normal.

Refraction through a rectangular glass slab

- To understand the refraction of light through a glass slab consider the figure given below which shows the refraction of light through a rectangular glass slab.



- Here in this figure *AO* is the light ray traveling in air and incident on glass slab at point *O*.
- Now on entering the glass medium this ray bends towards the normal NN' that is light ray *AO* gets refracted on entering the glass medium.
- After getting refracted this ray now travels through the glass slab and at point *B* it comes out of the glass slab as shown in the figure.

- Since ray *OB* goes from glass medium to air it again gets refracted and bends away from normal $N_1N'_1$ and goes in direction *BC*.
- Here *AO* is the incident ray and *BC* is the emergent ray and they both are parallel to each other and *OB* is the refracted ray.
- Emergent ray is parallel to incident ray because the extent of bending of the ray of light at the opposite parallel faces which are *PQ* (air-glass interface) and *SR* (glass-air interface) of the rectangular glass slab is equal and opposite.
- In the figure *i* is the angle of incidence, *r* is the angle of refraction and *e* is the angle of emergence.
- Angle of incidence and angle of emergence are equal as emergent ray and incident ray are parallel to each other.
- When a light ray is incident normally to the interface of two media then there is no bending of light ray and it goes straight through the medium.

Laws of refraction of light (Snell's law of refraction)

Refraction is due to change in the speed of light as it enters from one transparent medium to another.

Experiments show that refraction of light occurs according to certain laws.

So, Laws of refraction of light are

The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also known as *Snell's law of refraction.*

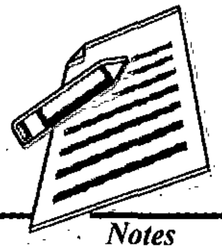
If i is the angle of incidence and r is the angle of refraction then sinisinr=constant=nsin isin r=constant=n (1)

This constant value is called the refractive index of the second medium with respect to the first.

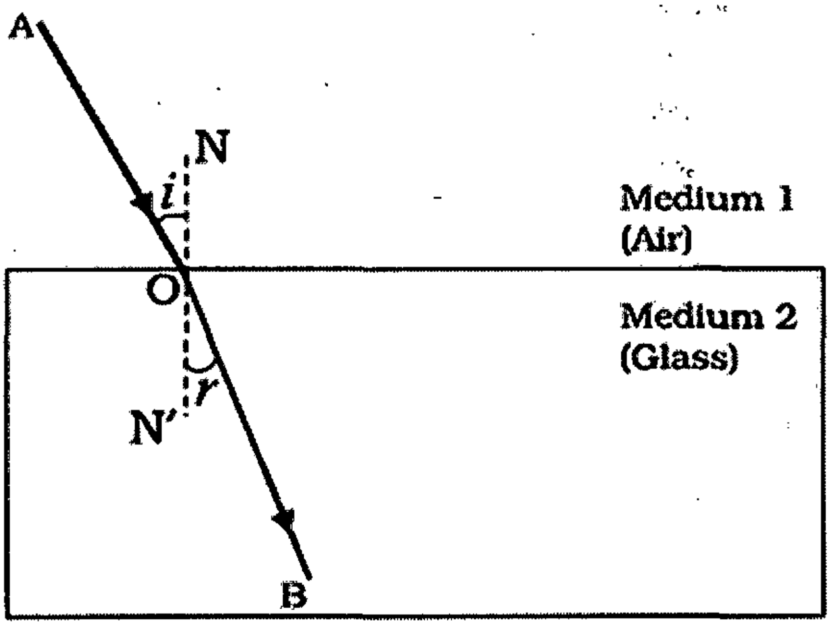
The Refractive Index

We now know about refraction of light and the extent of the change in direction that takes place in a given pair of media is expressed in terms of the *refractive index*, the "constant" appearing in equation 1.

The refractive index is related to an important physical quantity that is relative speed of propagation of light in different media as light propagates with different speeds in different media.



Consider the figure given below



Let v_1 be the speed of light in medium 1 and v_2 be the speed of light in medium 2 then the refractive index of medium 2 with respect to medium 1 is given by the ratio of the speed of light in medium 1 and the speed of light in medium 2. So,

$$n_{21} = \frac{\text{speed of light in medium 1}}{\text{speed of light in medium 2}} = \frac{v_1}{v_2}$$

where n_{21} is the refractive index of medium 2 with respect to medium 1.

The refractive index of medium 1 with respect to medium 2 is represented as n12. It is given by

$$n_{12} = \frac{\text{speed of light in medium 2}}{\text{speed of light in medium 1}} = \frac{v_2}{v_1}$$

If medium 1 is vacuum or air, then the refractive index of medium 2 is considered with respect to vacuum. This is called the *absolute refractive index* of the medium.

If c is the speed of light in the air and v is the speed of light in any medium then refractive index n_m of the medium would be

$$n_m = \frac{\text{speed of light in air}}{\text{speed of light in medium}} = \frac{c}{v}$$

Prove that the incident angle and the emergent angle in a rectangular glass slab are equal

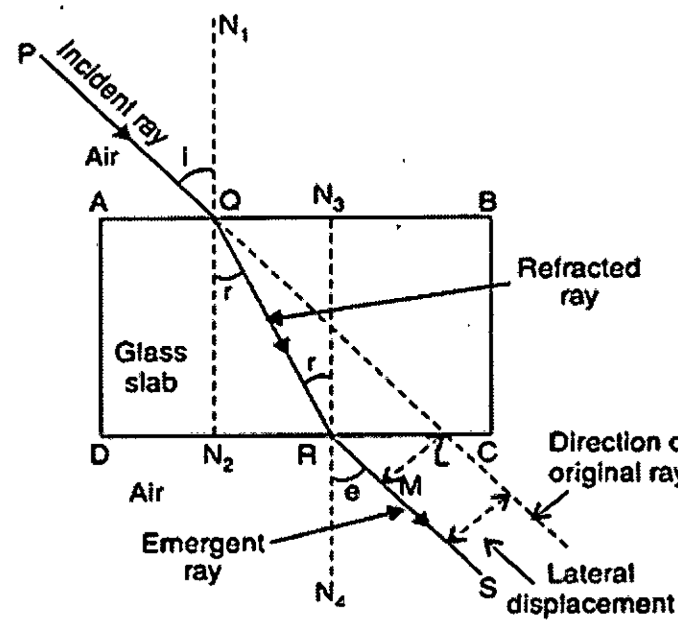


Figure: Refraction of light through rectangular glass slab

In the figure given above ABCD is a rectangular glass slab of thickness AD=BC=t. A ray PQ is incident on it a face AB at point Q, making an angle PQN1=iPQN1=i, called angle of incidence.

This ray refracts in the glass slab and goes along QR as refracted ray (as shown in the figure) and becomes incident on face DC at point R from inside the slab.

∠RQN2=∠QRN3=r∠RQN2=∠QRN3=r and is called angle of refraction.

Now the ray emerges or comes out of the slab along RS making ∠SRN4=e∠SRN4=e , called the angle of emergence.

This emergent ray is parallel to the incident ray. This can be proved as follows.

For refraction of Q :- from air to glassn=sinisinrn=sin isin rFor refraction at R :- from glass to air1n=sinrsine(1)(1)1n=sin rsin eor,n=sinesinr(2)(2)n=sin esin rfrom equations 1 and 2sini=sine⇒i=esin i=sin e⇒i=e

angle of incidence = angle of emergence

It means that incident ray and emergent ray makes equal angles with parallel normal N1QN2N1QN2 and N3RN4N3RN4 . Hence incident and emergent rays are parallel.

Refraction by Spherical Lenses

A Spherical lens is a piece of transparent glass bound by two spherical surfaces.

There are two types of Spherical Lenses

1. A convex lens bulges outward and is thick at the center and thinner at

the edges. Convex lens converges the light rays as shown below in the figure 1(a).

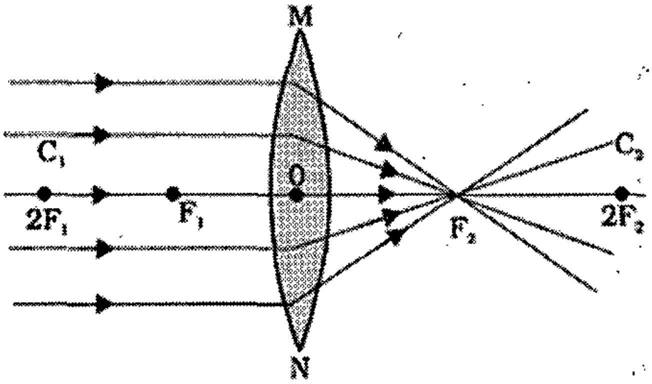


Figure 1(a) Converging action of convex lens

Hence convex lenses are called converging lenses.

2. A concave lens bulges inward and is thinner in the middle and thicker at the edges. Such lenses diverge light rays as shown in Figure 1(b)

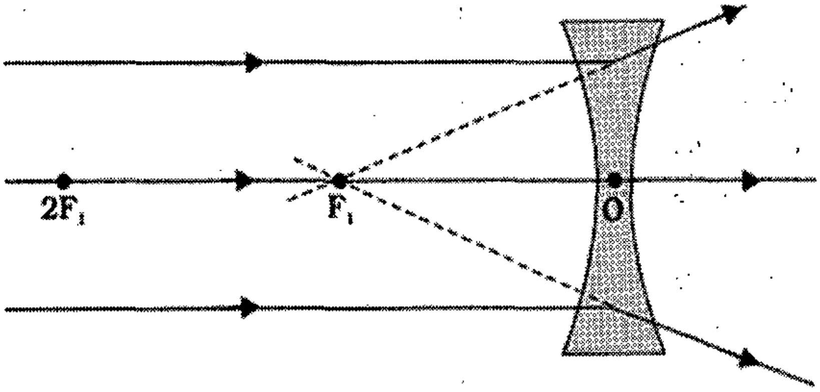


Figure 1(b) Diverging action of concave lens

Such lenses are called diverging lenses.

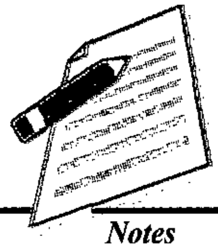
A lens, whether it is a convex lens or a concave lens, has two spherical surfaces which form a part of a sphere. The centers of these spheres are called centers of curvature of the lens usually represented by the letter C.

Since there are two centers of curvature, we may represent them as C_1 and C_2.

An imaginary straight line passing through the two centers of curvature of a lens is called its principal axis as shown in figure 1.

The central point of a lens is its optical centre. It is usually represented by the letter O.

A ray of light through the optical centre of a lens passes without suffering any deviation.



Notes

The effective diameter of the circular outline of a spherical lens is called its aperture.

In figure 1 (a) you can see several rays of light parallel to the principal axis are falling on a convex lens. These rays, after refraction from the lens, are converging to a point on the principal axis. This point on the principal axis is called the principal focus of the lens.

Letter F is usually used to represent principal focus. A lens has two principal foci.

Similarly, in figure 1

(b) several rays of light parallel to the principal axis are falling on a concave lens. These rays, after refraction from the lens, are appearing to diverge from a point on the principal axis. This point on the principal axis is called the principal focus of the concave lens.

The distance of the principal focus from the optical centre of a lens is called its focal length represented by letter f.

Image Formation by Lenses

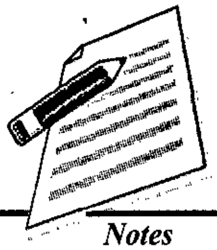
Lenses form images by refraction of light and type of image formation depends on the position of the object in front of the lens.

We can place the objects at

a. Infinity
b. Beyond $2F_1$
c. At $2F_1$
d. Between F_1 and $2F_1$
e. At focus F_1
f. Between focus F_1 and optical center O

Image formation by a convex lens for different positions of the object is shown below in the table

Position of the object	**Position of the image**	**Relative size of the image**	**Nature of the image**
Infinity	At focus F_2	Highly diminished, point sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At 2F2	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus $2F_1$	At infinity	Infinitely large or highly enlarged	Real and inverted
Between F_1 and optical center O	On the same side of the lens as the object	Enlarged	Virtual and erect



Nature, position and relative size of the image formed by a concave lens for various positions of the object is given below in the table

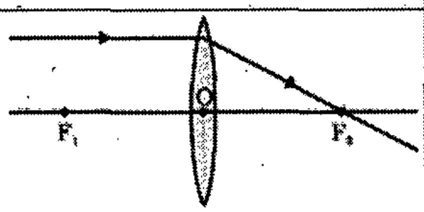
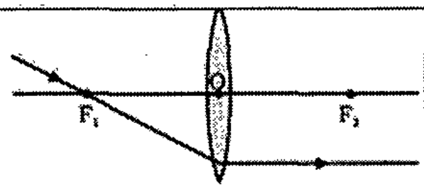
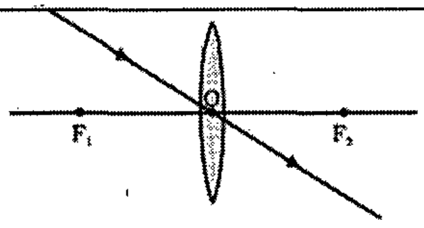
Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F	Highly diminished, point-sized	Virtual and erect
Between infinity and optical center O of the lens	Between F_1 and optical center O	Diminished	Virtual and erect

A concave lens will always give a virtual, erect and diminished image, irrespective of the position of the object.

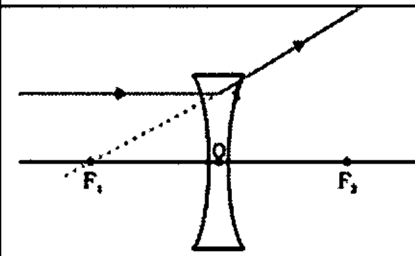
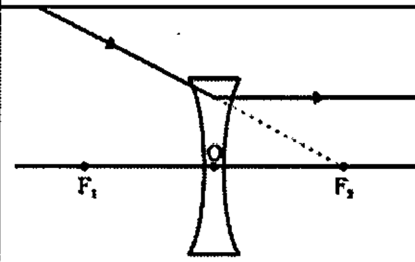
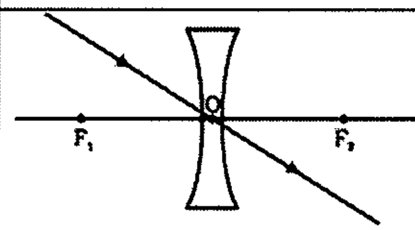
Image Formation in Lenses Using Ray Diagrams

Ray diagram helps us to study the nature, position and relative size of the image formed by lenses. For drawing ray diagrams, we first consider how light rays falling on both concave and convex lens in three different ways get refracted.

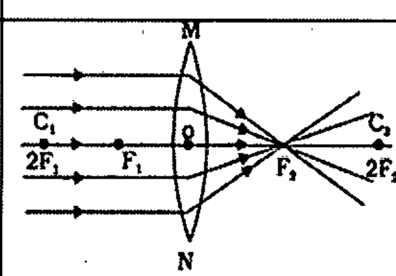
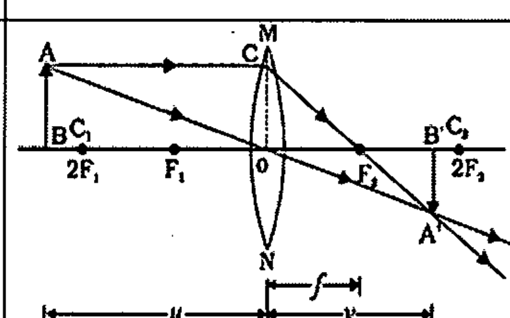
First consider the case for convex lens

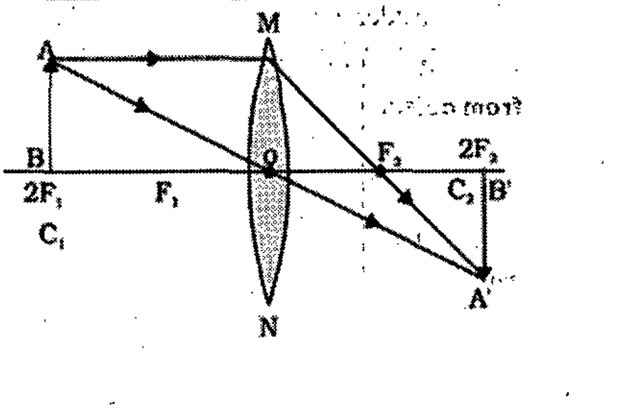
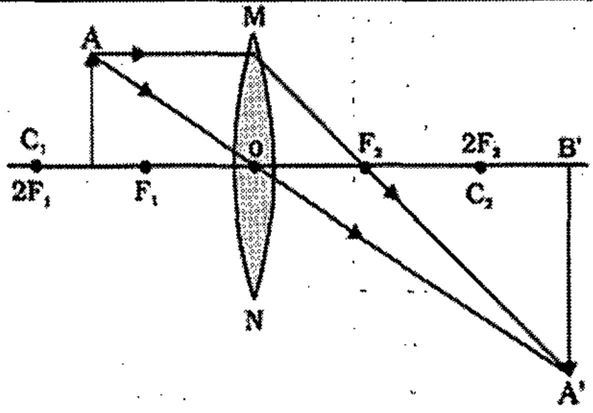
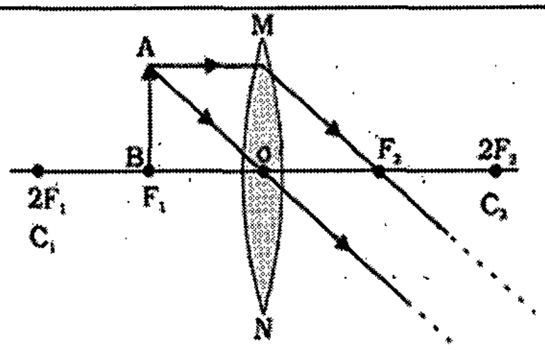
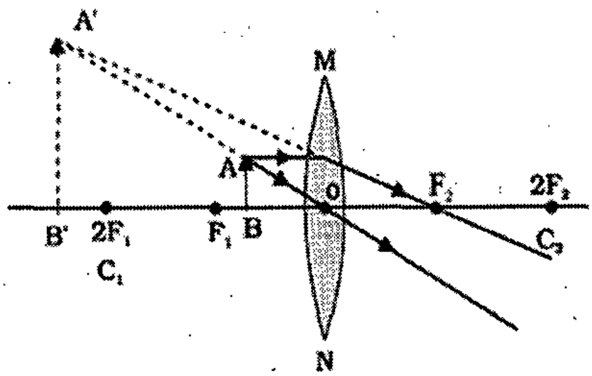
	Light ray from object is	Ray diagram	How it appears after refraction
1	parallel to the principal axis		After refraction from a convex lens, passes through the principal focus on the other side of the lens
2	Passing through a principal focus		After refraction from a convex lens, will emerge parallel to the principal axis
3	Passing through the optical centre of a lens		After refraction from a convex lens will emerge without any deviation

Secondly consider the case for concave lens

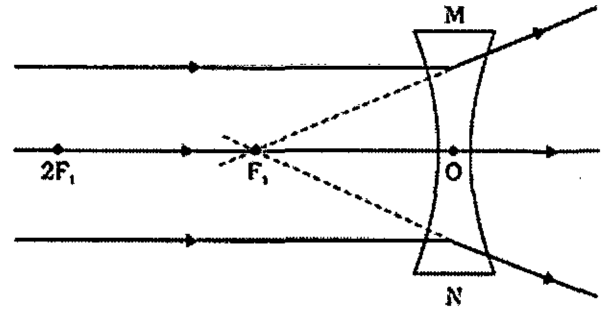
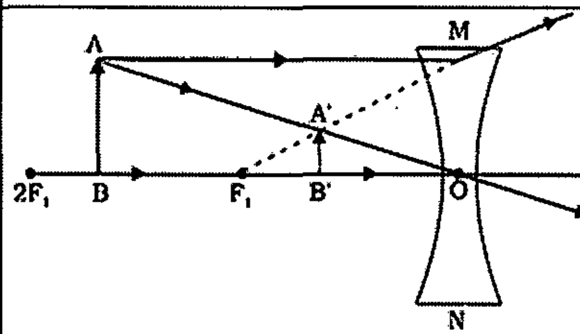
	Light ray from object is	Ray diagram	How it appears after refraction
1	parallel to the principal axis		After refraction from a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens
2	passing through a principal focus		After refraction from a concave lens, will emerge parallel to the principal axis
3	passing through the optical center of a lens		After refraction from a concave lens will emerge without any deviation

The ray diagrams for the image formation in a convex lens for a few positions of the object are summarized below in the table

Position of the object	Ray Diagram
Infinity	
Beyond $2F_1$	

At $2F_1$	
Between F_1 and $2F_1$	
At focus $2F_1$	
Between F_1 and optical center O	

The ray diagrams for the image formation in a concave lens for a few positions of the object are summarized below in the table

Position of the object	Ray Diagram
Infinity	
Between infinity and optical center O of the lens	

Sign Convention for Spherical Lenses

All the distances are measured from the optical center of the lens.

The distances measured in the same direction as that of incident light are taken as positive.

The distances measured against the direction of incident light are taken as negative.

The distances measured upward and perpendicular to the principle axis are taken as positive.

The distances measured downwards and perpendicular to principle axis is taken as negative.

Lens Formula and Magnification

Lens Formula gives the relationship between object distance (u), image image-distance (v) and the focal length (f) and is expressed as

1f=1v−1u1f=1v−1u

This formula is valid in all situations for any spherical lens.

The magnification produced by a lens is defined as the ratio of the height of the image and the height of the object.

$$m = \frac{Height\ of\ Image(h')}{height\ of\ object(h)}$$

Magnification produced by a lens is also related to the object-distance u, and the image-distance v and is given by

m=vum=vu

The power of a lens is defined as the reciprocal of its focal length. It is represented by the letter P. The power P of a lens of focal length f is given by

P=1fP=1f

Power of a convex lens is positive and that of a concave lens is negative.

The SI unit of power of a lens is 'diopter'. It is denoted by the letter D.

1 diopter is the power of a lens whose focal length is 1 meter so, 1D=1m–11D=1m–1.

Summary of the Chapter

- Light is a form of energy that produces in us the sensation of sight.
- **Reflection of light** is the phenomenon of bouncing back of light in the same medium on striking the surface of any object.
- The two laws of reflection are:
  - (i) the incident ray, the reflected ray and the normal (at the point of incidence), all lie in the same plane.
  - (ii) the angle of reflection (*r*) is always equal to the angle of incidence (*i*)

    $\angle r = \angle i$
- In a plane mirror, the image of a real object is always
  - (i) virtual,
  - (ii) erect
  - (iii) of same size as the object,
  - (iv) as far behind the mirror as the object is in front of the mirror.
  - (v) laterally inverted.
- Absolute refractive index(*n*) of a medium is the ratio of speed of light in vacuum or air(*c*) to the speed of light in the medium(*v*) i.e.

$$n = \frac{c}{v}$$

- Refraction of light is the phenomenon of change in the path of light in going from one medium to another.
- In going from a rarer to a denser medium, the ray of light bends towards normal and in going from a denser to a rarer medium, the ray of light bends away from normal.

- Snell's law of refraction,

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = {}^1n_2$$

- No refraction occurs, when
  - (i) light is incident normally on a boundary,
  - (ii) refractive indices of the two media in contact are equal.
- $n_{21} = \dfrac{n_2}{n_1} = \dfrac{v_1}{v_2}$
- Lens formula : $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$
- New Cartesian Sign Convention for spherical lenses:
  - (i) All distances are measured from optical centre *C* of the lens.
  - (ii) The distances measured in the direction of incidence of light are taken as positive and vice–versa.
  - (iii) All heights above the principal axis of the lens are taken as positive and vice versa.
- The linear magnification produced by a lens is

$$m = \frac{h'}{h} = \frac{v}{u}$$

- Power of the combination of lenses

$$P = p_1 + p_2 + p_3 \ldots$$

- Mirror formula: $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$
- Linear magnification produced by a spherical mirror is

$$m = \frac{-v}{u} = \frac{\text{size of image } (h_2)}{\text{size of object } (h_1)}$$

- For a convex mirror, *m* is +ve and less than one, as the image formed is virtual, erect and shorter than the object.
- For a concave mirror, *m* is +ve when image formed is virtual and *m* is –ve, when image formed is real.
- According to New Cartesian Sign Convention, for spherical mirror.
  - (i) All distances are measured from the pole of the spherical mirror.
  - (ii) The distances measured in the direction of incidence of light are taken as positive and vice–versa.
  - (iii) The heights above the principal axis of the mirror are taken as positive and vice–versa.
- In spherical mirror, focal length $(f) = \dfrac{\text{Radius of curvature } (R)}{2}$.

EXERCISE

Multiple Choice Questions

1. Focal length of plane mirror is
   (a) At infinity
   (b) Zero
   (c) Negative
   (d) None of these
2. Image formed by plane mirror is
   (a) Real and erect
   (b) Real and inverted
   (c) Virtual and erect
   (d) Virtual and inverted
3. A concave mirror gives real, inverted and same size image if the object is placed
   (a) At F
   (b) At infinity
   (c) At C
   (d) Beyond C
4. Power of the lens is -40, its focal length is
   (a) 4m
   (b) -40m
   (c) -0.25m
   (d) -25m
5. A concave mirror gives virtual, refract and enlarged image of the object but image of smaller size than the size of the object is
   (a) At infinity
   (b) Between F and C
   (c) Between P and F
   (d) At E
6. In optics an object which has higher refractive index is called
   (a) Optically rarer
   (b) Optically denser
   (c) Optical density
   (d) Refractive index
7. The optical phenomena, twinkling of stars, is due to
   (a) Atmospheric reflection
   (b) Total reflection
   (c) Atmospheric refraction
   (d) Total refraction
8. Convex lens focus a real, point sized image at focus, the object is placed
   (a) At focus
   (b) Between F and 2F
   (c) At infinity
   (d) At 2F

9. The unit of power of lens is
   (a) Metre
   (b) Centimeter
   (c) Diopter
   (d) M^{-1}
10. The radius of curvature of a mirror is 20cm the focal length is
   (a) 20cm
   (b) 10cm
   (c) 40cm
   (d) 5cm

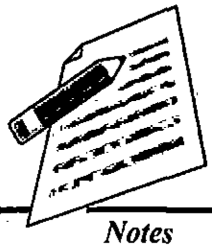
Answers

1. (a)	**2.** (c)	**3.** (c)	**4.** (c)	**5.** (c)
6. (b)	**7.** (c)	**8.** (c)	**9.** (c)	**10.** (b)

HIGH ORDER THINKING QUESTIONS

1. What is the magnification of a plane mirror
2. What is the radius of curvature of plane mirror?
3. Why paper catches fire when a convex lens is used to ficus sunlight?
4. What is silvering of mirror?
5. What is refractive mirror?
6. State the formula, lens formula and power of lens
7. The refractive index of water is 1.33 and kerosene is 1.44. Calculate refractive index of the kerosene with respect to water.
8. What kind of mirrors are used in big shopping stores to watch activities of customers?
9. Give mirror image of word AMBULANCE
10. The magnification produced by a plane mirror is +1. What does it mean?

Space for Notes



Theme: How Things Work
Unit IV: Effects of Current

10 MAGNETIC EFFECTS OF ELECTRIC CURRENT

Electric current, potential difference and electric current. Ohm's law; Resistance, resistivity, Factors on which the resistance of a conductor depends. Series combination of resistors, parallel combination of resistors and its applications in daily life. Heating effect of electric current and its applications in daily life. Electric power, Interrelation between P, V, I and R.

Magnetic effects of current: Magnetic field, field lines, field due to a current carrying conductor, field due to current carrying coil or solenoid; Force on current carrying conductor, Fleming's Left-Hand Rule, Electric Motor, Electromagnetic induction. Induced potential difference, Induced current. Fleming's Right Hand Rule.

Objective of the unit

The main objective of the unit is to make student understand about:

- Electric current
- Ohm's law_
- Interrelation between P, V, I and R.
- Magnetic effects of current
- Fleming's Right Hand Rule

Introduction

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. at is, an electric current is formed by moving electrons.

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'. it is depicted in Figure 2.6.

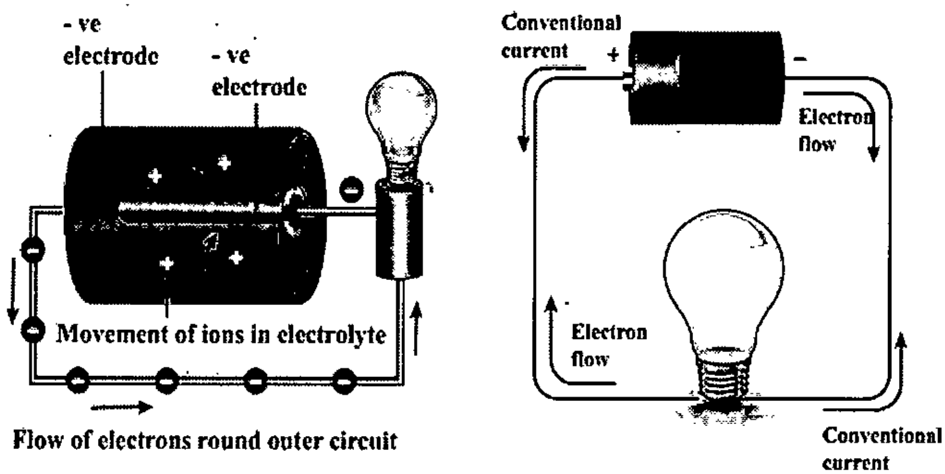


Figure 2.6 Electric current

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 ow. 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. 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. 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,

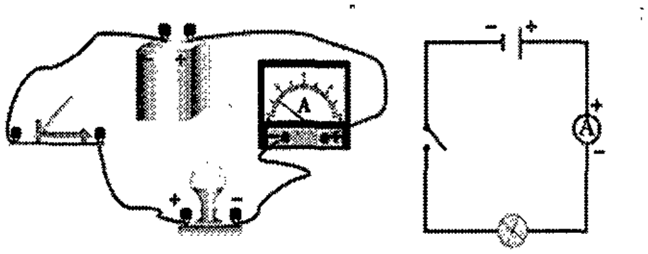
$I = q/t$

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 x t

Time has to be in second.

∴1hr = 1x 60 x 60 s= 3600 s

q = I x t = 0.2A x 3600s = 720C

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.

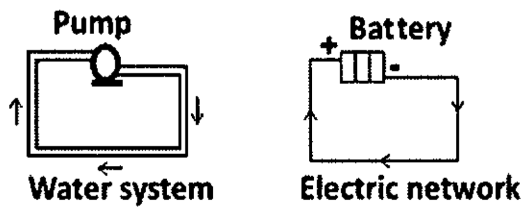


Figure 2.9 Battery is analogues to water pump

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 (e). 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: $\varepsilon = 1.5V$ and $q = 0.5C$

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

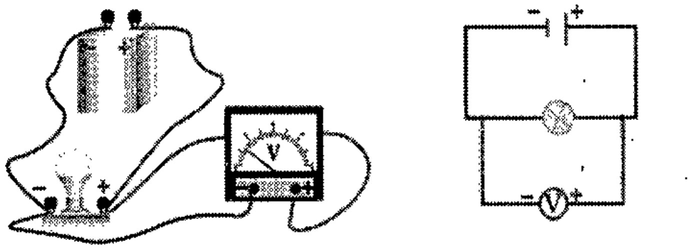
4. Potential difference (p.d)

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. 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).

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 $2x10^4$ 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 $5x10^6$ J / $2x10^4$

C = 250 V

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 o er different electrical resistance.

Even the conducting wires o er 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. at is why they are called good conductors. On the other hand, materials like nichrome, tin oxide etc., o er 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.

Fixed resistor Variable resistor Rheostat

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

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,

$V \infty I$

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

Hence, Ohm's law is written as,

$V = R\ I$ (or) $V = I\ R$

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 ( ).

Any appliance connected to the circuit offers resistance. We can measure it by measuring the current (I) owing 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)

CLASS-10

Science

Notes

RESISTORS

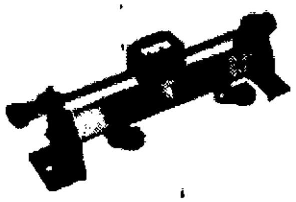
Fixed resistor

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

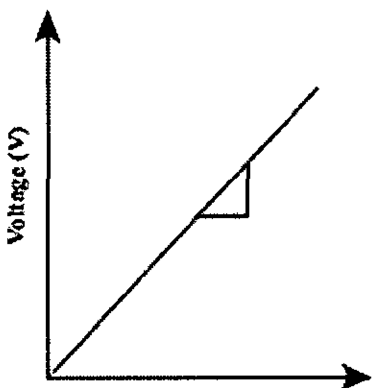


Figure 2.13 Relation between Current and Voltage

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 = 23

Electric circuit diagram

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

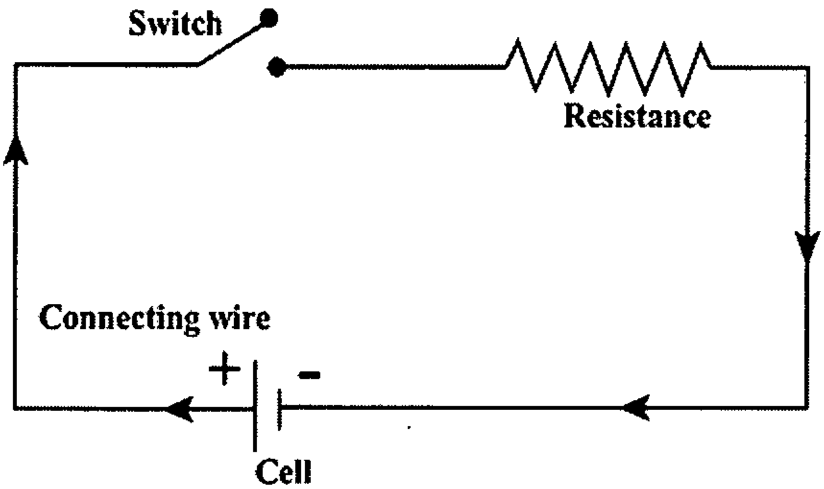


Figure 2.14 Typical electric circuit

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.

1. Some common symbols in the electrical circuit

Some of the symbols are shown in Table 1.

Symbol	Device	Symbol	Device	Symbol	Device
or	Switch		Wires joined	— G — or	galvanometer
	Cell		Wires crossed	A	ammeter
	Battery		Fixed resistor	V	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-dependent resistor (LDR)		Semiconductor diode		bell

Table 2.1 Common symbols in electrical circuits

2. Different electrical circuits

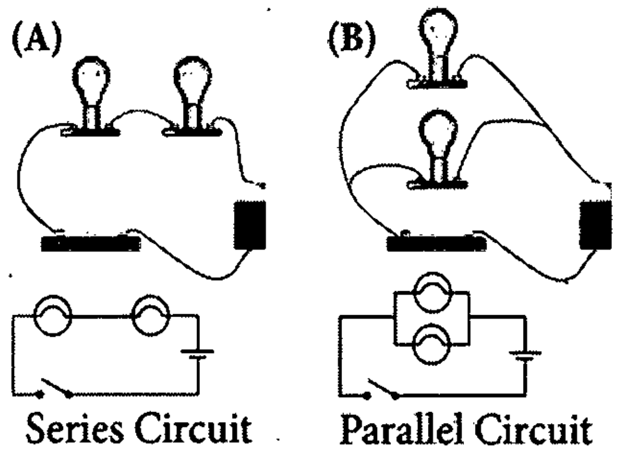


Figure 2.15 Series and parallel connections

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, $V = V_1 + V_2 + V_3$

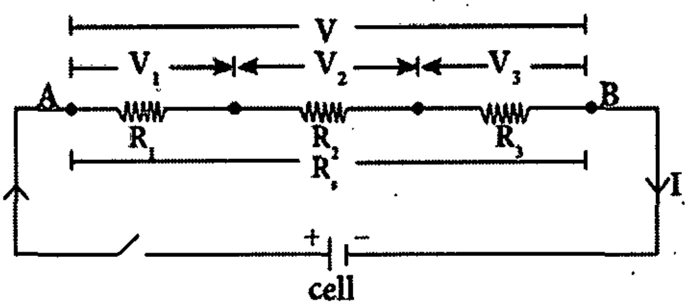


Figure 2.16 Resistors in series

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

$R_S = R_1 + R_2 + R_3$

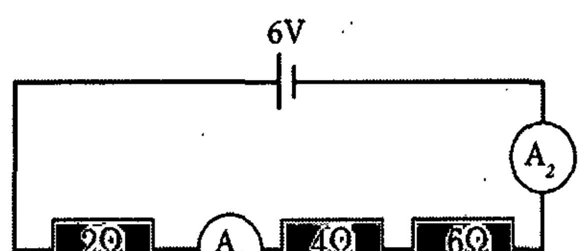
Thus, the equivalent resistance of a number of resistors in series connection is equal to the sum of the resistance of individual resistors.

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 5 R_1 1 R_2 1 R_3
= 2 + 4 1 6 = 12V

(b) Since, V= 6 V and effective resistance is 12V
I= V/R = 6V/12V = 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 2V, 4V, 6V resisters respectively, then

V_1 = I 3 R_1 = 0.5A 3 2V = 1V

V_2 = I 3 R_2 = 0.5A 3 4V = 2 V

V_3 = I 3 R_3 = 0.5A 3 6V = 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 ow. In a parallel circuit the sum of the individual current in each of the parallel branches is equal to the main current owing into or out of the parallel branches. Also, in a parallel circuit the potential difference across separate parallel branches are same.

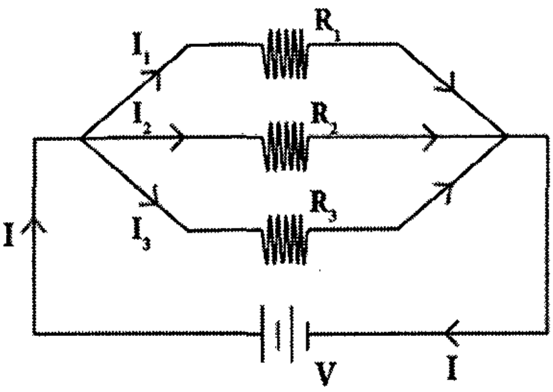


Figure 2.17 Resistors in parallel

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.

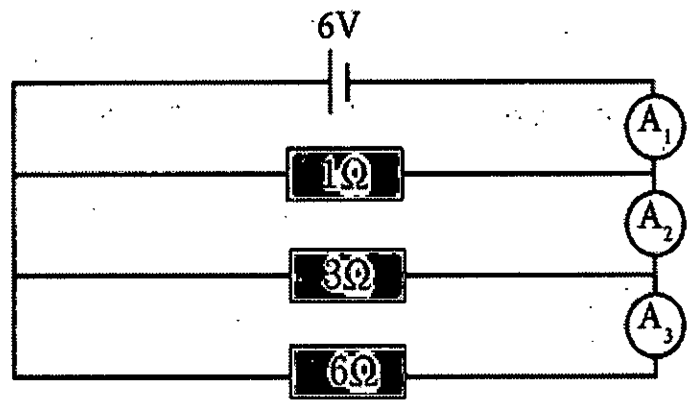
$(V/R_P) = (V/R_1) + (V/R_2) + (V/R_3) = Vx(1/R_1 + 1/R_2 + 1/R_2)$

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

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

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

$1/R_p = 9/6$

$R_p = 0.667$ W

(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 resistance R = 0.667 W, current measured by ammeter

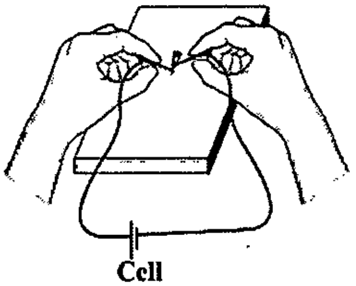
$A_3 = 6\ V / 0.667\ \Omega = 9\ A$

Effects of electric current

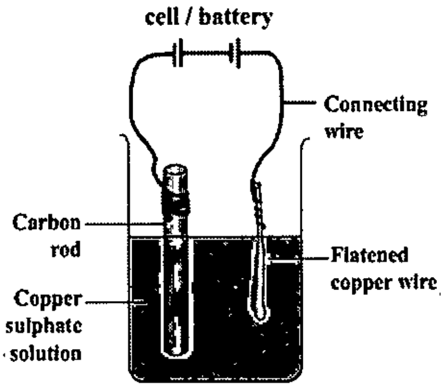
When current flows in a circuit it exhibits various effects. The main effects are heating, chemical and magnetic effects.

1. **Heating effect**

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



2. **Chemical effect**



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.

3. **Magnetic effect of Electricity**

   A wire or a conductor carrying current develops a magnetic field perpendicular to the direction of the flow of current. 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.

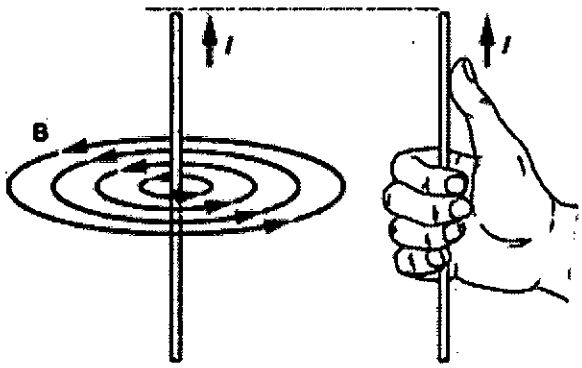


Figure 2.18 Direction of current and magnetic field

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).

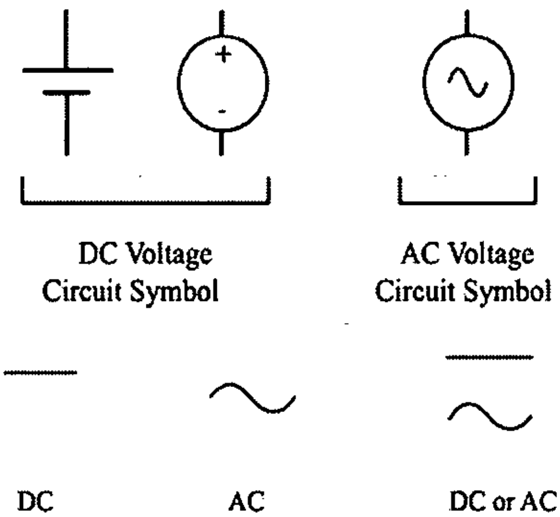


Figure 2.21 The symbol used in ac and dc circuit diagrams

Combination of resistors

In simple circuits with resistors, Ohm's law can be applied to find the effective resistance. The resistors can be connected in series and parallel.

1. **Resistors in series**

   Let us consider the resistors of resistances R1, R2, R3 and R4 connected in series as shown in Fig 2.6.

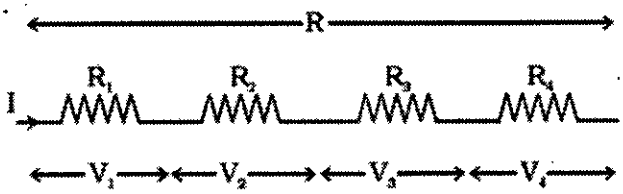


Fig 2.6 Resistors in series

When resistors are connected in series, the current flowing through each resistor is the same. If the potential difference applied between the ends of the combination of resistors is V, then the potential difference across each resistor R1, R2, R3 and R4 is V1, V2, V3and V4 respectively.

The net potential difference V = V1 + V2 + V3 + V4

By Ohm's law

V1 = IR1, V2 = IR2, V3 = IR3, V4 = IR4 and V = IRs

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

Hence, IRS = IR1 + IR2 + IR3 + IR4 or RS = R1 + R2 + R3 + R4 Thus, the equivalent resistance of a number of resistors in series connection is equal to the sum of the resistance of individual resistors.

2. **Resistors in parallel**

   Consider four resistors of resistances R1 , R2 , R3 and R4 are connected in parallel as shown in Fig 2.7. A source of emf V is connected to the parallel combination. When resistors are in parallel, the potential difference (V) across each resistor is the same.

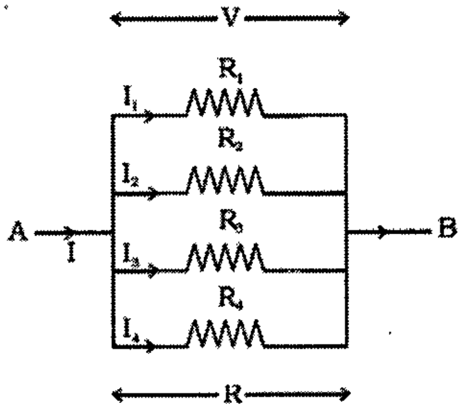


Fig 2.7 Resistors in parallel

A current I entering the combination gets divided into I1, I2, I3 and I4 through R1, R2, R3 and R4 respectively,

such that I = I1 + I2 + I3 + I4.

By Ohm's law

$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2},\ I_3 = \frac{V}{R_3},\ I_4 = \frac{V}{R_4} \text{ and } I = \frac{V}{R_P}$$

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

$$\therefore \frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} + \frac{V}{R_4}$$

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

Thus, when a number of resistors are connected in parallel, the sum of the reciprocal of the resistance of the individual resistors is equal to the reciprocal of the effective resistance of the combination.

HEATING EFFECT OF ELECTRIC CURRENT

When current flows through a resistor, some of the electrical energy delivered to the resistor is converted into heat energy and it is dissipated. This heating effect of current is known as Joule's heating effect. Just as current produces thermal energy, thermal energy may also be suitably used to produce an electromotive force. This is known as thermoelectric effect.

1. **Joule's law**

   If a current I flows through a conductor kept across a potential difference V for a time t, the work done or the electric potential energy spent is

$$\boxed{W = VIt \qquad (2.66)}$$

   In the absence of any other external effect, this energy is spent in heating the conductor. The amount of heat(H) produced is

$$\boxed{H = VIt \qquad (2.67)}$$

   For a resistance R,

$$\boxed{H = I^2Rt \qquad (2.68)}$$

This relation was experimentally verified by Joule and is known as Joule's law of heating. It states that **the heat developed in an electrical circuit due to the flow of current varies directly as**

(i) the square of the current

(ii) the resistance of the circuit and

(iii) the time of flow.

EXAMPLE 2.27

Find the heat energy produced in a resistance of 10 Ω when 5 A current flows through it for 5 minutes.

Solution

$R = 10\ \Omega,\ I = 5\ A,\ t = 5$ minutes $= 5 \times 60$ s

$H = I^2 R t$

$= 5^2 \times 10 \times 5 \times 60$

$= 25 \times 10 \times 300$

$= 25 \times 3000$

$= 75000$ J (or) 75 kJ

2. Application of Joule's heating effect

1. Electric heaters

Electric iron, electric heater, electric toaster shown in Figure 2.30 are some of the home appliances that utilize the heating effect of current. In these appliances, the heating elements are made of nichrome, an alloy of nickel and chromium. Nichrome has a high specific resistance and can be heated to very high temperatures without oxidation.

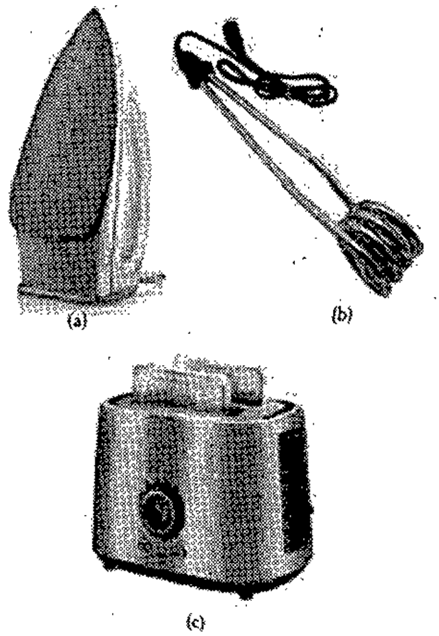
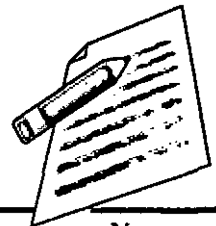


Figure 2.30 (a) Electric Iron box, (b) electric heater (c) electric Toaster

EXAMPLE 2.28

An electric heater of resistance 10 Ω connected to 220 V power supply is immersed in the water of 1 kg. How long the electrical heater has to be switched on to increase its temperature from 30°C to 60°C. (The specific heat of water is $s = 4200\ J\ kg^{-1}$)



Solution

According to Joule's heating law $H = I^2 Rt$

The current passed through the electrical heater = $220V/10\Omega = 22$ A

The heat produced in one second by the electrical heater $H = I^2 R$

The heat produced in one second $H = (22)^2 \times 10 = 4840$ J = 4.84 k J. In fact, the power rating of this electrical heater is 4.84 k W.

The amount of energy to increase the temperature of 1kg water from 30°C to 60°C is

$Q = ms\,\Delta T$ (Refer XI physics vol 2, unit 8)

Here m = 1 kg,

s = 4200 J kg^{-1},

$\Delta T = 30$,

so, $Q = 1 \times 4200 \times 30 = 126$ kJ

The time required to produce this heat energy $t = Q/ I^2R = 126 \times 10^3 / 4840 \approx 26.03$ s

2. Electric fuses

Fuses as shown in Figure 2.31, are connected in series in a circuit to protect the electric devices from the heat developed by the passage of excessive current. It is a short length of a wire made of a low melting point material. It melts and breaks the circuit if current exceeds a certain value. Lead and copper wire melt and burns out when the current increases above 5 A and 35 A respectively.

The only disadvantage with the above fuses is that once fuse wire is burnt due to excessive current, they need to be replaced. Nowadays in houses, circuit breakers (trippers) are also used instead of fuses.

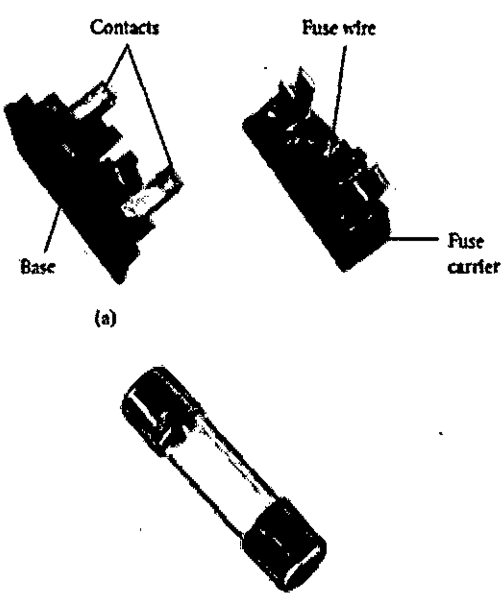


Figure 2.31 Electric Fuse

Whenever there is an excessive current produced due to faulty wire connection, the circuit breaker switch opens. After repairing the faulty connection, we can close the circuit breaker switch. It is shown in the Figure 2.32.

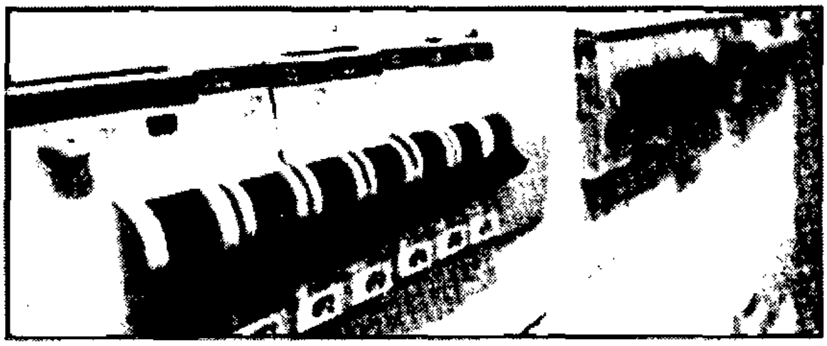


Figure 2.32 circuit breakers

3. **Electric furnace**

   Furnaces as shown in Figure 2.33 are used to manufacture a large number of technologically important materials such as steel, silicon carbide, quartz, gallium arsenide, etc). To produce temperatures up to 1500°C, molybdenum-nichrome wire wound on a silica tube is used. Carbon arc furnaces produce temperatures up to 3000 °C.

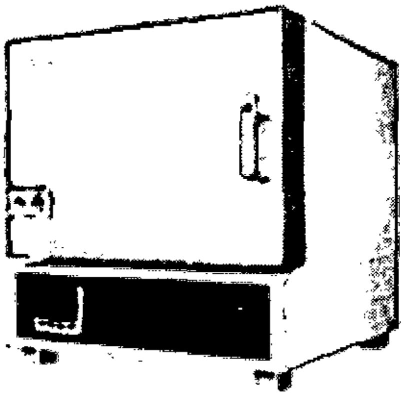


Figure 2.33 Electric furnace

4. **Electrical lamp**

   It consists of a tungsten filament (melting point 3380 °C) kept inside a glass bulb and heated to incandescence by current. In incandescent electric lamps only about 5% of electrical energy is converted into light and the rest is wasted as heat. Electric discharge lamps, electric welding and electric arc also utilize the heating effect of current as shown in Figure 2.34.

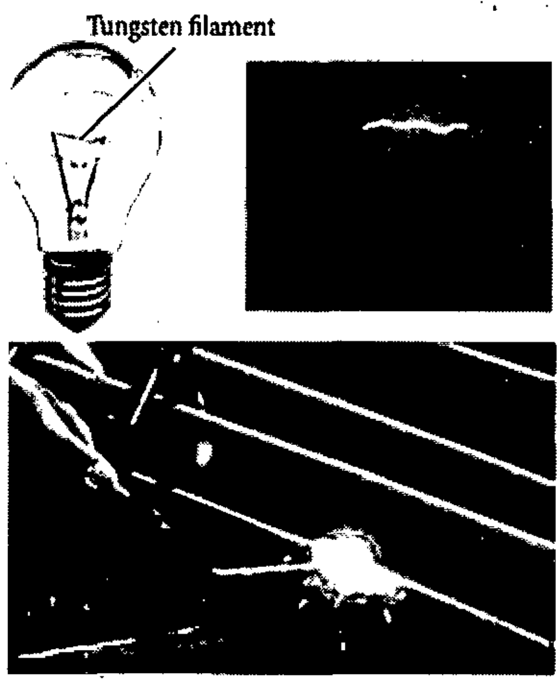


Figure 2.34 Electric bulb, electric arc and electric welding

Ohm's Law

It is the basic, foremost and significant law that explores the relationship between voltage, current and resistance in an electric circuit. It states that, at constant temperature the current flowing through the circuit is directly proportional to the voltage or potential difference across that circuit.

In algebraic form, $V \propto I$

$V = IR$

Where

I is the current flowing through the circuit and it is measured in Amps

V is the voltage applied across the circuit and it is measured in Volts

And R is the proportionality constant, called as Resistance which is measured in Ohms.

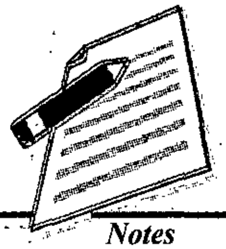
This resistance is also specified in kilo Ohms, Mega Ohms, etc.

Therefore, ohm's law tells that current flow in circuit is directly proportional to the voltage and is inversely proportional to the resistance in that circuit. Ohm's law can be applied to the individual parts or to an entire circuit.

Mathematically, Current, $I = V/R$

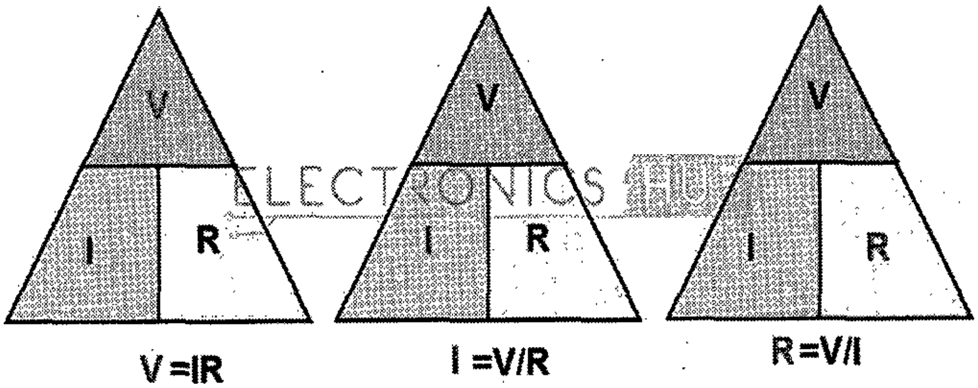
Voltage; $V = IR$

Resistance, $R = V/I$



Ohm's Law Triangle

Below arrangement shows that relation between different quantities in ohm's law, is referred as ohms law triangle. This is a simple method of describing and also easy to remember the relation between the voltage, current and resistance.



Above figure shows the ohm's law triangle where individual terms like voltage, current and resistance and their formulas are represented from basic ohms law equation. In the above figure, one parameter is calculated, from the remaining two parameters. Thus it can be concluded that, when the resistance is high, the current flow will be low and current flow is high, when resistance is low for any applied voltage.

Electric Power

The electric power gives the rate at which energy is transferred by a circuit. Electric power is measured in watts. This power is consumed when a voltage causes current to flow in circuit.

Therefore, the electric power is the product of voltage and current.

Mathematically, $P = VI$

From ohms law, $V = IR$ and $I = V/R$

Substituting in the power equation

$P = I^2 R$

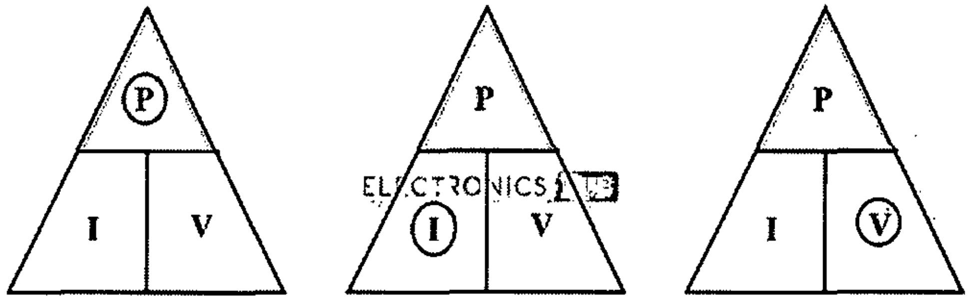
$P = V^2/ R$

Therefore, Electric power, $P = VI$ or $I^2 R$ or V^2/ R

These are the three basic formulas to find the electric power in a circuit. Thus power can be calculated when any of the two quantities are known.

Power Triangle

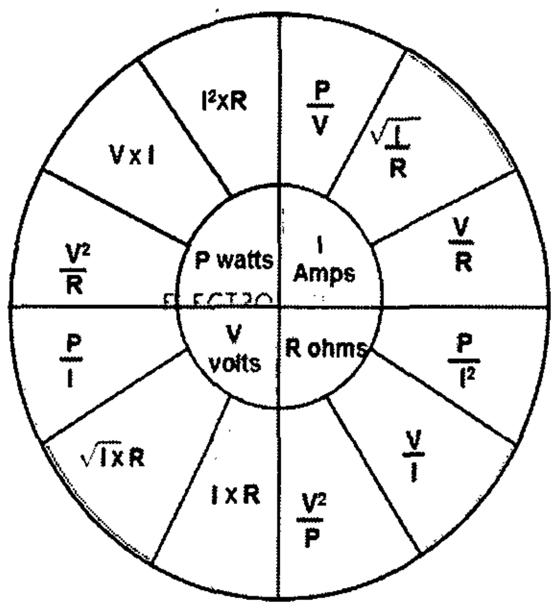
Similar to the ohms law triangle, below figure shows the power triangle to give the relation between the power, voltage and current. Individual parameter equations are easily remembered by this figure. Round off and hide the parameter which is to be measured and the remaining two parameters position gives the equation to find the hided or rounded parameter as shown in below figure.



P=IV   I = P/V   V=P/ I

Ohm's Law Pie Chart

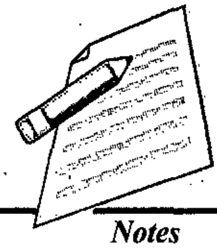
Preceding to the above two concepts, there is another method for finding circuit parameters using ohm's law that is Ohm's law pie chart. By using the ohm's law pie chart one can easily remember all the equations to find voltage, current, resistance and power which are necessary to simplify the electric circuits that can be simple or complex.

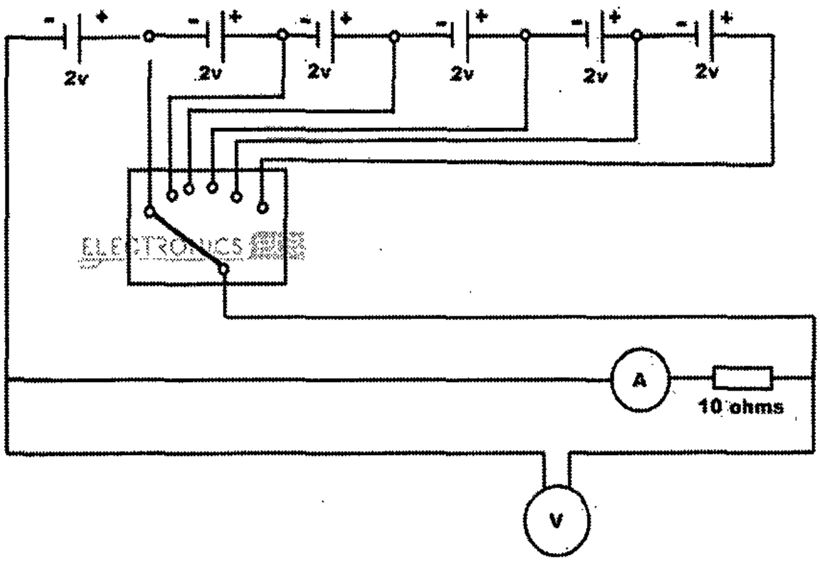


Above figure shows pie chart that gives a relationship between power, voltage, current and resistance. This chart is divided into four units for power, voltage, resistance and current. Each unit consists of three formulas with two known values for each formula. From the chart, for finding each parameter in a circuit, we can use any one from available three formulas.

Graphical Representation of Ohm's Law

For a better understanding of this concept, experimental set up is given below where an adjustable voltage source with six cells (2V each) is connected to the load resistor through a voltage selector switch. Measuring instruments like voltmeter and ammeter are also connected to the circuit to measure the voltage and current in the circuit.

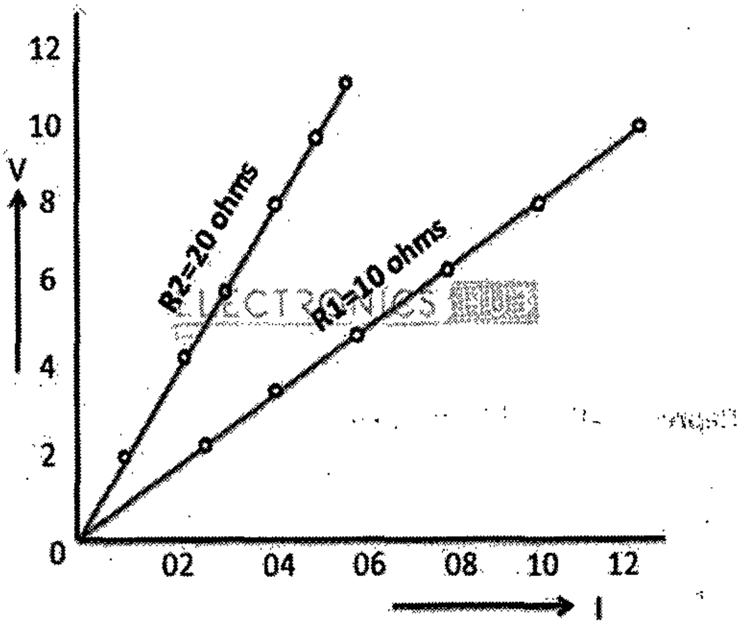




Adjustable voltage source with the load resistor

First connect the 10 ohms resistor and place the selector switch at position one. Then the ammeter reads 0.2A and voltmeter reads 2V because I = V/R, i.e. I = 2/10 = 0.2A. Next change the selector switch position to second cell, to apply the 4V across the load and note down the ammeter reading. As the selector changes stepwise from first position to the last we will get the current values like 0.2, 0.4, 0.6, 0.8, 1, 1.2 for voltages values of 2, 4, 6, 8, 10 and 12 respectively.

Similarly place the 20 ohms resistor in place of 10 ohms resistor and do the same procedure as above. We will get the values of current 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 for the voltage values of 2, 4, 6, 8, 10 and 12V respectively. Plot the graph of these values as shown below.

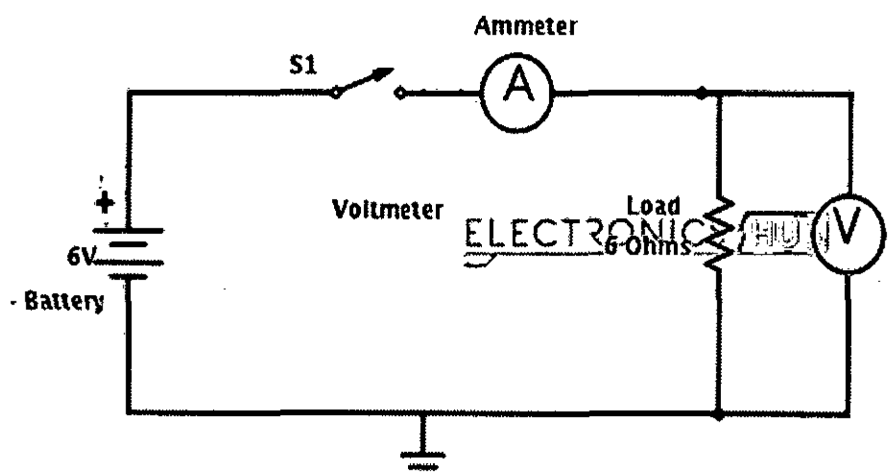


Graphical representation of ohms law

In the above graph, for a given voltage, the current is smaller when the resistance is greater. Consider the case of voltage 12V applied where current value is 1.2A if the resistance is 10 ohms and it is 0.6 ohms, when the resistance is 20 ohms. Similarly, for same current flow, the voltage is greater as the resistance is greater. From the above results, the ratio of voltage to current is constant when the resistance is constant. Therefore, the relationship between the voltage and current is linear and the slope of this linear curve get steeper as the resistance is greater.

Example of Ohm's law

Consider the below circuit where battery of 6V is connected to a 6 ohms load. Ammeter and voltmeters are connected to the circuit to measure the current and voltage practically. But using the ohm's law we can find the current and power as follows.



From ohm's law

$V = IR$

$I = V/R$

$I = 6/6$

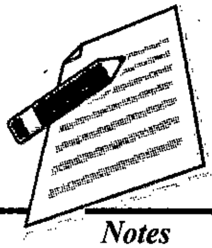
$I = 1$ ampere

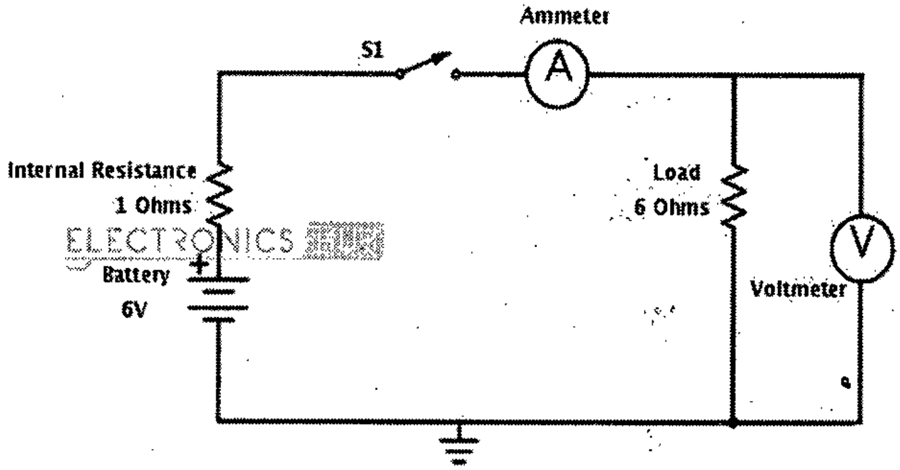
Power, $P = VI$

$P = 6 \times 1$

$P = 6$ watts

But practically the ammeter doesn't show the exact value due to the internal resistance of the battery. By including the internal resistance of the battery (Assume battery has internal resistance of 1 ohm), the current value is calculated as follows.





Total resistance of the circuit is 6 +1 = 7 ohms.

Current, I = V/R

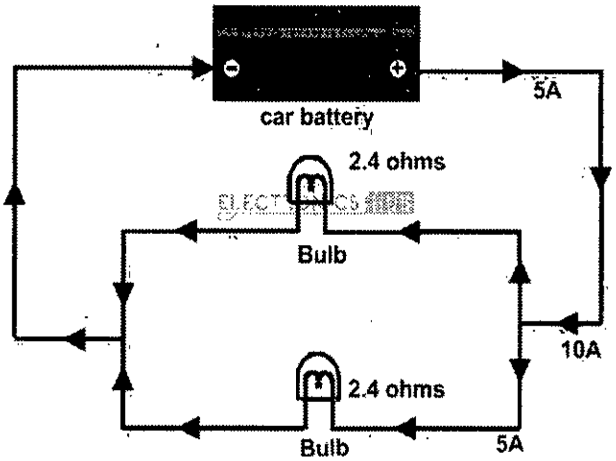
I = 6/7

I = 0.85 Amps

Back to top

Headlamps Circuit in a Car

The below figure shows the headlamps circuit in the motor car excluding the control circuitry. With the application of ohm's law, we can find out the current flowing through each light. Generally, each light is connected in parallel to the battery, which allows other lights to glow even if anyone is damaged. A battery of 12 V is supplied to these parallel lamps where lamps have the resistance of 2.4 each (considered in this case).



The total resistance of the circuit is R = R1x R2/ (R1 + R2) as they are in parallel.

R = 5.76/ 4.8 = 1.2

Then the current flowing through the circuit is I = V/R

I = 12/ 1.2

I = 10A.

CLASS–10

Science

Notes

Current flowing through individual lamp is I1 = I2 = 5 A (due to the same resistances)

Ohm's Law for AC circuits

In general, ohm's law can also be applied to AC circuits. If the load is inductive or capacitive, then reactance of the load is also considered. Therefore, with some modifications of ohms law by considering reactance effect, it can be applied to AC circuits. Due to the inductance and capacitance in AC, there will be a considerable phase angle between voltage and currents. And also, the AC resistance is called impedance and is represented as Z.

Thus, the ohms law for AC circuits is given as

$E = IZ$

$I = E/Z$

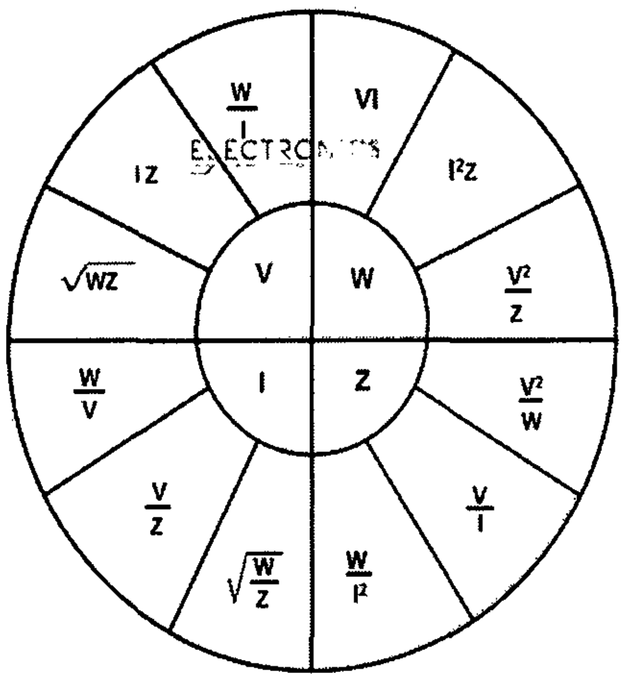
$Z = E/I$

Where E is the voltage in AC circuit

I is the current and

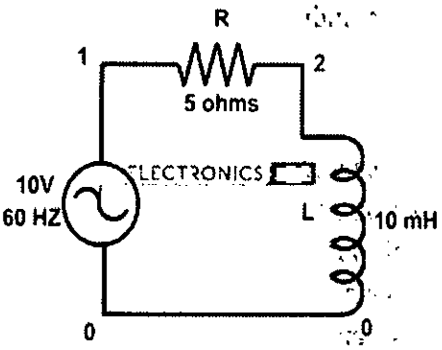
Z is the impedance.

All the parameters in the above equation are in complex form which includes the phase angle. Similar to the DC circuit pie chart, ohm's law pie chart for AC circuit is given below.



Example of Ohm's Law (AC Circuits)

Consider the below circuit where AC load (combination of resistive and inductive) is connected across the AC supply of 10V, 60Hz. The load has resistance value of 5 ohms and an inductance of 10mH.



Then the impedance value of the load, $Z = R + jX_L$

$Z = 5 + j\ (2\prod \times f \times L)$

$Z = 5 + j\ (2 \times 3.14 \times 60 \times 10 \times 10\text{-}3)$

$Z = 5 + j3.76$ ohms or 6.26 ohms at a phase angle of -37.016

The current flowing through the circuit is

$I = V/Z$

$= 10/\ (5 + j3.76)$

$= 1.597A$ at a phase angle of -37.016

MAGNETIC EFFECTS OF CURRENT

1. **Oersted experiment**

   In 1820, Hans Christian Oersted while preparing for his lecture in physics noticed that electric current passing through a wire deflects the nearby magnetic compass. By proper investigation, he observed that the deflection of magnetic compass is due to the change in magnetic field produced around current carrying conductor (Figure 3.32). When the direction of current is reversed, the magnetic compass deflects in opposite direction. This led to the development of the theory 'electromagnetism' which unifies the two branches in physics, namely electricity and magnetism.

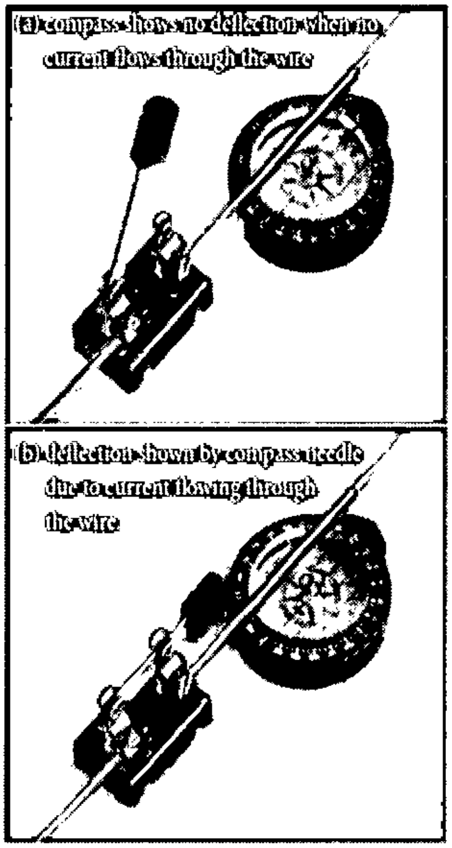


Figure 3.32 Oersted's experiment - current carrying wire and deflection of magnetic needle

2. **Magnetic field around a straight current carrying conductor and circular loop**

   (a) Current carrying straight conductor:

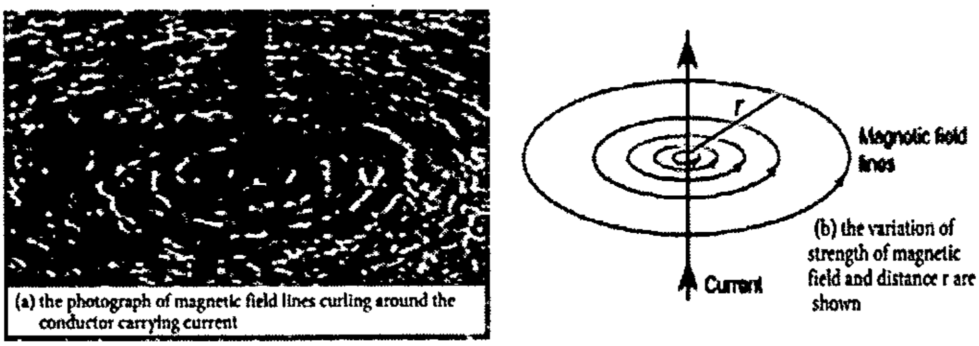


Figure 3.33 Magnetic field lines around straight, long wire carrying current

Suppose we keep a magnetic compass near a current carrying straight conductor, then the needle of the magnetic compass experiences a torque and deflects to align in the direction of the magnetic field at that point. Tracing out the direction shown by magnetic compass, we can draw the magnetic field lines at a distance. For a straight current carrying conductor, the nature of magnetic field is like concentric circles having their center at the axis of the conductor as shown in Figure 3.33 (a).

The direction of circular magnetic field lines will be clockwise or anticlockwise depending on the direction of current in the conductor. If the strength (or magnitude) of the current is increased then the density of the magnetic field will also increase. The strength of the magnetic field

(b) decreases as the distance (r) from the conductor increases are shown in Figure 3.33 (b).

(b) Circular coil carrying current

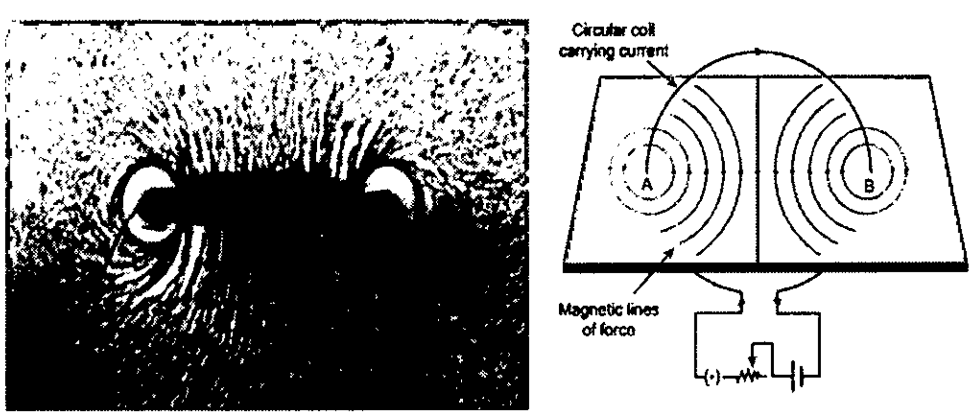


Figure 3.34 The magnetic field lines curling around the circular coil carrying current.

Suppose we keep a magnetic compass near a current carrying circular conductor, then the needle of the magnetic compass experiences a torque and deflects to align in the direction of the magnetic field at that point. We can notice that at the points A and B in the vicinity of the coil, the magnetic field lines are circular. The magnetic field lines are nearly parallel to each other near the center of the loop, indicating that the field present near the center of the coil is almost uniform (Figure 3.34).

The strength of the magnetic field is increased if either the current in the coil or the number of turns or both are increased. The polarity (north pole or south pole) depends on the direction of current in the loop.

3. **Right hand thumb rule**

The right-hand rule is a mnemonic to find the direction of magnetic field when the direction of current in a conductor is known.

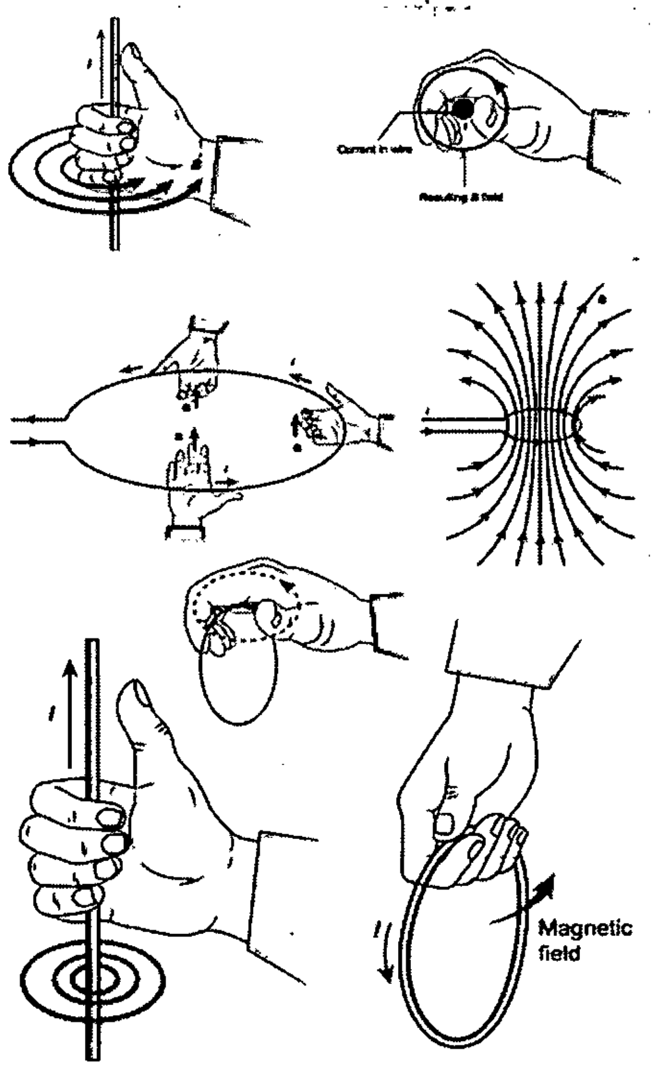


Figure 3.35 Right hand rule – straight conductor and circular loop

If we hold the current carrying conductor in our right hand such that the

thumb points in the direction of current flow, then the fingers encircling the wire points in the direction of the magnetic field lines produced.

The Figure 3.35 shows the right-hand rule for current carrying straight conductor and circular coil.

4. **Maxwell's right hand cork screw rule**

   This rule is used to determine the direction of the magnetic field. If we rotate a right-handed screw using a screw driver, then the direction of current is same as the direction in which screw advances and the direction of rotation of the screw gives the direction of the magnetic field. (Figure 3.36) .

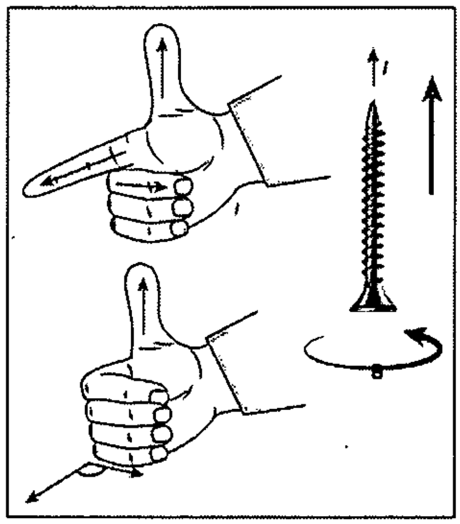
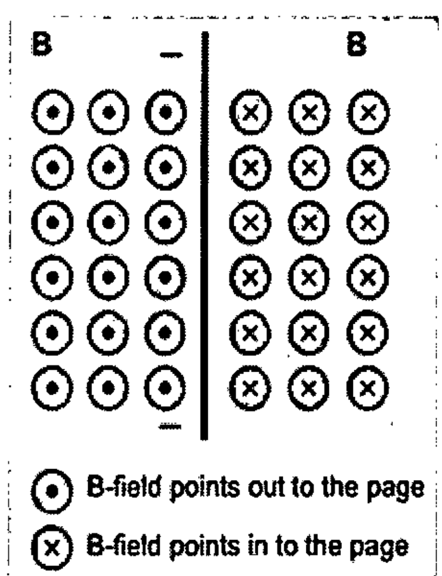


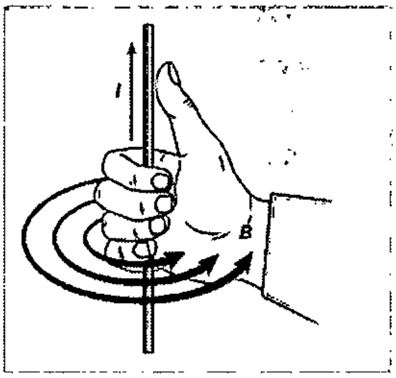
Figure 3.36 Maxwell's right hand cork screw rule

EXAMPLE 3.14

The magnetic field shown in the figure is due to the current carrying wire. In which direction does the current flow in the wire?



Solution



Using right hand rule, current flows upwards.

MAGNET AND MAGNETISM

- Magnets are the substances which have the property of attracting small pieces of iron, nickel, cobalt etc.,
- This property of attraction is called magnetism. Magnetism is mediated by "magnetic field".

MAGNETIC FIELD

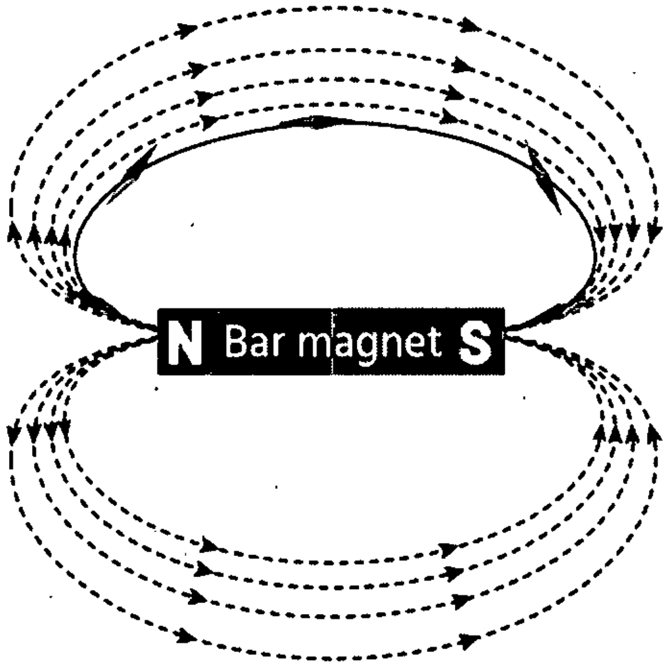
- Magnetic field is the region surrounding a magnet, in which the force of the magnet can be detected.
- Magnetic field is a quantity that has both direction and magnitude. It is a vector quantity.
- It is similar to an electric field surrounding a charge. A magnet attracts small pieces of iron even when they are at a certain distance away from it. This means that magnetic force acts at a distance like electric and gravitational forces. Magnetic field exists in the entire space surrounding the magnet.
- Magnetic field is created by an electric current or magnetic dipole and the field imparts magnetic forces on other particles that are in it.
- Interaction between magnet and magnetic field created by another that exerts a force on it.
- Magnetic field is denoted by B.

MAGNETIC FIELD LINES/LINE OF FORCE

- Magnetic field lines or lines of force are the imaginary lines to visualize magnetic field.
- This was introduced by Michael Faraday.
- For graphical representation of a field. If a magnet is placed on a cardboard and some iron fillings are sprinkled uniformly over it, the iron fillings are seen to arrange themselves in a pattern as shown. The iron fillings

act as small magnets that experience force due to the magnetic field of the magnet.

- The magnetic field lines always begin from the N-pole of a magnet and end on the S-pole of the magnet.
- The magnetic field lines are the path along which an isolated unit north pole would move along in the field.



- To plot the Magnetic Field Pattern due to a bar magnet by using a Compass, the magnetic field lines leave the north pole of a magnet and enter its south pole.
- The strength of magnetic field is indicated by the degree of closeness of the field lines. So, magnetic field is the strongest, where the field lines are closest together.

PROPERTIES (OR CHARACTERISTICS) OF THE MAGNETIC FIELD LINES

1. These are closed and continuous curves which start in air from the N-pole and end at the S-pole and then return to the N-pole through the interior of the magnet.
2. The magnetic field lines come closer to one another near the poles of a magnet but they are widely separated at other places. So magnetic field lines are crowded near the pole where the field is strong and are far from the magnet where the field is weak. Parallel and equidistant magnetic field lines represent a uniform magnetic field, like the Earth's magnetic field.
3. No two magnetic lines of force can intersect each other. If they intersect it would indicate two directions of magnetic field at that point which is not possible.

MAGNETIC FIELD PATTERN DUE TO STRAIGHT CURRENT-CARRYING CONDUCTOR

- The region around a magnet where magnetism acts is represented by the magnetic field.
- The force of magnetism is due to moving charge or some magnetic material.
- Like stationary charges produce an electric field proportional to the magnitude of charge, moving charges produce magnetic fields proportional to the current. In other words, a current carrying conductor produces a magnetic field around it. The sub-atomic particles in the conductor like the electrons moving in atomic orbitals are responsible for the production of magnetic field.
- The magnetic field lines around a straight conductor (straight wire) carrying current are concentric circle whose centres lie on the wire.

DISCOVERY OF MAGNETIC FIELD BY CURRENT CARRYING CONDUCTOR

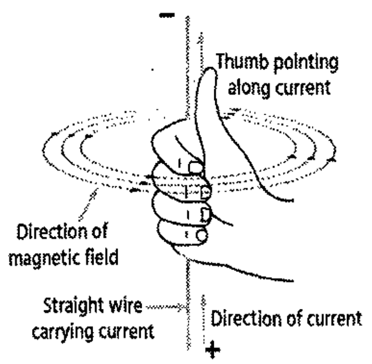
- During the early 19th century, a scientist named H. C. Oersted discovered that a current carrying conductor produces magnetic effect around it.
- Also, effect of lightning striking a ship caused the malfunctioning of compass needles, disrupting the navigation system. This was the basis for establishment of a relationship between moving electric charge or current and magnetic field.

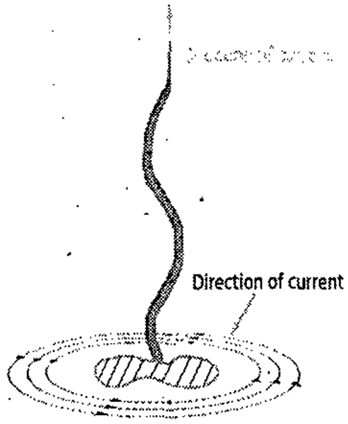
FACTOR ON WHICH THE MAGNETIC FIELD PRODUCED:

Magnetic field is directly proportional to the current passing through the wire and it is inversely proportional to the distance from the wire.

DETECTING DIRECTION OF MAGNETIC FIELD: RIGHT HAND THUMB RULE

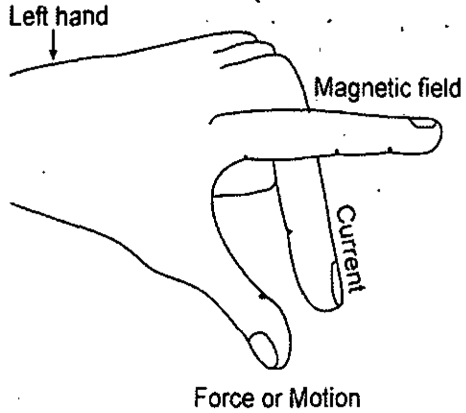
While grasping (or holding) the current-carrying wire in your right hand so that your thumb points in the direction of current, then the direction in which your fingers encircle the wire will give the direction of magnetic field lines around the wire.

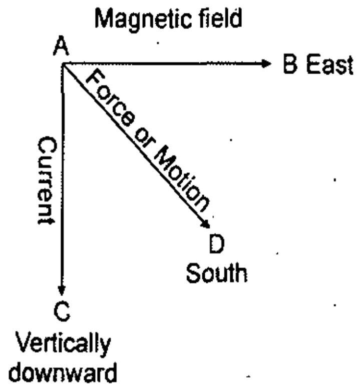




FLEMING'S LEFT-HAND RULE FOR THE DIRECTION OF FORCE

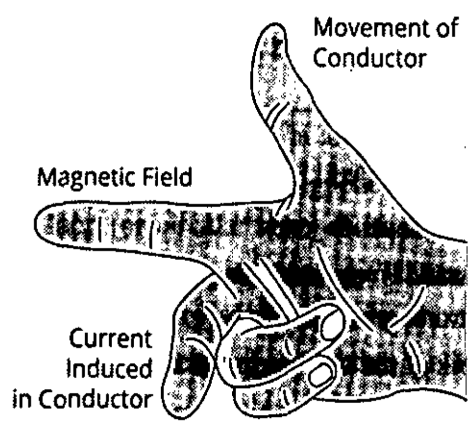
According to this rule if we hold the thumb, the forefinger and the central finger of the left-hand mutually perpendicular to each other and if the forefinger points in the direction of the magnetic field, central finger in the direction of the current, then the thumb points in the direction of motion (or the force) on the conductor.

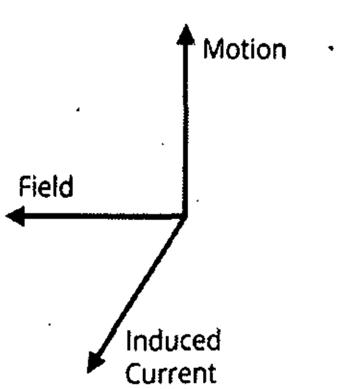




FLEMING'S RIGHT HAND RULE

When a conductor is placed in a magnetic field, current is induced in the conductor. The direction of induced current is determined by the Fleming's right Hand Rule. It is used to determine the direction of current flowing in a generator.





INTERPRETATION

This rule gives the direction of current induced in a conductor moving perpendicular to a magnetic field. Stretch the thumb, forefinger and the central finger of the right hand mutually perpendicular to each other. If the forefinger points in the direction of the magnetic field, thumb in the direction of motion of the conductor, then the central finger points in the direction of current induced in the conductor.

CONVENTIONS:

The following conventions are adopted in applying Fleming's Left Hand or Right-Hand Rule:

- Conventional current flows in the direction of positive charges – i.e. an electron moving to the right is equivalent to conventional current flowing to the left Angular momentum points 90 degrees up from the plane where rotation is clockwise Magnetic lines spread outward from a North Pole.
- If an upward force is applied to a conductor, conventional current flows from right to left. On the corollary, is (conventional) current passes in the direction left to right without moving the conductor, the force on the conductor acts upward. This is the reason motors and generators have "opposite functions": Motors use electricity and generators produce electricity.

Summary of the Chapter

Magnetic field produced at the centre is

- Proportion al to the current I
- Inversely proportional to the radius 'r'

Properties of magnetic field lines:

- They do not intersect each other.
- The direction of the magnetic field lines is from south to north.
- *The direction of the magnetic field lines inside the magnet is from* North to South.

Magnetic field due to current flowing in solenoid:

- Solenoid: Long coil of many turns of insulated copper wire wrapped in the shape of a cylinder.
- Magnetic field produced by a solenoid similar to bar magnet.
- Strength of magnetic field is proportional to number of turns and magnitude of current.

Electromagnets: An electromagnet consists of a long coil of insulated copper wire wound on a soft iron core.

Electric Motor

- A device that converts electrical energy to mechanical energy.
- Principle: When rectangular coil is placed in magnetic field and current is passed through it coils experience a torque, which rotates it continuously.

Electromagnetic Induction

- Phenomenon of inducing an electric current in a coil by changing magi tic field around it.
- Direction of induced current by Fleming right hand rule (MR):

  Forefinger - magnetic field

  Centre finger - induced current

  Thumb - motion of conductor

EXERCISE

Multiple Choice Questions

1. What should be the core of an electromagnet?
   (a) soft iron
   (b) hard iron
   (c) rusted iron
   (d) none of above
2. Who has stated the Right-hand Thumb Rule?
   (a) Oersted
   (b) Fleming
   (c) Einstein
   (d) Maxwell
3. In all the electrical appliances, the switches are put in the
   (a) live wire
   (b) earth wire
   (c) neutral wire
   (d) all of above
4. What is the condition of an electromagnetic induction?
   (a) there must be a relative motion between the coil of wire and galvanometer
   (b) there must be a relative motion between the galvanometer and a magnet
   (c) there must be a relative motion between galvanometer and generator
   (d) there must be a relative motion between the coil of wire and a magnet
5. No force acts on a current carrying conductor when it is placed-
   (a) perpendicular to the magnetic field
   (b) parallel to the magnetic field
   (c) far away from the magnetic field
   (d) inside a magnetic field
6. What is that instrument which can detect the presence of electric current in a circuit?
   (a) galvanometer
   (b) motor
   (c) generator
   (d) none of above
7. Which device produces the electric current?
   (a) generator
   (b) galvanometer
   (c) ammeter
   (d) motor e.
8. What is electromagnetic induction?
   (a) the process of charging a body
   (b) The process of rotating a coil of an electric motor.
   (c) producing induced current in a coil due to relative motion between a magnet and the coil
   (d) The process of generating magnetic field due to a current passing through a coil.

9. What happens to the current in short circuit?
   (a) reduces substantially
   (b) .does not change
   (c) increases heavily
   (d) vary continuously
10. An alpha particle is diverted towards west is deflected towards north by a field. The field is magnetic. What will be the direction of field?
   (a) Towards south
   (b) towards east
   (c) downward
   (d) upward

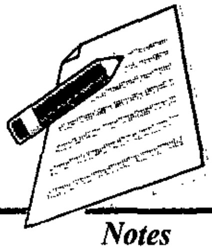
ANSWERS

1. (a) 2. (d) 3. (c) 4. (d) 5. (b) 6. (a) 7. (a) 8. (b) 9. (c) 10. (c)

HOTS

1. The MCB of a Rupa's room is tripped and keeps on tripping again and again. If it is a domestic circuit, what could be the reason of this phenomenon?
2. State any three appliances that function on Fleming's left-hand rule.
3. What is the need to convert Dynamo into alternating current?
4. Find the applications of solenoid.
5. Difference between short circuiting and overloading.
6. Show an activity to demonstrate the direction of the magnetic field generated around a current carrying conductor.
7. What is a fuse? What material is used for make fuse wire?
8. State the properties of magnetic lines of force.
9. Name two safety measures commonly used in electric circuits and appliances.
10. What is the direction of magnetic field in bar magnet?

Space for Notes



Notes

Theme: Natural Resources

Unit V: Natural Resources

11 MANAGAMENT OF NATURAL RESOURCES

Our environment: Eco-system, Environmental problems, Ozone depletion, waste production and their solutions. Biodegradable and non-biodegradable substances.

Objective of the unit

Objective of the Chapter

The main objective of the unit is to make student understand about:

- Eco-system
- Ozone depletion
- Biodegradable and non-biodegradable substances.

Introduction

Ecosystem

Organism – includes animals, plants and microorganisms.

Population – is a group of similar plants or animals living in an area.

Community – refers to all the plants and animals living in an area.

Ecosystem – all living and non-living things and their interaction within an area.

Life cannot exist in isolation. It flourishes in an environment which supplies and fulfils its material and energy requirements. A biotic community and its physical environment in which matter and energy flow and cycle is called as ecosystem.

The term *ecosystem* was first proposed by Arthur George Tansley in 1935. Tansley defined ecosystem as, 'the system resulting from the integration of all living and non-living factors of the environment'. The ecosystems can vary in size. It can be very small, extending to about a few square centimetres or it can extend over many square kilometres. Example; tropical forests.

Major components of an ecosystem

The ecosystem is made up of two main components:

1. Abiotic Component and
2. Biotic Component

A. Abiotic Component: This component of the ecosystem includes the non-living substance of the environment. Example; light, air, soil, water, climate, minerals, etc. Sun is the main source of energy for the earth.

B. Biotic Component: This includes a variety of living organisms such as microorganisms, plants and animals. The biotic component of an ecosystem can be further divided into producers, consumers and decomposers based on their capacity to sustain themselves (Figure 7.2).

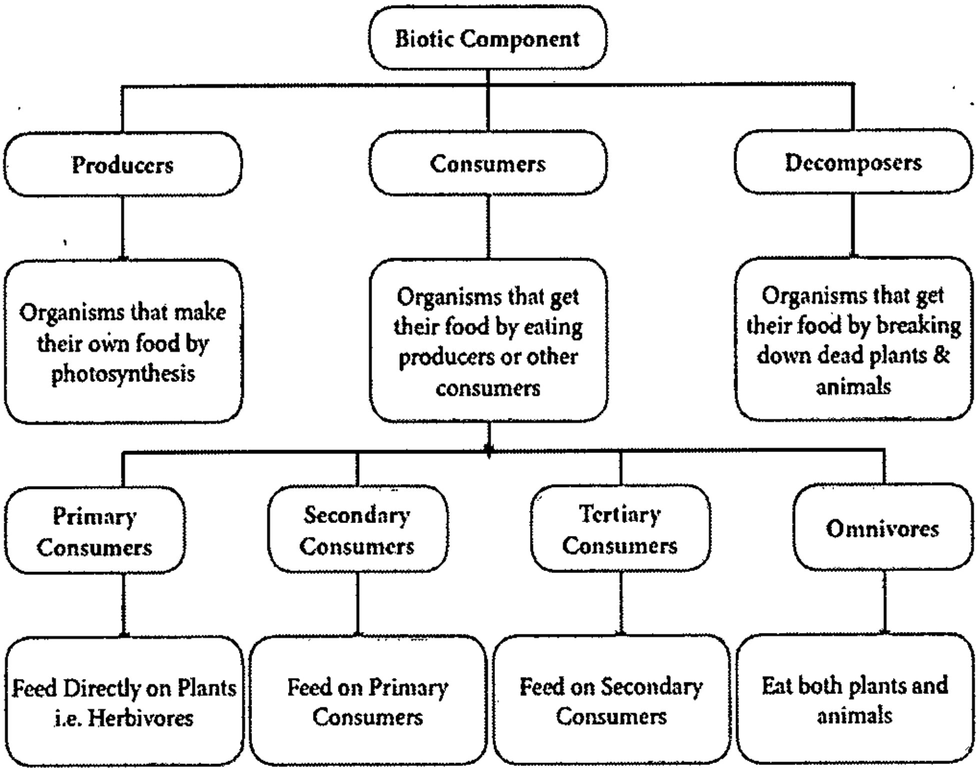


Figure 7.2 Biotic Components

a. Producers: Organisms that can produce or manufacture their own food are known as producers. Plants that have green pigments or chlorophyll, produce their own food in the presence of CO2 in the atmosphere, water from the soil and sunlight through a process called '*photosynthesis*'. These green plants are called as '*autotrophs*' (auto – self; trophs – nourishing) as they manufacture their own food.

b. Consumers: Consumers are organisms that cannot manufacture their own food and get their food and nutrients from producers directly or from other organisms. They are called as '*heterotrophs*' (hetero – others; trophs – nourishing).

Consumers can be divided into primary, secondary and tertiary consumers.

1. Primary Consumers

Organisms that feed on producers (green plants) are called primary consumers. They are also called as '*herbivores*' or plant eating organisms. Examples of terrestrial herbivore are grasshopper, sheep, goats, cow, rabbit, deer, elephant etc. Examples of aquatic herbivores are zoo plankton, krill, squid, small fish, sea urchin, etc.

2. **Secondary Consumers**

   Animals that kill and eat the herbivores or plant eating animals are called secondary consumers. They are also called as '*carnivores*', Example; lion, tiger, foxes, frogs, snakes, spider, crocodiles, etc.

3. **Tertiary Consumers**

   They are top predators in a food chain. They are carnivores at the topmost level in a food chain that feed on other carnivores or secondary consumers. Example: an owl eats a snake but an owl is eaten by a hawk, therefore a hawk is a tertiary consumer. Tertiary consumers that occupy the top trophic level, and are not predated by any other animals are called '*apex predators*. However, when they die their bodies will be consumed by scavengers besides the decomposers Example; alligator and hawk.

   Some organisms eat both plants and animals. These animals are called as '*omnivores*. Example; cockroach, foxes, seagull and human.

   Some omnivores are '*scavengers*', which eat food that other animals have left behind Example; hyena and vultures.

   Plants and animals that live on or inside other plants or animals are called as *Parasites*. Example; mistletoe lives on other plants. Other examples are tapeworms, round worms, lice, ticks, flea etc.

   '*Detritivores*' are consumers that feed on detritus. Detritus includes fallen leaves, parts of dead trees and faecal wastes of animals. Ants, termites, earthworms, millipedes, dung beetle, fiddler crabs and sea cucumbers are detritivores.

4. **Decomposers:**

   Decomposers are organisms that help decompose dead or decaying organisms. Decomposers are also heterotrophs. Decomposers are nature's built-in recycling system. By breaking down materials – decomposers return nutrients to the soil. They, in turn, create another food source for producers within the ecosystem. Mushrooms, yeast, mould, fungi and bacteria are common decomposers.

Food Chain and Food Web

Every living creature in an ecosystem has a role to play. Without producers, the consumers and decomposers would not survive because they would have no food to eat.

Without consumers, the populations of producers and decomposers would grow out of control. And without decomposers, dead producers and consumers would accumulate as wastes and pollute the environment.

All organisms of an ecosystem depend on one another for their survival. Each organism living in an ecosystem plays an important role in the flow of energy within the system. Organisms need energy for respiration, growth, locomotion, and reproduction. This movement of energy is usually understood through food chains or food webs. While a food chain shows one path along which energy can move through an ecosystem, food webs show all the overlapping ways that organisms live with and depend upon one another.

A. Food Chain

A food chain describes the flow of food in an ecosystem. This flow or feeding structure in an ecosystem is called '*trophic structure*'. Each level in this structure is called a trophic level. A food chain starts the movement of energy from one trophic level to the next (Figure 7.3). Example; Plant (primary producer) is eaten by a rabbit (herbivores, primary consumer), rabbit is eaten by a snake (carnivores, consumer or primary carnivore) and the snake is eaten by a hawk (tertiary consumer).

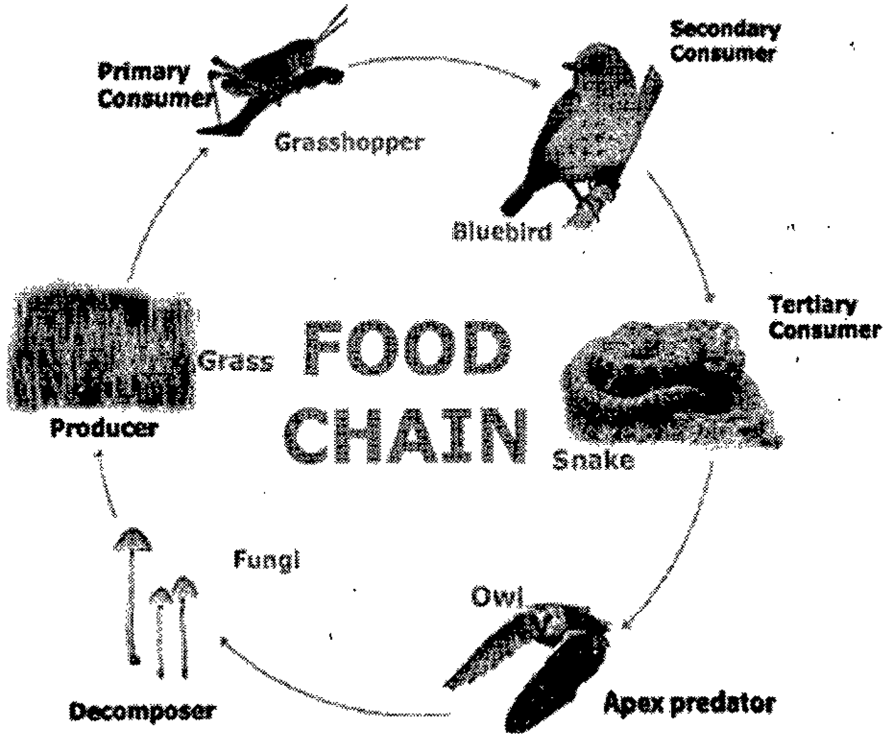


Figure 7.3 Food Chain

Food Web

A Food Web is a complex network of interconnected food chains. Food chains show a direct transfer of energy between organisms.

A chain might involve a mouse eating some seeds on the forest floor, a snake eating the mouse and later an eagle eating the snake.

With each step, some of the energy from the sun, which is trapped within the seeds, is getting passed on.

In a food web, the mouse might eat seeds, but it also might eat some grains, or maybe even some grass. The mouse might be eaten by a snake, or the eagle, or even a fox. The snake could be eaten by the eagle, but also might be eaten by a fox in the forest.

Since each organism can eat multiple organisms and be eaten by multiple organisms, a food web is a much more realistic scheme of the transfer of energy within an ecosystem (Figure 7.4).

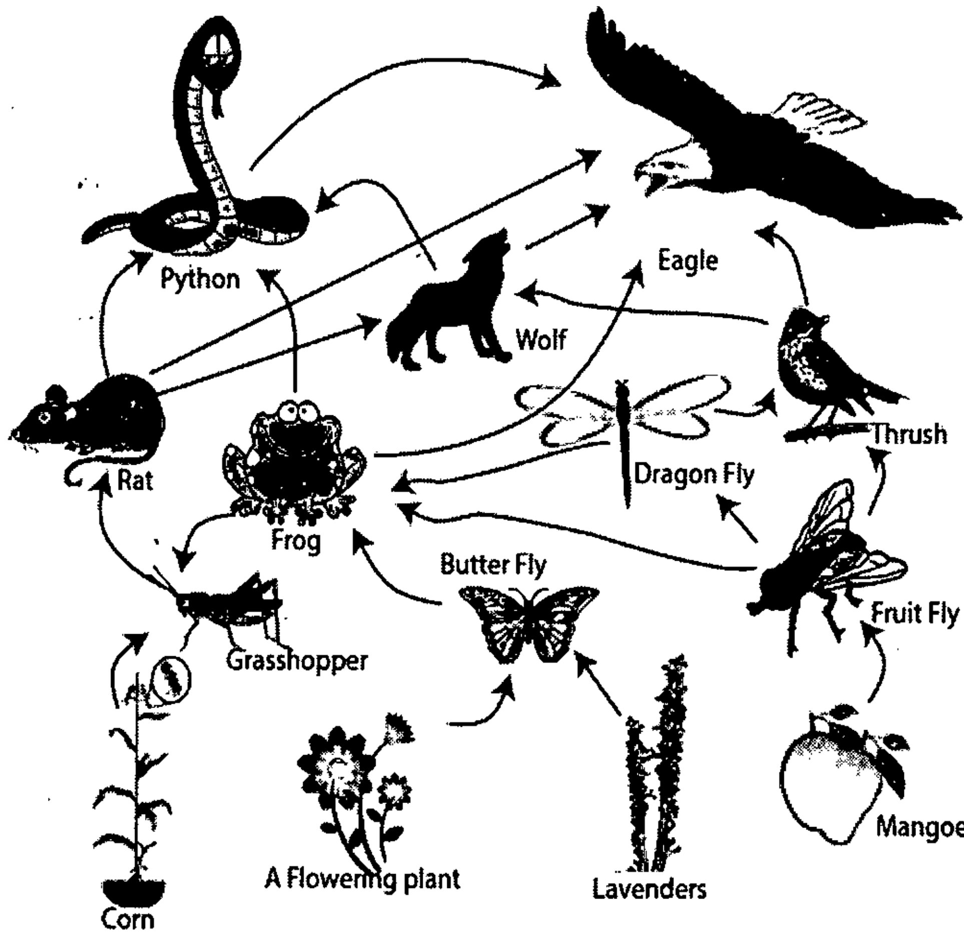


Figure 7.4 Food web

Food chains and food webs are found in both terrestrial and aquatic ecosystems.

Organisms in a food chain or food web are linked and dependent on one another for survival. If organisms in one trophic level become threatened, it impacts the organisms in other trophic levels. Primary consumers get less food due to loss or destruction of habitat.

This in turn means fewer primary consumers for secondary and tertiary consumers to feed on.

The plant and animal species in such an environment could become endangered or even extinct. For this reason, it is vital that an ecosystem remains balanced containing an appropriate proportion of producers and consumers.

Energy Flow in an Ecosystem

Energy in an ecosystem flows from producers to consumers. The available energy in a food chain decreases with each step or trophic levels up in the food chain. As such, there is less energy available to support organisms at the top of the food chain. That is why the tertiary and quaternary consumers are far less in number in an ecosystem than organisms at lower trophic levels.

Energy Pyramids

Energy pyramids are another tool that ecologists use to understand the role of organisms within an ecosystem. As you can see, most of the energy in an ecosystem is available at the producer level. As you move up on the pyramid, the amount of available energy decreases significantly. It is estimated that only about 10% of the energy available at one trophic level gets transferred to the next level of the energy pyramid. The remaining 90 percent of energy is either utilized by the organisms within that level for respiration and other metabolic activities or lost to the environment as heat.

The energy pyramid shows how ecosystems naturally limit the number of each type of organism it can sustain (Figure 7.5).

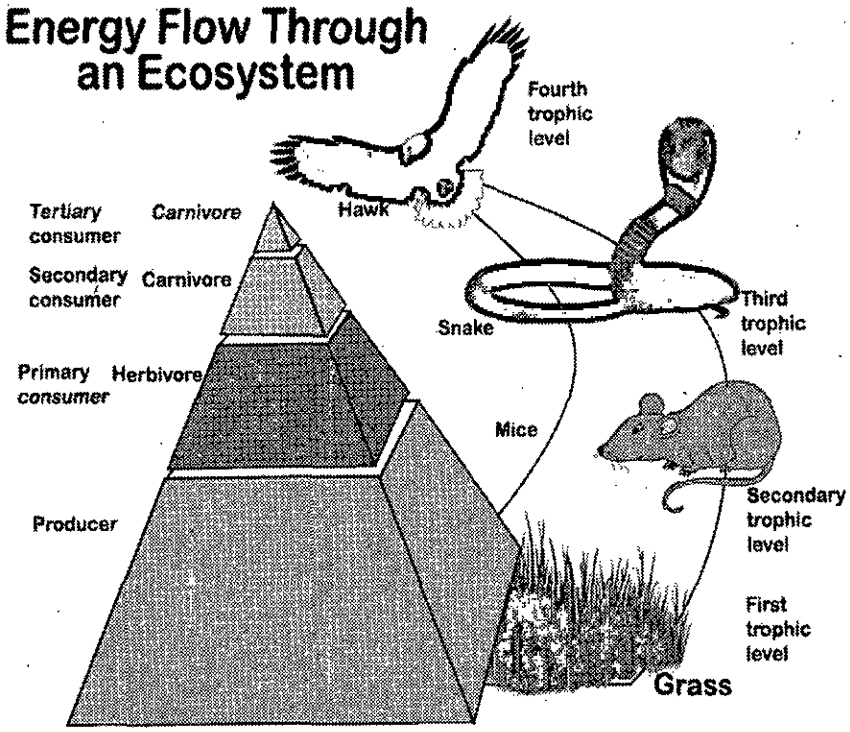


Figure 7.5 Energy Pyramid

Cycles in an Ecosystem

Nutrients move through the ecosystem in cycles is called *'biogeochemical cycles.* A biogeochemical cycle is a circuit or pathway by which a chemical element moves through the biotic and the abiotic components of an ecosystem. All life processes are associated with the atmosphere by important cycles such as the Carbon, Oxygen, Nitrogen cycles etc. Through these cycles energy and materials are transferred, stored and released into various ecosystems. Let us discuss one of biogeochemical cycles in detail - the Carbon cycle.

The Carbon Cycle

Carbon is exchanged, or cycled among all the spheres of the earth. All living organisms are built of carbon compounds. It is the fundamental building block of life and an important component of many chemical processes. Living things need carbon to live, grow and reproduce. Carbon is a finite resource that cycles through the earth in many forms.

Carbon is an essential element in all organic compounds and since there is only a limited amount available it must be recycled continuously. This takes place in the biosphere. Atmospheric carbon is fixed in green plants through photosynthesis.

This carbon is passed on to other living organisms through the food chain. The carbon food compound is utilized and later released to the atmosphere through the process of respiration.

By-products of respiration are carbon-dioxide and water which are returned to the air.

A carbon cycle is completed by decomposers like bacteria and fungi which break down dead plants and animal tissues there by releasing some carbon to the air, water and soil.

All producers and consumers are not decomposed. The organic matter of some of them is preserved in fossil fuels such as coal and petroleum for millions of years.

In a carbon cycle (Figure 7.6), carbon moves between reservoirs. Carbon reservoirs include the atmosphere, the oceans, vegetation, rocks, and soil.

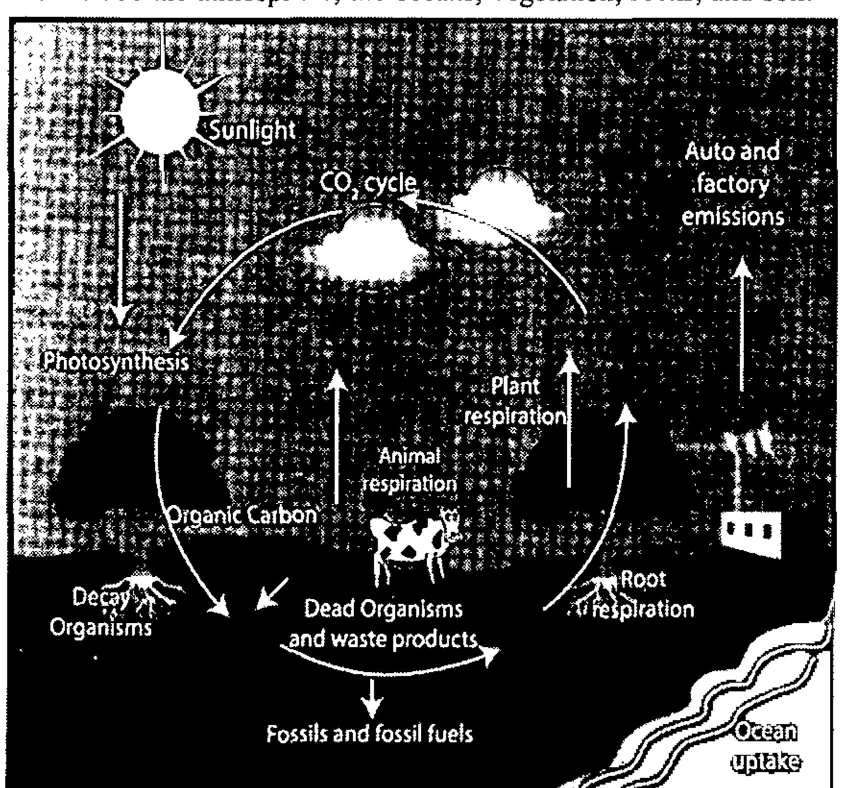


Figure 7.6 Carbon Cycle

Today, the carbon cycle is changing. Human activities have added more carbon into the atmosphere. More carbon is moving to the atmosphere when fossil fuels, like coal and oil, are burned. More carbon is moving to the atmosphere as humans destroy the forest. This increase in carbon in the atmosphere causes the earth to warm up more than the normal level, leading to climate change and many problems connected with it.

Environmental Issues

Environment is the basic life support system that provides air, water, food and land to all living organisms. But human beings degrade the environment through rapid industrialization.

Human life will be at risk if they don't live in harmony with the environment. Environmental problems are not limited to the local, regional and national level, but there are several global issues. Scientific and technological revolutions have given a lot of facilities to mankind, but at the same time it is responsible for the depletion of resources. Thus, several environmental problems have emerged. Some of the environmental issues that we are going to learn are:

- Deforestation
- Pollution such as air, water, noise, etc
- Urbanisation
- Fracking
- Waste disposal

1. Deforestation

Deforestation is the cutting down of trees permanently by the people to clear forests in order to make the land available for other uses.

Effects of Deforestation:

Deforestation results in many effects like floods and droughts, loss of soil fertility, air pollution, extinction of species, global warming, spread of deserts, depletion of water resource, melting of ice caps and glaciers, rise in sea level and depletion of ozone layer.

The United Nations Conference on Environment and Development (UNCED) by name Earth Summit Conference held at Rio de Janeiro, Brazil, on June 1992 concluded that all member countries should reduce their emission of carbon dioxide, methane and other greenhouse gases thought to be responsible for global warming.

Conservation of forests

(i) Conservation of forests can be done through the **regulation of cutting of trees**.

(ii) **Control over forest fire:** Through regular monitoring and controlling the movement of the people forest fire can be prevented.

(iii) **Reforestation and afforestation:** Reforestation involve the replanting or regeneration of areas of forest which have previously been damaged or destroyed. Sometimes forests are able to regenerate naturally. Afforestation is the process of planting trees or sowing seeds on barren land devoid of any trees to create a forest.

The term afforestation should not be confused with reforestation, which is the prlocess of specifically planting native trees into a forest that has decreasing number of trees. While reforestation is increasing the number of trees of an existing forest, afforestation is the creation of a new forest.

(iv) **Proper use of forest products:** We depend on forests for our survival from the air we breathe, to the wood we use. Besides providing habitats for animals and livelihoods for humans, forest products are one of the most essential things in our day to day life. Therefore, we must use forest products properly.

(v) **Sustainable forest management:** The use of forest and forest lands in a way and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil the global levels should not cause damage to other eco systems.

Forest Management seeks to achieve a balance between the society's increasing demands for forest products, its benefits and the preservation of forest health and diversity too. This balance is critical to the survival of forests and to the prosperity of forest dependent communities.

2. Pollution

Environmental pollution occurs when pollutants contaminate the natural surroundings. Pollution disturbs the balance of our eco system affecting our normal life styles and gives rise to human illnesses and global warming. The word 'pollute' means to degrade or to make dirty. Pollution is thus, an unfavourable modification of the natural world, caused entirely or partly due to direct or indirect actions of human beings.

There are many types of pollution degrading the environment. They are

A. Air pollution
B. Water pollution
C. Land pollution
D. Noise pollution
E. Light pollution

A. Air pollution

Due to some human activities or natural processes, the amount of solid wastes or concentration of gases, other than oxygen increases in air. Air thus becomes polluted and this process is called air pollution.

The pollutants are generally grouped as natural and manmade. The natural pollutants are volcanic eruptions, wind erosion, pollen disposal, evaporation of organic compounds and radioactive elements etc., Natural air pollution does not occur in abundance and also creates a little impact on the environment.

But, manmade pollutants like vehicular emission, industrial wastes, smoke from thermal power plants and refineries badly affect the environment. The main pathological effects caused by air pollutants, particularly oxides of sulphur, nitrogen and carbon-di- oxide, include respiratory disorders, jaundice, irritation of eyes and throat, headache, cancer and even death.

Greenhouse effect

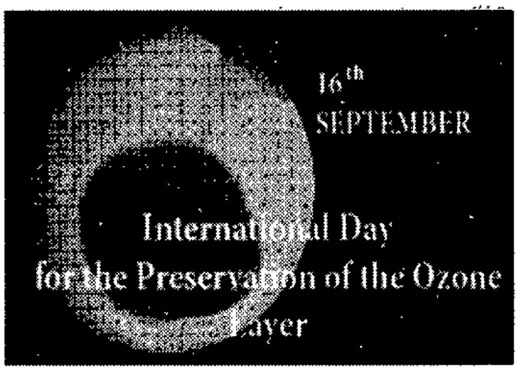
Global warming is caused by the increase of greenhouse gases such as carbon dioxide, methane, water vapour and Chloro Fluoro Carbons (CFC), carbon monoxide, photo chemical oxidants and hydrocarbons, which are responsible for the heat retention ability of the atmosphere. Global warming causes climatic change, ozone layer depletion, rise in sea level and drowning of coastal inhabited land, melting of ice, etc., They are posing an even greater threat to human existence and so, man must start thinking of protecting the environment from pollution.

Acid Rain

When pollutants combine with water vapour in the presence of sunlight and oxygen, they form dilute sulphuric and nitric acids in the atmosphere. When this mixture precipitates from the atmosphere, it is called acid rain. The gases that cause acid rain are sulphur-di-oxide, nitrogen oxides, carbon-di-oxide and other minute bio-products, caused by the burning of fossil fuels.

Ozone Depletion

Ozone layer is depleted by the pollutants like CFCs, HFCs, methyl bromide, etc. Due to the depletion of ozone layer, UV rays fall on the earth's surface, warming the earth surface and leads to impervious diseases like skin cancer, blindness, loss of plankton etc.,

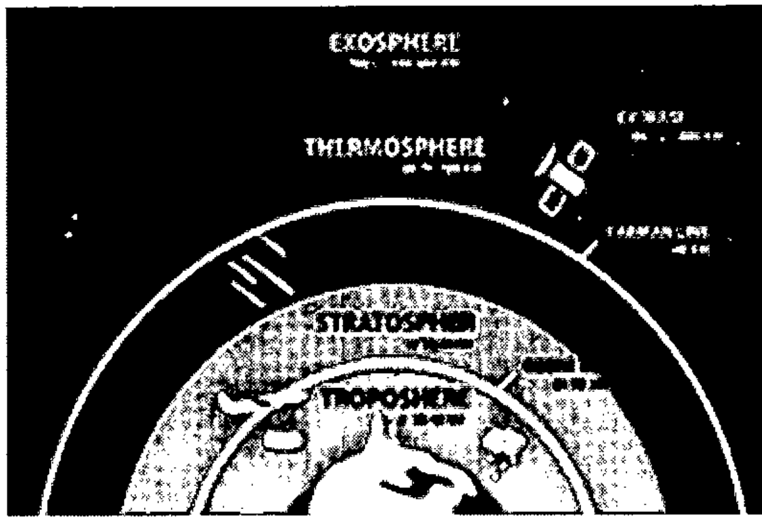


Ozone layer

Ozone is a poisonous gas made up of molecules consisting of three oxygen atoms (O3). This gas is extremely rare in the atmosphere, representing just three out of every 10 million molecules.

The ozone layer is not really a layer at all, but has become known as such because most ozone particles are scattered between 19 and 30 kilometre up in the earth's atmosphere, in a region called the stratosphere.

Ozone layer in the atmosphere absorbs most of the harmful ultraviolet radiation from the sun. It also screens out the deadly UV-C radiation the ozone shield is this essential to protect life.



B. Water Pollution

Water pollution is any chemical, physical or biological change in the quality of water that has a harmful effect on any living thing that drinks or uses or lives in it. The water bodies including ponds, lakes, rivers, ground water and oceans are contaminated by the chemical wastes from industries, domestic wastes and sewage etc.

Major water pollutants

(a) The disease – Causing agents; bacteria, viruses, protozoa and parasitic worms that enter sewage – systems and untreated waste.

(b) Oxygen demanding bacteria: Wastes that can be decomposed by oxygen requiring bacteria.

(c) Water soluble inorganic pollutants: Acids, Salt and toxic metals.

(d) Organic compounds: Oil, plastics and pesticides in the water.

Our role in conserving water;

1. Do not dump in or around rivers. Clean up rivers that have a lot of trash in and around them.
2. Never dispose of cooking fats and oils by pouring them down the sink.
3. In the bathroom, take short showers and draw less water for baths. When you buy a new toilet, purchase a low flow model (1.6 gallons or less per flush). Check your toilet for "silent" leaks by placing a little food colouring in the tank and see if it leaks into the bowl.
4. Turn off water while brushing teeth, washing, gardening and shaving.
5. Keep a gallon of drinking water in the refrigerator, rather than running the tap for cold water. Run your washing machine with a full load of clothes. Wash with warm water instead of hot water, rinse with cold water instead of warm water.

Causes of Water Pollution

Main pathological problems caused due to water pollution include diarrhoea, liver cirrhosis, lung cancer, kidney diseases, paralysis, chronic pain, bone deformities, cancer and even death and so on.

C. Land Pollution

Land pollution is contaminating the land surface of the earth through dumping of urban waste matter. It arises from the breakage of underground storage tanks, application of pesticides and percolation of contaminated surface water, oil and fuel dumping, leaching of wastes from landfills or direct discharge of industrial wastes to the soil.

Preventive Measures

1. Things used for domestic purposes can be reused and recycled.
2. Organic waste matter should be disposed of far away from the settlements.
3. Inorganic wastes can be separated, reclaimed and recycled.

D. Noise Pollution

Noise pollution is basically a problem of urban areas, industrial areas, transport areas due to bombardment, traffic etc. It has an impact on the habitat of animal's migration and health of inhabitants. E.g. Chandipur Missile Launching Centre has created migration of sea birds. Hearing loss, hypertension, stress and mental illness are the major health hazards that human beings face.

The control measures of noise pollution

1. Development of green belt vegetation.
2. Installation of decibel meters along highways and in places of public gatherings.
3. Planting trees along the compound wall to protect houses. resources, wildlife, humans and astronomy research.

LOUDSPEAKER PROHIBITION:

The major cause of noise pollution in public areas are loudspeakers. For the welfare of the people it should be banned at any cost. Those who violate and play loudspeakers in crowded areas and public places strict laws should be imposed against them.

Write your opinion on the prohibition act.

E. Light pollution

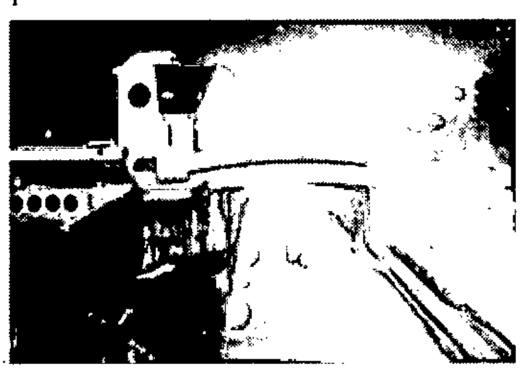
Light pollution is an unwanted consequence of outdoor lighting and includes such effects as sky glow, light trespass and glare. It is caused by streetlights, parking lot lights, floodlights, signs, sports field lighting decorative and landscape lights. It affects the environment, energy resources, wildlife, humans and astronomy research.

3. Urbanisation

Urbanisation refers to the process of increase in urban population and urban areas in a country.

Problems of urbanisation

As the town expands, it mounts more pressure on transport system, water supplies, sewage and profuse disposal. The overall development creates problems like air pollution, water pollution, traffic congestion and noise pollution etc., This disturbed environment affects the human beings as mental illness, heart troubles, breathing problems etc.

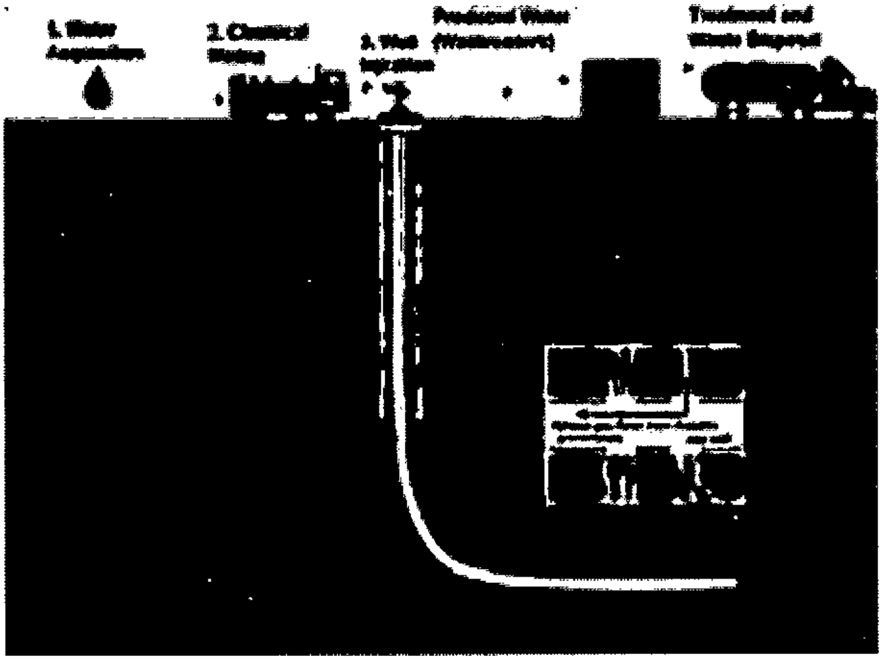


4. Fracking

The modern technology applied to extract oil and gas while fracturing the rocks artificially with the use of pressurized liquid is called fracking. Fracking fluid is a mixture of water, sand and thickening agents. The first successful implementation of the process was done in 1950.

Methane is one of the most important chemicals used in fracking process. It is estimated that four percent of methane escapes into the atmosphere during extraction.

Methane is 25 times stronger than carbon di- oxide in terms of trapping heat. The spills of this gas is detrimental to the air quality of the surrounding fracking sites. Pollutants decrease the availability of clean air for workers and local residents.



Other Environmental Concerns

Fracking not only pollutes water and air but also pollutes the soil. The oil spills during fracking can harm the soil and the surrounding vegetation. The use of high pressure at the time of oil extraction and the storage of waste water on site may cause earthquakes.

5. Waste disposal

Things become waste when their purpose of consumption is over. Wastes can be classified into five types, which are commonly found around the house. These include liquid waste, solid rubbish, organic waste, recyclable rubbish and hazardous waste like e-waste.

How to dispose of waste:

- Do not litter your surroundings. Use a proper waste bin to store your wastes.
- People should practise to segregate degradable and non-degradable wastes and should dispose them in proper coloured bins. Wastage is generally classified into three types. They are

Wet Waste: which comes from the kitchen/ cooking/food, etc.

Dry Recyclable Waste: such as newspapers, cardboard, packing plastics, bottles, cans, etc., should go to a different bin.

Rejected Waste: which does not belong to the above two categories, including bio waste like diapers and bandages, etc.

Sewage sludge is produced by waste water treatment processes. Due to rapid urbanization, there has been an increase in municipal waste water. Common disposal practices of sewage should be sent to sewage treatment plant through proper drainage pipes.

Electronic Waste (e-waste): It can be defined as any electrical goods, devices or components that you no longer want or have already thrown away. For example, computers, televisions, mobiles and fax machines.

This waste can take many years to break down, if at all and can contain toxic chemicals such as mercury, lead and lithium that leach into the ground and cause illness. Even short- term exposure to high levels of lead can result in vomiting and diarrhoea. Instead of sending e-waste to the dump, components from electronics can be reused to make new products.

EXERCISE

Multiple Choice Questions

1. Which of the following is a greenhouse gas?
   (a) Nitrogen dioxide
   (b) Sulphur dioxide
   (c) Carbon dioxide
   (d) Carbon monoxide
2. Floods can be prevented by
   (a) Afforestation
   (b) Removing top soil
   (c) Deforestation
   (d) Agriculture
3. Narmada bachao andolan was to
   (a) Clean narmada
   (b) Expand narmada
   (c) Save narmada
   (d) None of above

4. Which of the following is best method from environment point of view?
   (a) Reduce
   (b) Recycle
   (c) Reuse
   (d) All of above
5. The full form of UV rays is
   (a) Ultra violet
   (b) Ultra-violent
   (c) Ultra-valve
   (d) Ultimate violet
6. Synthetic material/ chemical which depleted Ozone layer is
   (a) CFCs
   (b) CFLs
   (c) CO_2
   (d) None of above
7. What is coliform?
   (a) Group of bacteria
   (b) Group of viruses
   (c) Group of microorganisms
   (d) Group of diseases
8. What is the name given for replenishment of forest?
   (a) Afforestation
   (b) Silviculture
   (c) Deforestation
   (d) Sericulture
9. Why should we conserve forest and wild life?
   (a) To protect biodiversity
   (b) To maintain ecosystem
   (c) To maintain balance
   (d) To continue food chain
10. Water harvesting is a method which
   (a) Increase ground water level
   (b) Not practiced in modern days
   (c) Has no relation with ground water
   (d) Decrease ground water level

ANSWERS

1. (c) **2.** (a) **3.** (c) **4.** (d) **5.** (a) **6.** (a) **7.** (a) **8.** (a) **9.** (b) **10.** (a)

HOTS

1. Define biodiversity.
2. Name the bacteria whose presence in the water indicates its contamination with disease causing microbes.

3. Name the place where Chipko Andolan organized.
4. Name the gas responsible for global warming.
5. Who started Chipko Movement?
6. Why do we need to use resources carefully?
7. Prejudice against the traditional use of forests has no basis. Comment.
8. Which is better recycle or reuse? Give reason with example.
9. Give three measures that can lower the use of coal and petroleum.
10. What is rain water harvesting? How can it be done at local level? What are the benefits?

Space for Notes

Theme: Natural Resources
Unit V: Natural Resources

12 WASTE MANAGEMENT

Human activities related to livelihood and welfare generate waste. All wastes are pollutants and they create pollution in one way or other. Fundamentally air, land and water pollution results mostly due to improper disposal of wastes.

Classification of wastes

1. **Bio - degradable waste**

   These are wastes capable of being removed or degraded by biological or microbial action. Waste from agricultural products, animal wastes and waste from food processing, leather, fibre, paper and wood etc. come under this group.

2. **Non bio-degradable waste**

   The substances which are normally not acted upon and decomposed by microbes are non-bio degradable wastes. It includes mineral waste, mining waste and industrial waste and non-degradable metallic and plastics substances.

3. **Mixture of biodegradable and non-biodegraded wastes**

   It includes municipal waste and industrial waste. Municipal waste contains household garbage, piles of food scrapes, old newspaper, discarded and throw away materials, glass, cans, old appliances, broken materials, leather shoes, fibres, plastics and others. Construction waste materials, packaging materials, sewage, hospital waste, junk and vehicles are varied types of urban wastes. All these wastes are found in the form of semisolid, solid, semiliquid, sludge and in fly ash form.

Management of hazardous wastes

Hazardous wastes may remain dangerous for thousands of years. The hazardous waste includes radioactive refuse, metallic compounds, organic solvents, acid asbestos, organic cyanides, pathological hospital wastes, disposable medical equipment's and tools.

The following methods are adopted for the disposal of hazardous wastes.

1. **Landfills:** There are permanent storage facilities for military related liquid and radioactive waste materials in secured lands. High level radioactive wastes are stored in deep underground storage.

   Wastes are carefully contained to prevent cross - mixing of reactive substances. The land fill is capped with impervious clay to prevent infiltration and percolation of water through the fill. Fill bottom is lined and provided with drainage system to contain and remove any leakage that occurs. Monitoring the wells provides a final check.

2. **Deep - well injection:** It involves drilling a well into dry, porous material below groundwater. Hazardous waste liquids are pumped into the well. They are soaked into the porous material and made to remain isolated indefinitely. However, fractures in the impermeable layer may permit the injected wastes to escape and contaminate ground water.
3. **Surface impoundments:** This method is used to dispose large amounts of water carrying relatively small amounts of chemical wastes. Surface impoundments are simple excavated depressions (ponds) into which liquid wastes are drained. Solid wastes settle and accumulate while water evaporates. If the pond bottom is well sealed and if evaporation equals input, wastes may be stored in the impoundment indefinitely.
4. **Incineration:** The hazardous biomedical wastes are usually disposed of by means of incineration. Human anatomical wastes, discarded medicines, toxic drugs, blood, pus, animal wastes, microbiological and biotechnological wastes etc are called **Bio-medical wastes**.
5. **Bioremediation:** This is another rapidly developing clean up technology. Cleaning the environment with biological options such as microbes and plants is called bioremediation. Some naturally occurring bacteria and other microorganisms have the capability to degrade or absorb or detoxify the wastes such as heavy metals. Many plant materials are successfully used as adsorbents for xenobiotics (phytoremediation). Genetically Engineered Microorganisms (GEMS) are currently produced in large scale to remove the hazardous radionuclides and heavy metals such as mercury, chromium, cadmium etc. Certain plants such as *Gibberella fusarium* were able to breakdown cyanide and reduce it to a non-toxic form. The bacteria *Pseudomonas,* nicknamed as 'super - bug' are capable of degrading variety of toxic compounds and also degrade oil.

Management of non-hazardous wastes- Solid Waste Management

1. **Sanitary landfills:** The refuse is spread in a hollow land or in a trench and compacted with a layer of clear sand fill. The sanitary landfills are far more desirable than open dumps but the ground water contamination is always a potential problem. Once a land fill operation has been completed the site must be inspected periodically. This land fill is suitable for recreational activities such as parks and play ground.
2. **Incineration:** Municipal incinerators burn combustible solid waste and melt certain non-combustible materials. Since the high temperature destroys pathogens and their vectors, it is a good method of disposal from health

point of view. The incineration can reduce the volume of solid waste by 80 to 90 percent.

3. **Reuse and recycling techniques:** Resource recovery is a broad term that is used for the retrieval of valuable materials or energy from a waste. The separating out of materials such as rubber, glass, paper and scrap metal from refuse and reprocessing them for reuse is named as reclamation of waste or recycling.

Paper (54% recovery) can be repulped and reprocessed into recycled paper, cardboard, and other paper products; finally ground and sold as cellulose insulators or shredded and composted.

Glass (20% recovery) can be crushed, remelted and made into new containers or crushes used as a substitute for gravel or sand in construction materials such as concrete and asphalt.

Some forms of plastics (2.2 % recovery) can be remelted and fabricated into carpet fibre, fill for insulated apparel, irrigation drainage, tiles and sheet plastics.

Metals can be melted and refabricated (39% recovery).

Food wastes and yard wastes (leaves, grass etc.) can be composted to produce humus soil conditioner.

Textiles can be shredded and used to strengthen recycled paper products.

Old tyres can be remelted or shredded and incorporated into highway asphalt.

Waste water treatment and management

The main steps in typical water - treatment plants are coagulation, settling and filtration to remove suspended particles, aeration to remove the volatile substances most responsible for taste and odour, and chlorination to kill pathogenic organisms.

For the treatment of sewage, **primary treatment** consists of mechanical filtration, screening, and settling, followed by chlorination. It removes 50 to 65% of the suspended solids.

In **secondary treatment** the organic wastes are transformed by bacteria in the treatment plant, where oxygen is provided by aeration, instead of depleting dissolved oxygen in the receiving waters. The sludge from this process, consisting largely of bacterial masses, is concentrated and processed further in an anaerobic digester.

Definition of Biodegradable

The degradation or decomposition refers to the substances that get decay with the help of natural agent such as microorganisms, air, water, soil, sunlight, ozone, etc. into the organic manure. Further, these organic matters are profitable to the environment in some, or the other way is known as biodegradable substances.

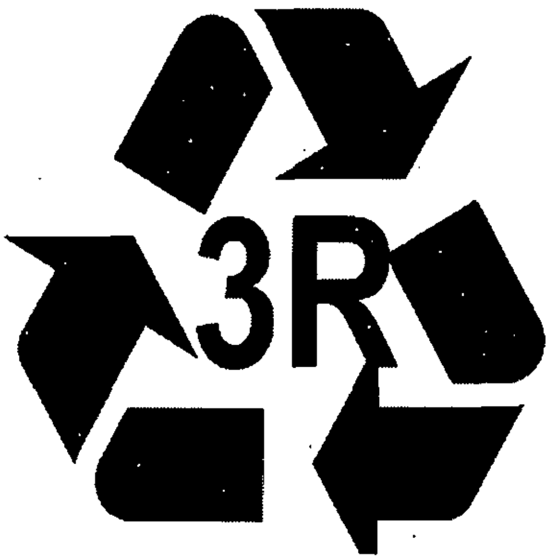
These materials are non-toxic to the environment and mainly include the natural substances only. Plants and animals waste, even the dead plants and animals, fruits, paper, vegetables, etc. get convert into the simpler units, which further get into the soil and are used as manures, biogas, fertilizers, compost, etc. They are non-toxic, non-pollutants, eco-friendly to the environment.

Nowadays, an emphasis is given to using biodegradable and eco-friendly items as much as possible to reduce the level of pollution and substance responsible for it. This will also contribute to reducing the pollution up to some level, which is becoming one of the major problems worldwide and is hazardous to every living being.

Definition of Non-biodegradable

Materials that remain for a long time in the environment, without getting decompose by any natural agents, also causing harm to the environment are called non-biodegradable substances. These materials are metals, plastics, bottles, glass, poly bags, chemicals, batteries, etc.

But as these are readily available, convenient to use, and are of low cost, the non-biodegradable substances are more often used. But instead of returning to the environment, they become solid waste which cannot be broken down and become hazardous to the health and the environment. Hence are regarded as toxic, pollution causing and are not considered as eco-friendly.



Many measures are taken these days, concerning the use of non-biodegradable materials. The three 'R' concept which says Reduce-Recycle -Reuse is in trend, which explains the use of the non-biodegradable materials. As we already discuss that these substances do not decompose or dissolve easily so can be recycled and reuse. And one can help in reducing this waste by instead of throwing the plastics and poly bags in the garbage; it can be put in the recycling bags to use again.

Comparison Chart

BASIS FOR COMPARISON	BIODEGRADABLE SUBSTANCES	NON-BIODEGRADABLE SUBSTANCES
Meaning	The wastes that decompose naturally in the environment and are considered safe for the environment are called as biodegradable substances.	Such wastes which do not decompose naturally in the environment causes pollution and are also harmful to the living being are called the non-biodegradable substances.
Examples	Dead plants and animals, their waste, fruits, vegetables, flowers, paper, etc.	Chemicals, paints, plastic, rubber, toxic, plastic, metals, etc.
The rate of decomposition	High.	Slow.
Decomposed by	Bacteria, fungi, and other living organisms have the capability of decomposing the material into the soil.	These substances do not degrade easily or by the action of natural agents.
Use	After degradation, they can be used to produce biogas, manure, fertilisers, compost.	As their degradation rate is slow and the separation and recycling are not easy and expensive too.
	Biodegradable substances are not harmful to the environment.	They are harmful to the environment.

Summary of the Chapter

Environment: Our surrounding is called environment. Note:

1. Living and non-living present in environment.
2. They are dependent each other.

Living Thing: Organisms that can ability to grow, reproduce, take in and use energy, excrete waste, respond to the environment, and possess an organized structure

These are three types:

1. **Producers (Autotrophs):** Organisms which produce their own food, e.g. Plants.
2. **Consumers:** Organism which depend on other organisms for food, e.g. Lion, Elephant and Human etc.

These are three types:

1. **Herbivores:** Eat only plants e.g. Deer, Elephant and Cow etc.
2. **Carnivores:** Eat only other animals e.g. Lion, Snake etc.
3. **Omnivores:** Eat both plants and animals e.g. Humans, Crow etc.

Key Words:

- Environment
- Ecosystem
- biodegradable pollutant.

EXERCISE

Multiple Choice Questions

1. Which of the following is a biodegradable substance?
   (a) Glass
   (b) Plants
   (c) Plastics
   (d) Polythene
2. Which of the following is a non-biodegradable substance?
   (a) Virgin plastic
   (b) Plastic
   (c) Plants
   (d) Plant producers
3. The constituents which do not form eco-system are
   (a) Biotic constituents
   (b) Plastic bags
   (c) Abiotic constituents
   (d) All of these
4. The functional unit of environment is
   (a) Ecosystem
   (b) Nitrogen
   (c) Carbon
   (d) Oxygen
5. Which of the following is an example of producers?
   (a) Plastic pens
   (b) Plastic cans
   (c) Polythene
   (d) Green plants
6. Which of the following is an example of herbivores?
   (a) Cow
   (b) Shark
   (c) Lion
   (d) Tiger

7. Which of the following is not example of abiotic factors?
   (a) Light
   (b) Plants
   (c) Heat
   (d) Temperature
8. _______ is not a biodegradable pollutant.
   (a) Paper
   (b) Cotton cloth
   (c) Cotton
   (d) DDT
9. Which of the following is terrestrial ecosystem?
   (a) A natural forest
   (b) A lake
   (c) A pond
   (d) An aquarium
10. _______ is an omnivore animal.
    (a) Lion
    (b) Hawk
    (c) Jackal
    (d) Man
11. The formula of Ozone is _______
    (a) O_3
    (b) O_2
    (c) O_4
    (d) O_6
12. The number of atoms of oxygen present in ozone are
    (a) 3
    (b) 4
    (c) 2
    (d) 1

ANSWERS

1. (b)	**2.** (b)	**3.** (b)	**4.** (a)	**5.** (d)	**6.** (a)
7. (b)	**8.** (d)	**9.** (a)	**10.** (d)	**11.** (a)	**12.** (a)

Review Questions

1. What is bad ozone?
2. Differentiate between natural and artificial ecosystem.
3. Why are plastic bags non-biodegradable?
4. Name two decomposers and two producers.
5. Why are pesticides considered as pollutants despite being useful to the farmers?
6. Name two artificial eco-system.
7. What is the role of consumers in the food chain?
8. Give one advantage and one disadvantage of ozone.

9. What is an ecosystem? Mention its components.
10. Difference between biodegradable and non-biodegradable substance.
11. Why are green plants called producers?
12. What are the two main components of our environment?

Space for Notes

BOARD OF OPEN SCHOOLING AND SKILL EDUCATION
Near Indira Bypass, NH-10, Gangtok, East Sikkim- 737102
Telephone : 03592-295335, 94066 46682 Email : bosse.org.in