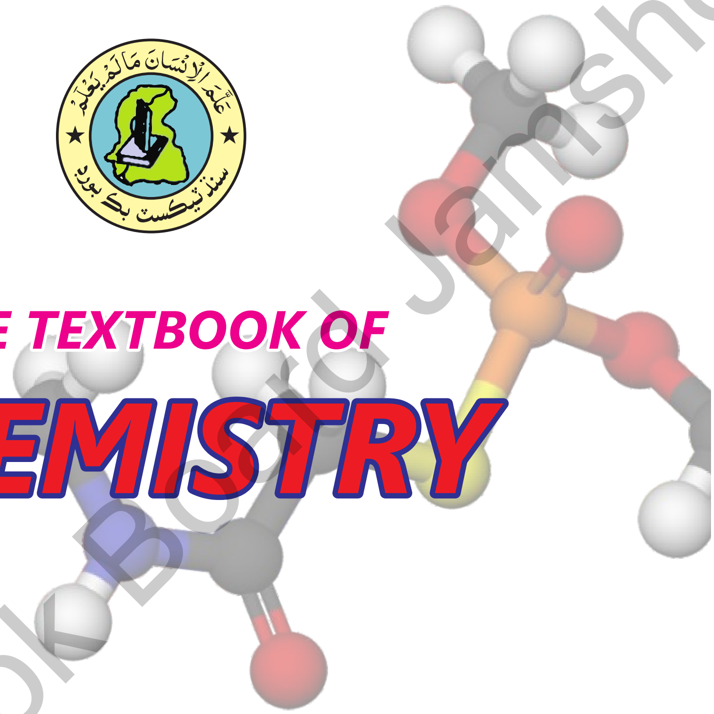
TEST EDITION

THE TEXTBOOK OF

CHEMISTRY



For Class - X

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AUTHORS
- Dr. Aftab Ahmed Kandhro
- Dr. Mazhar Iqbal
- Mr. Hanif Durrani
- Ms. Parveen Arain
- Mr. Mir Muhammad

REVIEWERS
- Prof. Dr. Aftab Ahmed Kandhro
- Mr. Muhammad Hanif Khan
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Editor
- Naresh Kumar Shivani
- Anwar Ali Chandio

Technical Assistance & Coordination
- Mr. M.Arslan Shafaat Gaddi

Composing Designing & Illustration
- Muhammad Arslan Chauhan

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PREFACE

The century we have stepped in, is the century of Science and Technology. The modern disciplines of Chemistry are strongly influencing not only all the branches of science but each and every aspect of human life.

To keep the students abreast with the recent knowledge; it is must that the curricula at all the levels be updated. Moreover regularly by introducing the rapid and multidirectional development taking place in all the branches of Chemistry.

The recent book of Chemistry for class X has been written in this preview and in accordance with the revised curriculum. Prepared by Ministry of Education, Govt of Pakistan, Islamabad. Reviewed by independent team of Directorate of Curriculum, Assessment and Research Jamshoro Sindh. Keeping in view the importance of Chemistry, the topics have been revised and re-written according to the need of the time.

Among the new editions the introductory paragraphs, information boxes, summaries and a variety of extensive exercises have been included. Which I think will not only develop the interest but also add a lot to the utility of the book.

The Sind Textbook Board has taken great pains and incurred expenditure in publishing this book inspite to its limitations. A textbook is indeed not the last word and there is always room for improvement. While the authors have tried their level best to make the most suitable presentation, both in terms of concept and treatment. There may still have some deficiencies and omissions. Learned teachers and worthy students are therefore requested to be kind enough to point out the short comings of the text or diagrams and to communicate their suggestions and objections for the improvement of the next edition of this book.

In the end, I am thankful to Association for Academic Quality (AFAQ), our learned authors, editors and specialist of Board for their relentless service rendered for the cause of education.

Chairman
Sindh Textbook Board

CONTENT

Chapter 1

Chemical Equilibrium

Time Allocation

Teaching periods = 12
Assessment period = 02
Weightage = 12%

MAJOR CONCEPTS:

1.1 Reversible Reaction and Dynamic Equilibrium.
1.2 Law of Mass Action and Derivation of the expression for the Equilibrium Constant.
1.3 Equilibrium constant and Its Units.
1.4 Importance of Equilibrium Constant.

STUDENTS LEARNING OUT COMES (SLO'S)

Students will be able to:

- Define chemical equilibrium in terms of reversible reaction. (Understanding)
- Write both forward and reverse reaction and describe macroscopic characteristics of each reaction. (Applying)
- Define law of Mass action. (Understanding)
- Derive an expression for equilibrium constant and its unit. (Applying)
- State necessary conditions for equilibrium and the ways that equilibrium can be recognized. (Understanding)
- Describe equilibrium constant (Kc) equation for a reaction. (Remembering)

Introduction:

You know that many physical and chemical changes are occurring in our surrounding which may be due to chemical reaction. In these reactions reactants are converted into one or more products. The reactions may be reversible (condensation, evaporation, freezing, melting) or irreversible (Combustion, rusting). The reversible chemical reaction never goes to completion because product reacts and reproduce reactants again and take place in forward and reverse direction. This state in which forward reaction rate and reverse reaction rate are equal known as equilibrium. Which we will discuss in detail in this chapter.

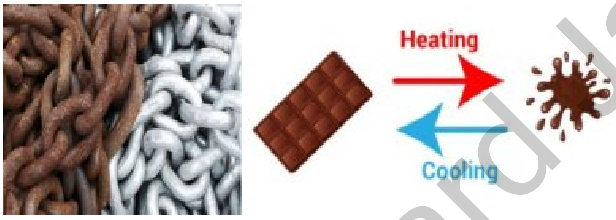


Figure 1.1 Irreversible and Reversible Changes

Do You Know?

Equilibrium in our Body

Equilibrium is present in our bodies. Hemoglobin is macromolecule that transports oxygen around our bodies. Without it we would not survive. The haemoglobin has to be able to take up oxygen, but also to release it and this is done through changes in the chemical equilibrium of this reaction in different places in our bodies.

1.1 Reversible reaction and Dynamic Equilibrium

As we know that a reaction which never complete and exist in forward and reverse direction such as conversion of ice into water by melting and conversion of water into ice by freezing is an example of reversible reaction. As shown in figure 1.2.

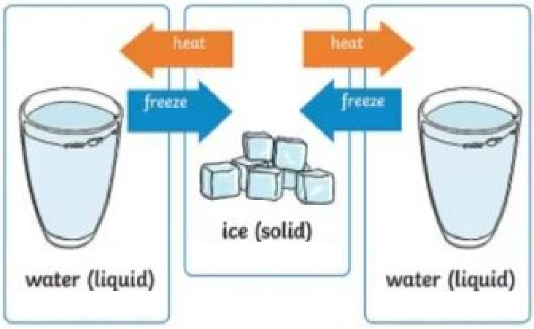


Figure 1.2 Changing of state by reversible reaction

A chemical reaction is a chemical change which involve reactants and products. For example, formation of water from hydrogen gas and oxygen gas, decomposition reaction of sodium bicarbonate into sodium carbonate , water, and carbon dioxide etc. A chemical reaction contains two quantities; reactant and product which are separated by an arrow.

$$\underset{\textbf{REACTANT}}{\underset{\downarrow}{2NaHCO_3}} \longrightarrow \underset{\textbf{PRODUCT}}{\underset{\downarrow}{Na_2CO_3 + CO_2 + H_2O}}$$

The direction of a reaction can be predicted by type of arrow; single headed arrow (→) used for irreversible reactions and a double half headed arrows (⇄)are used for reversible reaction, that never goes to completion. A reversible reaction containing two processes; forward and reverse. Hence, a reversible reaction can move in either direction depends upon conditions.

Figure 1.3
The original laboratory apparatus designed by Fritz Haber and Robert Le Rossignol in 1908 for synthesizing ammonia

Let us take an example of manufacturing of ammonia.When one mole of nitrogen gas reacts with three moles of hydrogen it produces two moles of ammonia gas.
This is known as 'Forward reaction'.

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

On contrast, two moles of ammonia gas may also be converted into one mole of nitrogen and three moles of hydrogen. This is known as ' Reverse reaction'.

$$N_{2(g)} + 3H_{2(g)} \leftarrow 2NH_{3(g)}$$

When both of these reactions are written together as a reversible reaction, they are represented as:

$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)}$$

You know equilibrium means a 'balance'. Equilibrium exists in many ways in our surrounding.

The reaction rate depends on the concentration of the reactants. At the beginning the quantity of reactant is higher, and the rate of product formation is the higher. As the reactant amount decreases, the rate of reactant transformation also decreases, and the rate of product formation decreases. After a certain time, the concentrations of reactants and products become constant, and this state is called dynamic equilibrium.

Rate of forward reaction = Rate of reverse reaction

In a reversible reaction, dynamic equilibrium is established before the completion of reaction. The rate of both farward and reverse reaction becomes equal upon reaching the equilibrium point.The following graph which is of concentrations vs. time, shows that the concentrations of both reactants and product becomes constant at equilibrium.

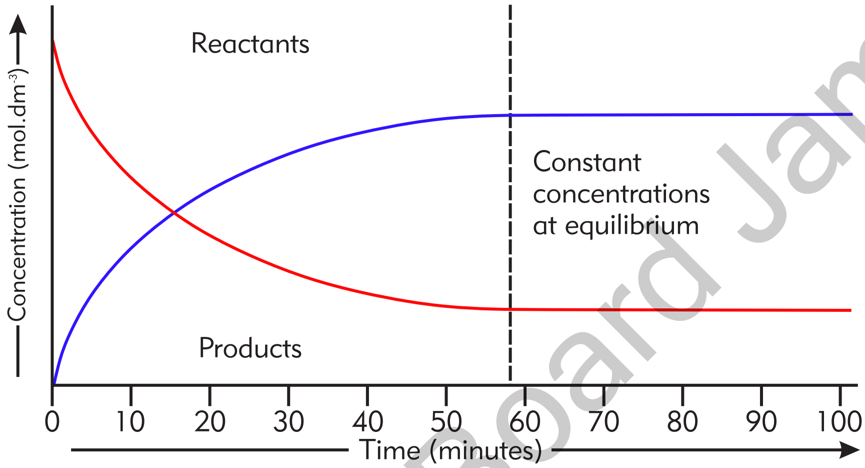


Figure 1.4 Dynamic equilibrium

An example of a reaction at equilibrium is a reaction of hydrogen and iodine in a closed container to produce hydrogen iodide. At the start of the reaction there is a high concentration of hydrogen and iodine and, after that the concentration decreases as hydrogen iodide is formed.

The concentration of hydrogen iodide increases as the forward reaction proceeds. As hydrogen iodide is formed, the reverse reaction is then able to occur.

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

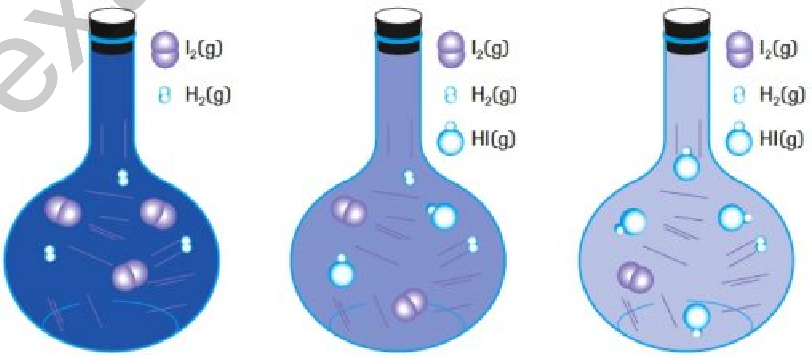


Figure 1.5 Hydrogen-iodine equilibrium system

So, there is no observable changes although both forward and reverse reactions are occurring. The reaction has not stopped but reached dynamic equilibrium.

Macroscopic characteristics of forward and reverse reaction

Forward reaction:

1. It is always directed from left to right in a chemical reaction
2. Reactants produce products(Reactants → Products)
3. Initially rate is fast but gradually slow down

Reverse reaction:

1. It is always directed from right to left in a chemical reaction
2. Product produce reactant (Reactants ← Products)
3. Initially rate is slow but gradually speed up

Macroscopic characteristics of forward and reverse reaction in dynamic equilibrium

1. A dynamic equilibrium can only exists in a closed system – neither reactants nor products can enter or leave the system
2. At equilibrium, the concentrations of reactants and products remain constant
3. At equilibrium, the forward and reverse reactions are taking place at equal and opposite rates.
4. Equilibrium can be approached from either side of the reaction equation
5. An equilibrium state can be disturbed and again achieved under the given condition of concentration, pressure, and temperature.

Test Yourself

1. Write down forward and reverse reactions for the following.

$$N_2\,(g) + O_2\,(g) \rightleftharpoons 2NO\,(g)$$

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

$$COCl_2\,(g) \rightleftharpoons CO\,(g) + Cl_2\,(g)$$

1.2 Law of Mass action and derivation of expression for equilibrium constant

The rate at which a substance reacts is directly proportional to its active mass and the rate of a reaction is directly proportional to the product of the active masses of the reacting substances.

The law of mass action also suggests that the ratio of the reactant concentration and the product concentration is constant at a state of chemical equilibrium.

Let us apply law of mass action on a hypothetical reversible reaction.

$$aA + bB \leftrightharpoons cC + dD$$

First let us discuss forward reaction, where A and B are reactants whereas 'a' and 'b' are number of moles needed to balance a chemical equation. The rate of forward reaction according to law of mass action is:

$$R_f \ \alpha \ [A]^a [B]^b$$

$$R_f = k_f [A]^a [B]^b$$

Where K_f is the rate constant for forward reaction.

Likewise, rate of reverse reaction is directly proportional to product of molar concentrations of C and D whereas 'c' and 'd' are number of moles needed to balance a chemical reaction.

$$R_r \ \alpha \ [C]^c [D]^d$$

$$R_r = k_r [C]^c [D]^d$$

Where K_r is the rate constant for reverse reaction. You know at equilibrium rate of forward and reverse reaction becomes equal. So,

$$R_f = R_r$$

Putting the values of R_f and R_r, we have

$$k_f [A]^a [B]^b = k_r [C]^c [D]^d$$

By taking constants on L.H.S and variables on R.H.S, we have

$$\frac{k_f}{k_r} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

OR

$$Kc = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

OR

$$Kc = \frac{kf}{kr}$$

Hence,

$$Kc = \frac{[\text{Product}]}{[\text{Reactant}]}$$

Where Kc is called equilibrium constant.

Hence proven that law of mass action describe relation between active masses of reactants and products with rate of reaction. All the reversible reactions can be expressed in this form. Such as:

Do You Know?

What is Active Mass?

The concentration of reacting substance is called Active mass. The unit of active mass is mol dm^{-3} and its value is expressed in square brackets.

Example 1:

For the reaction of sulphur dioxide and oxygen to form sulphur trioxide, the balanced reversible reaction is:

$$2SO_{2(g)} + O_{2(g)} \leftrightharpoons 2SO_{3(g)}$$

According to law of mass action

Rate of forward reaction: $R_f = k_f [SO_2]^2 [O_2]$

Rate of reverse reaction: $R_r = k_r [SO_3]^2$

The expression for equilibrium constant Kc is:

$$Kc = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

Test Yourself

- Define the term active mass
- Figure out coefficients for given hypothetical reaction.
  $9X_{(g)} + Y_{3(g)} \rightleftharpoons 3X_3Y_{(g)}$
- Write down Kc equation for given reactions.
  - $S_{(s)} + O_{2(g)} \leftrightharpoons SO_{2(g)}$
  - $SO_{2(g)} + NO_{2(g)} \rightleftharpoons NO_{(g)} + SO_{3(g)}$
  - $NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(l)}$

1.3 Equilibrium constant and its units

Equilibrium constants are determined by observing the concentrations of each ingredient in a single reaction until it reaches equilibrium and then calculating its numerical value. You have to figure out the ratio of product to reactant concentrations. It is impossible to change a given reaction's equilibrium constant since concentrations are measured at equilibrium, and this is true regardless of initial concentrations. The temperature is the single factor affecting the equilibrium constant's value.

Important characteristics of equilibrium constant expression are as follows:

1. Kc only works in equilibrium.
2. It represents the equilibrium concentration of the reactant and product in $mol.dm^{-3}$.
3. Kc is independent of reactant and product concentrations.
4. Kc varies with temperature.
5. Kc is a balanced chemical equation coefficient. In a balanced chemical equation, each reactant and product has a concentration equal to its coefficient.
6. Kc represents equilibrium position. If Kc is larger than 1, the reaction is forward. If Kc is less than 1, the reaction is a reverse reaction.
7. Remember that equilibrium constant Kc is a ratio of reactant to product that is utilized to define chemical behavior.

At equilibrium :

Rate of the forward reaction = Rate of the backward reaction.

An equal number of moles on both sides of the equation has no unit in Kc. Because Kc expression uses concentration units that cancel. The unit of concentration is mol.dm^{-3}. Consider a reaction:

$$CO_{2(g)} + H_{2(g)} \leftrightharpoons CO_{(g)} + H_2O_{(l)}$$

$$Kc = \frac{[CO][H_2O]}{[CO_2][H_2]}$$

$$Kc = \frac{[\cancel{mol.dm^{-3}}][\cancel{mol.dm^{-3}}]}{[\cancel{mol.dm^{-3}}][\cancel{mol.dm^{-3}}]} = \text{no unit}$$

For reactions when the number of moles of reactants and product are not equal, Kc has a unit. Let us consider the following reaction:

$$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$$

$$Kc = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$Kc = \frac{[mol.dm^{-3}]^2}{[mol.dm^{-3}][mol.dm^{-3}]^3} = \frac{1}{[mol.dm^{-3}]^2} = mol^{-2}.dm^6$$

Numerical 01

Equilibrium occurs when nitrogen monoxide gas reacts with oxygen gas to form nitrogen dioxide gas.

$$2NO_{(g)} + O_{2(g)} \rightleftarrows 2NO_{2(g)}$$

At equilibrium at 230°C, the concentrations are measured to be : [NO] = 0.0542 mol. dm^{-3}, [O_2] = 0.127 mol.dm^{-3}, and [NO 2] = 15.5mol.dm^{-3}. Calculate the equilibrium constant at this temperature.

Solution

Given equilibrium concentrations of reactants and product are:

$[NO] = 0.0542$ mol.dm^{-3}
$[O_2] = 0.127$ mol.dm^{-3}
$[NO_2] = 15.5$ mol.dm^{-3}

Write equilibrium expression as:

$$Kc = \frac{[NO_2]^2}{[NO]^2[O_2]}$$

Now put equilibrium concentration values in equilibrium constant expression

$$Kc = \frac{\left[15.5\text{mol}.dm^{-3}\right]^2}{\left[0.0542\text{mol}.dm^{-3}\right]^2\left[0.127\text{mol}.dm^{-3}\right]}$$

$$Kc = 6.44\times10^5\ \text{mol}^{-1}\cdot\text{dm}^3$$

Numerical 02

A reaction takes place between iron ion and chloride ion as:

$$Fe^{+3}_{(aq)} + 4Cl^-_{(aq)} \rightleftharpoons FeCl_4^-{}_{(aq)}$$

At equilibrium, the concentrations are measured to be (Fe^{+3}) is 0.2mol.dm^{-3}, Cl^- is 0.28mol.dm^{-3} and $FeCl_4^-$ is $0.95\times10^{-4}\ \text{mol.dm}^{-3}$. Calculate equilibrium constant Kc for given reaction.

Solution

Given equilibrium concentrations of reactants and product are:

$[Fe^{+3}] = 0.2\ \text{mol.dm}^{-3}$

$[Cl^-] = 0.28\ \text{mol.dm}^{-3}$

$[FeCl_4^-] = 0.95\times10^{-4}\ \text{mol.dm}^{-3}$

Write equilibrium expression as:

$$Kc = \frac{[FeCl_4^-\ ]}{[Fe^{+3}][Cl^-]^4}$$

Now put equilibrium concentration values in equilibrium constant expression

$$Kc = \frac{[\,0.95\times10^{-4}\ \ \text{mol .dm}^{-3}]}{[0.2\ \text{mol .dm}^{-3}][0.28\text{mol.dm}^{-3}]^4}$$

$$Kc = \frac{[0.95\text{x}10^{-4}\text{mol .dm}^{-3}]}{[0.2\ \text{mol .dm}^{-3}][0.28\text{mol.dm}^{-3}]^4}$$

$$Kc = 7.72\text{x}10^{-2}\text{mol}^{-4}\cdot\text{dm}^{12}$$

Numerical 03

Nitrogen oxides are air pollutants produced by the reaction of nitrogen and oxygen at high temperature. At 2000 °C, the value of the equilibrium constant for the given reaction is 4.1×10^{-4}

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$$

Find the concentration of NO in an equilibrium mixture at 1 atm pressure at 2000°C. In air, $[N_2] = 0.036$ mol/L and $[O_2] = 0.0089$ mol/L.

We are given all of the equilibrium concentrations except that of NO. Thus, we can solve for the missing equilibrium concentration by rearranging the equation for the equilibrium constant.

$$Kc = \frac{[NO]^2}{[N_2][O_2]}$$

$$[NO]^2 = Kc[N_2][O_2]$$

Taking square root on both the sides, we have

$$\sqrt{[NO]^2} = \sqrt{(4.1 \times 10^{-4}\,\text{mol/L})\,(0.036\,\text{mol/L})\,(0.0089\,\text{mol/L})}$$

$$[NO] = 3.6 \times 10^{-4}\,\text{mol/L}$$

1.4 Importance of equilibrium constant

The value of Kc varies depending on the response. Kc isn't only a calculating constant. It affects both the direction and the extent of a chemical reaction.

1. Direction of a chemical reaction

When dealing with reversible reactions, it is critical to determine the reaction's direction at any given time. For example, to produce ammonia efficiently from nitrogen and hydrogen, we must optimize the process. So it's critical to forecast the reaction's condition at any given time.The reaction quotient, Qc, can help make such predictions. It has the same mathematical structure as Kc, but Qc is a ratio of real concentrations computed at a given moment (not a ratio of equilibrium concentrations).

Comparing Kc and Qc values predicts response direction. We have three categories:

1. If Qc = Kc, the actual product and reactant concentrations are equal to the equilibrium concentrations, and the system is stable.
2. If Qc < Kc then there is increase in product concentration for equilibrium. So the forward reaction occurs, forming additional products.

3. If Qc > Kc, There is decrease in product concentration & to achieve equilibrium. As, the process reverses, forming more reactants.

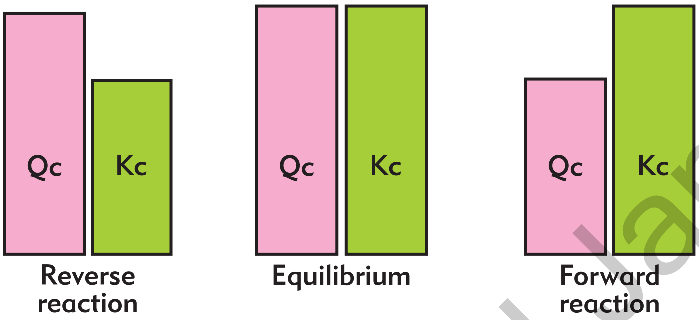


Figure 1.6 Directions of chemical reaction

2. Extent of chemical reaction

At a certain temperature, the extent of a reaction is measured. The magnitude of an equilibrium constant can predict the scope of a chemical reaction. As magnitude may be very high, very low, or moderate, so can be Extent of chemical reaction.

i. Kc is very small

Reactions with low Kc never finish. That is, maximum reactant concentration and minimum product concentration. These are called 'reverse or backward responses.

$$F_{2(g)} \rightleftharpoons 2F_{(g)} \qquad Kc = 7.4 \times 10^{-13} \text{ at } 227^\circ C$$

ii. Kc is very large

Reactions with high Kc values are virtually complete. That is, maximum product concentration and minimum reactant concentration. This type of reaction is known as 'Forward reaction'.

$$2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} \qquad Kc = 2.4 \times 10^{47} \text{ at } 227^\circ C$$

iii. Kc is neither very small nor very large

Reactions which have moderate value of Kc are considered to be at equilibrium. The concentration of reactants and products is almost same. For example:

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)} \qquad Kc = 0.36 \text{ at } 25^\circ C$$

Do You Know?

Equilibrium constants exist for certain groups of equilibria, such as for weak acids, weak bases, the autoionization of water, and slightly soluble salts.

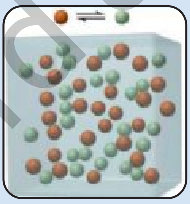
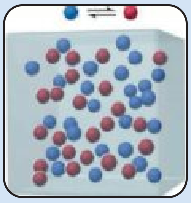
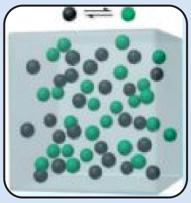
Test Yourself

- The value of K_c for the following reaction at 717 K is 48.

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

At a particular instant, the concentration of H_2, I_2 and HI are found to be 0.2 mol L^{-1}, 0.2 mol L^{-1} and 0.6 mol L^{-1} respectively. Calculate reaction quotient for given reaction. Also predict direction of reaction.

- **Match each of the following statement with appropriate diagram.**

A	Small Kc indicates that reaction mixture mostly contains reactants.	(i)	
B	Moderate Kc indicate that reaction mixture contains equal amount of reactant and product.	(ii)	
C	Large Kc indicates that reaction mixture mostly contain product.	(iii)	

Society, Technology and Science

The atmosphere is composed of nitrogen, oxygen, carbon dioxide, methane, nitrous oxide and ozone but the nitrogen and oxygen gases are the most important part of the atmosphere. They are 99% of the atmosphere and use to manufacture chemicals such as nitrogen is used for preparation of ammonia and ammonia is used to prepare nitrogenous fertilizers. Oxygen is used for preparation of sulphur dioxide and sulphur dioxide is used to prepare sulphuric acid.

Summary

- In our daily life we must have observed certain changes occurring, either physically or chemically. In chemical change a stage observed, in which rate of forward reaction becomes equal to the rate of reverse reaction indicating a state of equilibrium.
- Chemical equilibrium always observed in reversible reactions. In reversible reactions reactants and product interconvert into each other. These reactions will never reach to completion. Reversible reactions proceed in either direction i,e forward and backward.
- In dynamic equilibrium the rate of forward reaction is high, and rate of reverse reaction is slow in beginning. As equilibrium achieved both the rates become equal.
- Dynamic equilibrium can only be achieved in a closed container with fixed temperature.
- According to law of mass action:

  "At any instant, the rate of a chemical reaction at a given temperature is directly proportional to the product of the active masses of the reactants at that instant."

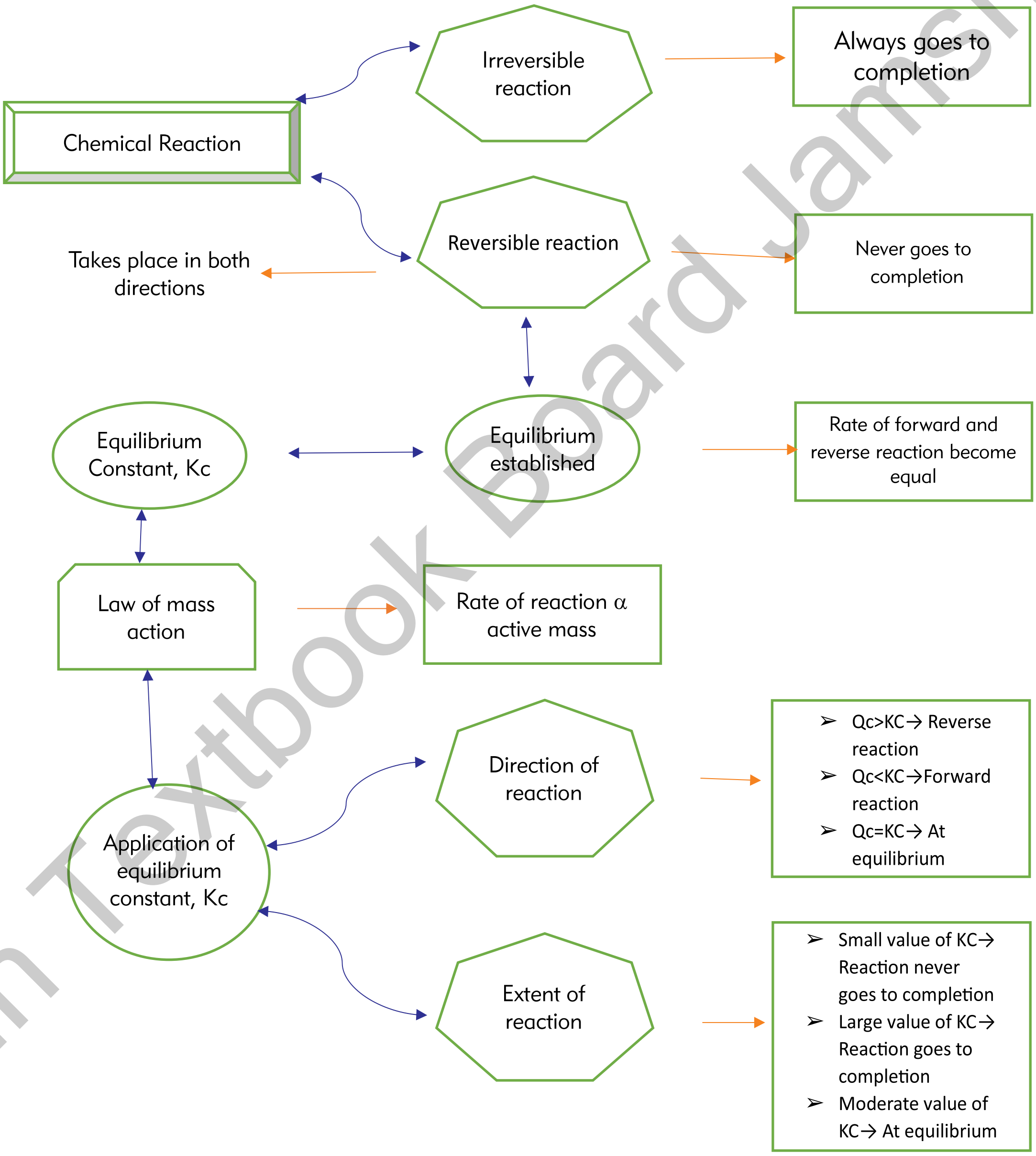
  $$aA + bB \leftrightharpoons cC + dD$$

  the equilibrium equation is given by:

  $$Kc = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$

  Where Kc is equilibrium constant.
- An equilibrium constant Kc is used to show relationship between molar concentration of product and molar concentration of reactant. As Kc is a ratio and usually has no unit. Kc is independent of initial concentration of reactant and product. Kc is temperature dependent.
- The value of equilibrium constant, Kc tells us the extent of a reaction, i.e., it indicates how far the reaction has proceeded towards product formation at a given temperature. It also gives direction of reaction.
- Under non-equilibrium conditions, reaction quotient 'Qc' is defined as the ratio of the product of active masses of reactant and products raised to the respective stoichiometric coefficients in the balanced chemical equation to that of the reactants.

CONCEPT DIAGRAM



Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

Tick the correct answer from the following.

1. Which one of the following statements is false about dynamic equilibrium?
   a. It takes place in a close container
   b. Concentration of reactant and products are not changed
   c. Rate of forward reaction is equal to rate of reverse reaction
   d. Equilibrium cannot be disturbed by any external stress

2. Consider the following reaction and indicate which of the following best describe equilibrium constant expression Kc.

   $$4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_20$$

   a. $Kc = \frac{[NO]^4\,[H_2O]^6}{[NH_3]^4\,[O_2]^5}$
   b. $Kc = \frac{[NH_3]^4\,[O_2]^5}{[NO]^4[H_2O]^6}$
   c. $Kc = \frac{[NH_3][O_2]}{[H_2O][NO]}$
   d. $Kc = \frac{[4NO][6H_2O]}{[4NH_3][5S_2]}$

3. A reaction which is never goes to completion is known as reversible reaction. Reversible reaction is represented by:
   a. Doted lines
   b. Single arrow
   c. Double arrow
   d. Double straight line

4. When the magnitude of Kc is small, indicates
   a. Reaction mixture contain most of the reactant
   b. Reaction mixture contain most of the product
   c. Reaction mixture contain almost equal amount of reactant and product
   d. Reaction goes to completion

5. For which system does the equilibrium constant, Kc has units of concentration

a. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

b. $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

c. $H_{2(g)} + I_{2(g)} \rightleftharpoons 2\,HI_{(g)}$

d. $CO_{2(g)} + H_{2(g)} \rightleftharpoons CO_{(g)} + H_2O_{(l)}$

6. The unit of Kc for reaction $N_2 + O_2 \rightleftharpoons 2NO$

a. $mol\ dm^{-3}$

b. $mol^{-2}\ dm^{6}$

c. $mol^{-1}\ dm^{3}$

d. no unit

7. The system is stable in equilibrium when:

a. $Q_c = K_c$

b $Q_c > K$

c $Q_c < K$

d None of these

8. Qc can be defined as:

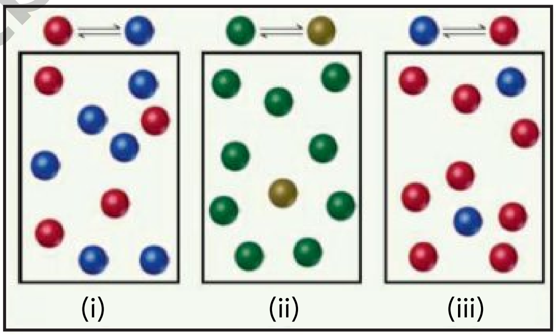
a. ratio of product and reactants

b. ratio of molar concentration of product and reactant at specific time

c. ratio of molar concentration of product and molar volume of reactant

d. ratio of molar concentration of product and reactant raised to the power of coefficient

9. Which of the following represent backward reaction?



a. (i) and (ii)

b. (ii) and

c. (ii) only

d. (iii) o nly

10. The value of Kc increases when:
   a. [Product] is less
   b. [Product] is more
   c. [Reactant] is more
   d. [Reactant = product]

SECTION- B: SHORT QUESTIONS:

1. Define chemical equilibrium with example.
2. Why chemical equilibrium is dynamic?
3. When writing an equation, how is a reversible reaction distinguished from irreversible reaction?
4. Write an equilibrium equation of monoatomic carbon and a molecule of oxygen as reactant and carbon monoxide as product.
5. Outline the characteristics of reversible reaction.
6. Distinguished between reversible and irreversible reaction.
7. State law of mass action. How is the active mass is represented?
8. Why equilibrium constant may or may not have unit? Justify with example.
9. How direction of a reaction can be predicted if Kc is known to you.
10. Write equilibrium constant expression for the following equations:
   i) $N_2 + 2O_2 \rightleftharpoons 2NO_2$
   ii) $N_2 + 3H_2 \rightleftharpoons 2NH_3$
   iii) $H_2 + Br_2 \rightleftharpoons 2HBr$

SECTION- C: DETAILED QUESTIONS:

1. Describe dynamic equilibrium with two examples.
2. State law of mass action. Derive an expression for equilibrium constant.
3. Describe the characteristics of equilibrium constant.
4. How can you predict the following stages of a reaction by comparing the values of Kc and Qc.
   i) Net reaction proceeds in forward direction.
   ii) Net reaction proceeds in reverse direction
5. Predict which system at equilibrium will contain maximum amount of product and which system will contain maximum amount of reactant?
   a) $2CO_{2(g)} \rightleftharpoons 2CO_{(g)} + O_{2(g)}$ $Kc(927^\circ C) = 3.1 \times 10^{-18}$ $mol.dm^{-3}$
   b) $2O_{3(g)} \rightleftharpoons 3O_{2(g)}$ $Kc(298K) = 5.9 \times 10^{55}$ $mol.dm^{-3}$

SECTION- D: Numerical

1. Dinitrogen tetra oxide N_2O_4 decomposed into nitrogen dioxide NO_2 in a reversible reaction. Derive equilibrium constant expression for the reaction of decomposition. Also interpret unit of Kc for balanced chemical reversible reaction.
2. PCl_5, PCl_3 and Cl_2 are at equilibrium at 500K in a closed container and their concentrations are 0.8×10^{-3} mol dm^{-3}, 1.2×10^{-3} mol dm^{-3} and 1.2×10^{-3} mol dm^{-3} respectively. Calculate the value of K_C for the reaction along with unit.
3. The value of Kc for the reaction is 1×10^{-4}

$$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$$

At a given temperature, the molar concentration of reaction mixture is
HI = 2×10^{-5} mol dm^{-3}, $H_2 = 1 \times 10^{-5}$ mol dm^{-3} and $I_2 = 1 \times 10^{-5}$ mol dm^{-3}.
Predict the direction of the reaction.

Chapter

2 Acid, Base and Salt

Time Allocation

Teaching periods	= 14
Assessment period	= 02
Weightage	= 15%

MAJOR CONCEPTS:

2.1 Concepts of Acids, Bases
2.2 Concept of pH and pOH
2.3 Salts

STUDENTS LEARNING OUT COMES (SLO'S)

Students will be able to:

- Define and give examples of Arrhenius acids and bases. (Understanding)
- Use the Bronsted-Lowry theory to classify substances as acids or bases, or as proton donors or proton acceptors. (Applying)
- Classify substances as Lewis acids or bases. (Analyzing)
- Write the equation for the self-ionization of wate .(Remembering)
- Give the hydrogen ion or hydroxide ion concentration, classify a solution as neutral, acidic, or basic. (Applying)
- Compute and balance a neutralization reaction. (Applying)
- Define Buffers and give examples. (Understanding)

Introduction:

We use in our daily life a large number of substances such as common salt, sugar, vinegar, lemon and tamarind. Do these all substances have same taste? Some of these compounds have a sour flavor, while others have a bitter flavor, a sweet flavor, or a salty flavor for example curd, vinegar, lemon, and orange juice have a sour flavor, they are acidic. Bitter-gourd, coffee, and chocolate have a bitter flavor, making them basic in nature, but common salt and alum have a salty taste, making them salts. The acids are quite beneficial in the production of homeopathic and allopathic medications, syrups, and tablets. Batteries, paints, paper, fertilizer, detergent, and fertilizer all employ the H_2SO_4 acid.

In our stomach, HCl is utilized to breakdown food. Carbonic, citric, and phosphoric acids are utilized in soda to neutralize gastric acidity. The bases are beneficial in a variety of situations. In the soap and paper industries, sodium hydroxide (NaOH) is utilized. Cement and plaster of Paris are both made from calcium hydroxide ($CaOH_2$). Ammonia is used in the production of fertilizers. Ammonium nitrate, for example, is used in fertilizers, silver bromide is used in photography, and calcium chloride is utilized as a drying agent.

2.1 Concepts of acids and bases

2.1.1 Arrhenius theory of acids and bases (1880s)

The Svante Arrhenius put forwarded a theory related to acids and bases. According to this theory, the acids are those substances that produce Hydrogen (H^+) ions when dissolved in water are called acids (HCl, HNO_3, CH_3COOH, HCN) and bases are those substances that produce hydroxide ions (OH^-) when dissolved in water. (NaOH, KOH, NH_4OH, $Ca(OH)_2$).

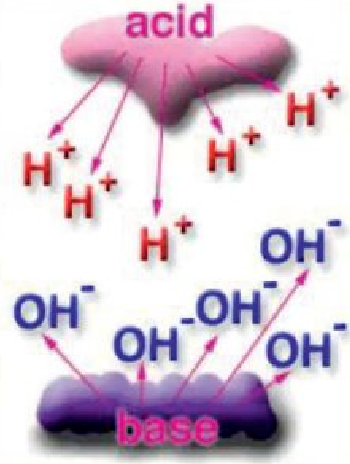


Figure 2.1 Hydrogen and Hydroxide ions of Acid and Base.

Properties of acids are due to presence of Hydrogen ions (H^+)

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

$$HNO_{3(aq)} \longrightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$$

Properties of bases are due to presence of Hydroxide ions (OH^-)

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

$$Ca(OH)_{2(aq)} \longrightarrow Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$$

A salt is an ionic compound that is formed by the reaction of an acid and base.

$$HBr + KOH \longrightarrow KBr + H_2O$$

$$\text{acid} + \text{base} \longrightarrow \text{salt} + \text{water}$$

Limitations of Arrhenius theory

- Hydrogen ions do not exist in water solution and they react with water to form Hydronium ions (H_3O^+).
- The Arrhenius theory does not explain the basicity of ammonia (NH_3), acidity of Carbon dioxide (CO_2) and other similar compounds.
- It is only applicable in aqueous solutions.

2.1.2 Bronsted-lowry theory of acids and bases (1923)

In 1923 a Danish chemist Bronsted and an English chemist Lowry proposed new definitions of acid and base. According to this theory any substance behaves as an acid when it donates a proton (H^+) to a base and any substance which accepts a proton, it behaves like a base, so acids are proton donor and bases are proton acceptors they both react with water to produce hydronium ions (H_3O^+).

Let us consider the dissolution of hydrogen chloride in water. In this reaction HCl donates its one proton to water (H_2O), and water (H_2O) accepts one proton to become H_3O^+.

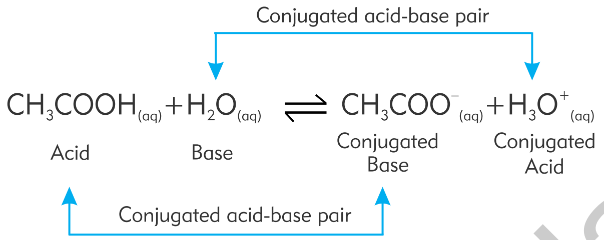
$$HCl_{(aq)} + H_2O_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$$

Thus HCl is a Bronsted acid and H_2O is Bronsted base. H_3O^+ is Conjugated acid and Cl^- is a Conjugated base.

Let us consider another following reaction

$$\underset{\text{Acid}}{CH_3COOH_{(aq)}} + \underset{\text{Base}}{H_2O_{(aq)}} \rightleftharpoons \underset{\substack{\text{Conjugated}\\\text{Base}}}{CH_3COO^-_{(aq)}} + \underset{\substack{\text{Conjugated}\\\text{Acid}}}{H_3O^+_{(aq)}}$$

It is a reversible reaction. In the forward reaction acetic acid is an acid which is donating proton while water is a base and accepting proton. Like this we have pairs of conjugated acid-base pairs. Conjugated acid is produced by accepting proton by a base and conjugated base is produced by donating proton from an acid.



$$CH_3COOH_{(aq)} + H_2O_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

Table 2.1 Bronsted –Lowry conjugated acid-base pairs

Acid		Base		Conjugated acid		Conjugated base
HCl	+	H_2O	$\rightleftharpoons$	H_3O^+	+	Cl^-
H_2SO_4	+	H_2O	$\rightleftharpoons$	H_3O^+	+	HSO^-_4
HSO^-_4	+	H_2O	$\rightleftharpoons$	H_3O^+	+	SO_4^{2-}
CH_3COOH	+	H_2O	$\rightleftharpoons$	H_3O^+	+	CH_3COO^-
NH^+_4	+	H_2O	$\rightleftharpoons$	H_3O^+	+	NH_3
H_2O	+	CN^-	$\rightleftharpoons$	HCN	+	OH^-
HCl	+	NH_3	$\rightleftharpoons$	NH_4^+	+	Cl^-

Limitations of Bronsted-Lowry concept

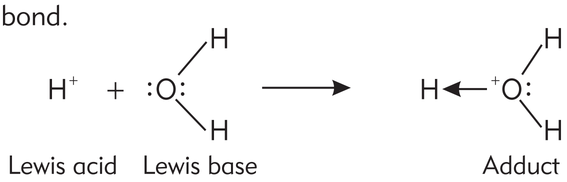
- It could not explain the acidic nature of compounds having no tendency to lose H^+ ions. Examples CO_2, $AlCl_3$, SO_3.
- It could not explain the basic nature of compounds having OH^- ions, Examples NaOH, $Ca\,(OH)_2$, KOH.

2.1.3 Lewis theory of Acid-Base (1923)

Gilbert N. Lewis put forwarded his definitions of acids and bases in the year 1923. According to this theory,

"An acid is a substance that is capable of accepting an electron pair, and base is a substance that is capable of donating an electron pair." Thus, a Lewis acid is an electron pair acceptor, and a Lewis base is an electron pair donor.

The proton (H^+) is capable of accepting a pair of electrons while H_2O is capable of donating a pair of electrons to form a covalent bond. So, according to the Lewis concept, H^+ is a Lewis acid and H_2O is a Lewis base. In the Lewis sense, it is the formation of a coordinate covalent or "donor-acceptor" bond.



Consider the reaction,

$$\underset{\text{base}}{:NH_3} + \underset{\text{acid}}{BF_3} \longrightarrow \underset{\text{product}}{H_3N: \rightarrow BF_3 \text{ or } H_3NBF_3}$$

$:NH_3$ is a donor of electron pair and BF_3 is acceptor of a pair of electrons. So, according to the Lewis concept, NH_3 is a Lewis base, and BF_3 is Lewis acid.

Limitations of Lewis Acid and Base concept

- It could not explicate the release of energy during the formation of a covalent bond.
- It could not clarify the shapes of molecules and amount of energy released during covalent bond formation.
- It could not explain the nature of attractive forces between the constituent atoms of a molecule.

Table 2.2 Summarized form of acid base theories.

The Arrhenius theory	The Bronsted-Lowry theory	The Lewis Theory
Acids are substances that produce Hydrogen ion and Bases are substances that produce Hydroxyl (OH^-) when dissolved in water.	An acid is a proton donor (H^+). and A base is proton acceptor.	Acids are electron pair acceptors. and Bases are electron pair donors.
HCl and NaOH	NH_3 and H_2O	BF_3 and NH_3

Balancing of neutralization reaction

As we know that a neutralization reaction takes place by the reaction of an acid and a base in aqueous solution producing a salt and water. A neutralization reaction shown by a balanced chemical equation which have equal number of atoms as well as positive and negative charges on reactants and product sides. The balancing of a neutralization involves the equal consumption of H^+ and OH^- in aqueous solution due to this we have to look the acidity of base and basicity of acid in balancing equation. For example, in chemical equation of neutralization of sodium hydroxide and hydro chloric acid is as follows

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

NaOH and HCl are neutralizing each other in ratio 1:1, because one mole of NaOH releases one mole of OH^- and one mole of HCl releases one mole of H^+. Similarly, NaOH or KOH when reacted with HBr, HI, HNO_3 shows ratio of 1:1. One mole of each HI, HNO_3 and HBr releases one mole of H^+.

Test Yourself

1. Why Arrhenius theory is only applicable on aqueous solutions?
2. Write down conjugated acid and conjugated base of following reactants?
   (I) $HCl + H_2O$ (II) $H_2SO_4 + H_20$ (III) $NH_4^+ + H_2O$

2.2 Concept of pH and pOH

Water ionization:

The water is a neutral liquid which posses equal number of hydrogen(H^+)and hydroxide ion (OH^-) due to this pure water is consider as a weak electrolyte. It ionize according to following reaction,

$$H_2O_{(aq)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

The equilibrium constant of (K_c) of water is given by,

$$K_c = \frac{[H^+][OH^-]}{[H_2O]}$$

The square brackets represents the molar concentration of species and its units are mole dm^{-3}. As we know that ionization of water is very small so the concentration is approximately unchanged and consider as constant (Kw) so, the equation will be

$$K_c[H_2O] = [H^+][OH^-]$$

$$K_c[H_2O] = K_w$$

$$K_w = [H^+][OH^-]$$

Where K_w is ionic product constant of water and its value is $1\times10^{-14}(mol\ dm^{-3})^2$.

pH and pOH

The concept of pH was first introduced by th Danish chemist Soren Peder Lauritz Sorensen at the Carlsberg Laboratory in 1909."pH" is an abbreviation for "potential hydrogen" and is a scale used for measuring the relative acidity or alkalinity of a liquid solution.

pH: A measurement of the concentration of Hydrogen ions (H^+) in a solution. It may also be defined as "the negative logarithm of Hydrogen ion concentration".
Mathematically

$$pH = -\log [H^+]$$

pOH: A measurement of the concentration of Hydroxyl ions (OH^-) in a solution. It may also be defined as "the negative logarithm of Hydroxyl ion concentration".
Mathematically

$$pOH = -\log [OH^-]$$

pH Scale: The pH scale measures the acidity or basicity of a substance. The scale has values ranging from zero (the most acidic) to 14 (the most basic). The pH of different solutions can be measured by pH paper, pH indicator and pH meter.

Table 2.3 Relationship between $[H^+]$, the $[OH^-]$, and pH of solutions

	$[H^+]$ (mol dm^{-3})	$[OH^-]$ (mol dm^{-3})	pH	Aqueous system
Increasing acidity ↑	1×10^{0}	1×10^{-14}	0.0	1M HCl (0.0)
	1×10^{-1}	1×10^{-13}	1.0	0.1M HCl (1.0)
	1×10^{-2}	1×10^{-12}	2.0	Gastric juice (1.6–1.8)
	1×10^{-3}	1×10^{-11}	3.0	Lemon juice (2.3), vinegar (2.4–3.4)
	1×10^{-4}	1×10^{-10}	4.0	Soda water (3.8), tomato juice (4.2)
	1×10^{-5}	1×10^{-9}	5.0	Black coffee (5.0)
	1×10^{-6}	1×10^{-8}	6.0	Milk (6.3–6.6), urine(5.5–7.0)
Neutral	1×10^{-7}	1×10^{-7}	7.0	Pure water (7.0), saliva (6.2–7.4)
Increasing basicity ↓	1×10^{-8}	1×10^{-6}	8.0	Blood (7.35–7.45), bile (7.8–8.6)
	1×10^{-9}	1×10^{-5}	9.0	Sodium bicarbonate (8.4), sea water (8.4)
	1×10^{-10}	1×10^{-4}	10.0	Milk of magnesia (10.5)
	1×10^{-11}	1×10^{-3}	11.0	Household ammonia (11.5)
	1×10^{-12}	1×10^{-2}	12.0	Washing soda (12.0)
	1×10^{-13}	1×10^{-1}	13.0	0.1M NaOH (13.0)
	1×10^{-14}	1×10^{0}	14.0	1M NaOH (14.0)

Note: pH + pOH = 14

Example. 1

A solution of HCl has pH of 2.3: calculate its pOH and $[H^+]$?

Solution: pH + pOH = 14

pOH = 14

-pH,

pOH = 14-2.3,

pOH = 11.7

pH = -log $[H^+]$,

$10^x = [H^+]$,

$10^{-pH} = [H^+]$,

$10^{-2.3} = [H^+]$,

Example. 2

Find pH, pOH, $[OH^-]$ and $[H^+]$ of 2.46×10^{-9} M KOH solution?

Solution: $KOH \longrightarrow K^+ + OH^-$

$[2.46 \times 10^{-9}]$

$[H^+][OH^-] = 1 \times 10^{-14}$ pH = -log $[H^+]$

$H^+ = \frac{1 \times 10 - 14}{2.46 \times 10^{-9}}$ pH = -log $[4.07 \times 10^{-6}]$

$[H^+] = 4.07 \times 10^{-6}$ pH = 5.39

$[OH^-] = 2.46 \times 10^{-9}$

pH + pOH = 14 pOH = 14 - pH,

pOH = 14-5.39,

pOH = 8.61

Test Yourself

1. Why pure water is consider as weak electrolyte?
2. What is the pH value of following?
   Lemon Juice, Soda Water, Black Coffee, Milk, Washing Soda

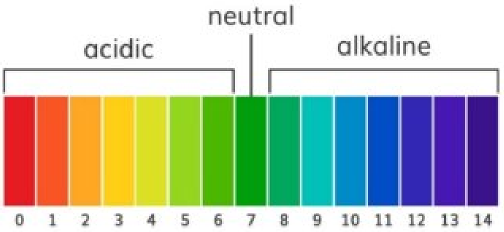


Figure 2.2 pH scale

2.3 Salts

Salt is an ionic compound that contains a cation (from base) and an anion (from acid).

It is present in large quantities in seawater, where it is the main mineral constituent. Salt is important for animal life and saltiness is one of the basic human tastes. Salt is an ionic compound that has a cation other than H^+ and an anion other than OH^- and is obtained along with water in the neutralization reaction between acids and bases.

Examples: NaCl, $CuCl_2$ etc.

$$\textbf{Acid + Base} \longrightarrow \textbf{Salt + water}$$

$$NaOH + HCl \longrightarrow \underset{\text{(Sodium chloride)}}{NaCl} + H_2O$$

$$2KOH + H_2SO_4 \longrightarrow \underset{\text{(Potassium sulphate)}}{K_2SO_4} + 2H_2O$$

$$Ca(OH)_2 + 2HNO_3 \longrightarrow \underset{\text{(Calcium nitrate)}}{Ca(NO_3)_2} + 2H_2O$$

2.3.1 Preparation of Salts

1. Salts are produced by the action of acids on metals, metal oxides, metal hydroxide, metal carbonates and metal bi carbonates

$$\underset{\text{(Calcium oxide)}}{CaO_{(s)}} + H_2SO_{4(aq)} \longrightarrow \underset{\text{(Calcium sulphate)}}{CaSO_{4(s)}} + H_2O_{(l)}$$

$$\underset{\text{(Potassium hydroxide)}}{KOH_{(aq)}} + HNO_{3(aq)} \longrightarrow \underset{\text{(Potassium nitrate)}}{KNO_{3(aq)}} + H_2O_{(l)}$$

$$\underset{\text{(Barium carbonate)}}{BaCO_{3(s)}} + 2HCl_{(aq)} \longrightarrow \underset{\text{(Barium chloride)}}{BaCl_{2(aq)}} + CO_{2(g)} + H_2O_{(l)}$$

2. Salts are produced by the action of a base with an acid or a metal with a base

$$H_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow \underset{\text{(Sodium sulphate)}}{Na_2SO_{4(aq)}} + 2H_2O_{(l)}$$

2.3.2 Types of Salts

(I) Acidic salt: Acidic salts are those salts which are distinctly acidic in nature they produce acidic solution when dissolved in water. For example NH_4Cl, $Ca(NO_3)_2$, $NaHSO_4$, NaH_2PO_4. Such salts solution have pH less than 7.

(ii) Basic salt: Basic salts are those salts which are distinctly basic in nature they produce alkaline solution when dissolved in water. For example CH_3COONa, K_2CO_3, $Na_2CO_3^-$, KCN. Such salts solution have pH more than 7.

(iii) Neutral salt: Neutral salts are those salts which are formed by the complete neutralization of a strong base and strong acid. The aqueous solutions of these salts are neutral to litmus paper. For example NaCl, KCl, K_2SO_4, $NaNO_3$. Such salts are neutral with pH 7.

2.3.3 Uses of some salts

Salts play an important role in our daily life. The following are some uses of salts

1. Most of the chemical fertilizers used in agriculture by farmers are salts. for example: ammonium chloride, ammonium nitrate, ammonium phosphate, potassium chloride and nitrogen, phosphorus and potassium (NPK) fertilizers.
2. Certain salts are used as pesticides to kill or destroy insects, pests, weeds and fungi. For examples: Copper (II) sulphate, Iron (II) sulphate and mercury chloride.
3. In medical field hydrated calcium sulphate, $CaSO_4.2H_2O$, is found in plaster of Paris. It is used to make plaster casts for supporting broken bones.
4. Patients suffering from anemia use iron (II) sulphate heptahydrate, $FeSO_4.7H_2O$ is an ingredient in 'iron pills' as food supplement.
5. Sodium hydrogen carbonate is an ingredient in anti-acids. This salt can neutralize the excess acid secreted by the stomach.
6. Barium sulphate is used to make barium meals for patients who need to take an X-ray of their stomach. The salt helps to make internal soft organs like intestines appear on X-ray films.
7. Potassium per manganate (VII) can kill bacteria and hence is suitable for use as a disinfectant.

2.3.4 Concept of buffers

There are two key terms associated with buffers. A buffer is an aqueous solution that has a highly stable pH. A buffering agent is a weak acid and its conjugated base or weak base and its conjugated acid. That helps to maintain the pH of an aqueous solution after adding another acid or base. If you add an acid or a base to a buffered solution, its pH will not change significantly. Similarly, adding water to a buffer or allowing water to evaporate will not change the pH of a buffer. "So a buffer is a solution that can resist pH change upon the addition of acidic or basic components. It is able to neutralize small amounts of added acid or base, thus maintaining the pH of the solution relatively stable."

- The pH of a buffer is independent of ionic strength.
- The pH of a buffer is dependent on temperature.

Test Yourself

1. Which of the following are salt?
   HCl , $NaCl$, $NaOH$, KOH, K_2SO_4, KNO_3 ,HNO_3, $BaCl_2$
2. List down the types of Salts?

Do You Know?

Types of buffer

There are two types of buffers

Acidic buffer

are made from a weak acid and its salts

Example:

$CH_3COOH-CH_3COONa$

- CH_3COOH - weak acid
- $CH_3COO^-Na^+$

SALT(CONJUGATED BASE)

Basic buffer

are made from a weak base and its salts

Example:

NH_3-NH_4Cl

- NH_3 -weak base
- NH_4Cl^-

SALT(CONJUGATED acid)

Society, Technology and Science

pH dependent food

The food we eat are considered as acidic, alkaline or neutral, such as meat, fish, dairy products, eggs and grains are acidic. Natural fats, starch and sugar are neutral in nature while fruits, nuts, legumes and vegetables are alkaline in nature. The pH of acidic food is 0 to 7 while the neutral food has exact pH 7 and alkaline food is from pH 7 to 14. A healthy human body required a controlled pH level in the serum upto 7.4, which is slightly alkaline.

Harmful effects of acid rain

It affects both animals and humans' respiratory systems.

Acid rain has an impact on the aquatic ecology when it falls and runs into rivers and ponds. It creates water pollution by changing the chemical composition of the water to a state that is damaging to the aquatic ecosystem's ability to exist.

Acid rain also causes water pipelines to corrode, resulting in heavy metals such as iron, lead, and copper seeping into drinking water.

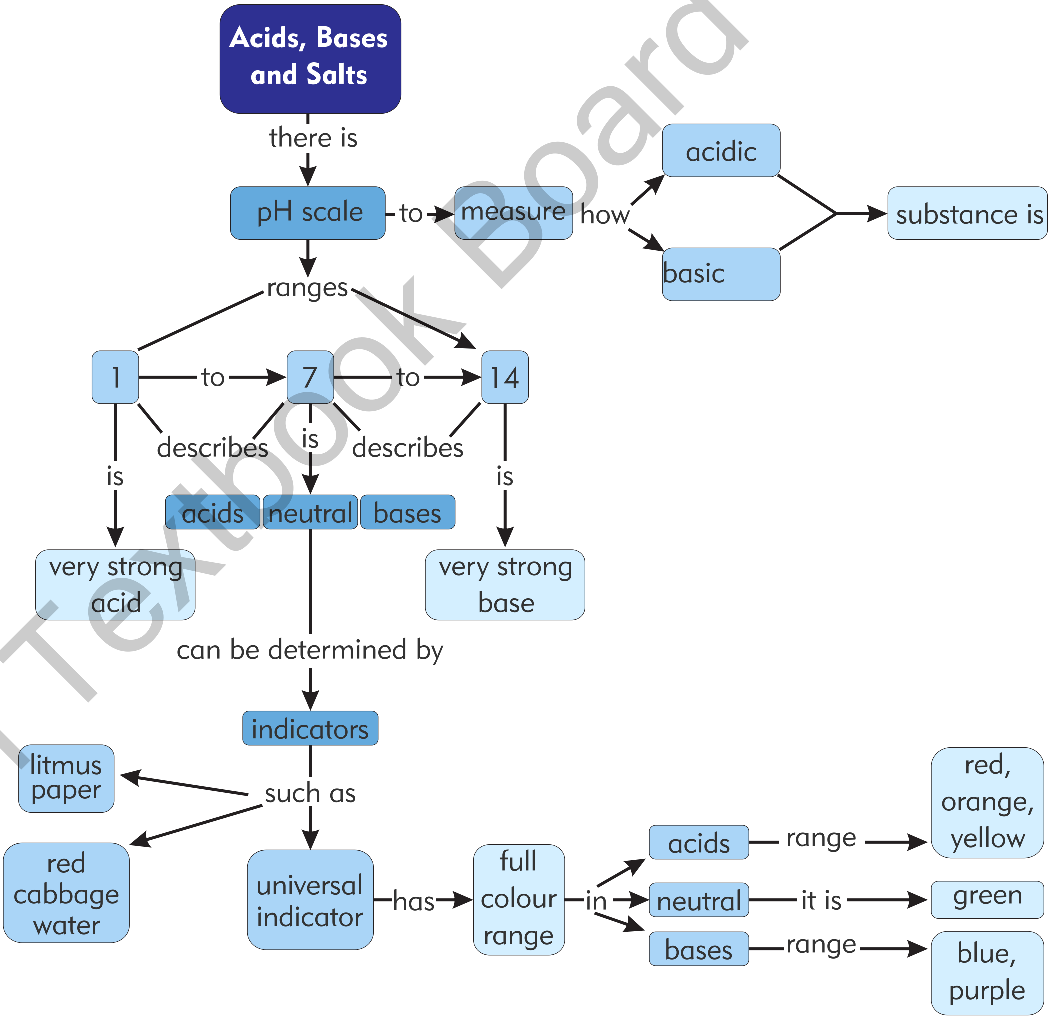
It causes damage to stone and metal structures and monuments.

Stomach acidity

Stomach acid, also known as gastric acid, is a colorless, watery fluid generated by the lining of the stomach. It's very acidic and aids digestion by breaking down meals. This makes it easier for your body to absorb nutrients when food passes through your digestive tract.

Laying on your back or bending down at the waist after eating a large meal. Snacking right before night. Consuming citrus, tomato, chocolate, mint, garlic, onions, or spicy or fatty meals. Consuming alcoholic beverages, carbonated beverages, coffee, or tea etc.

CONCEPT MAP FOR ACID AND BASE



Summary

- Acids are sour in taste, give H^+ ion in aqueous solution and change the color of blue litmus paper to red.
- Acids are corossive.
- Bases are bitter in taste, give OH^- ion in aqueous solution and change the color of red litmus paper to blue.
- According to Arrhenius theory acids gives H^+ ion in aqueous solution while base gives OH^- ion in aqueous solution.
- According to Brønsted-Lowry theory acids are proton donor and bases are proton acceptor.
- Conjugate acid is specie which is formed as a result of acceptance of proton by a base.
- Conjugate base is specie which is formed as a result of donation of proton from the acid.
- Lewis acid is a substance that can accept a pair of electron to form a coordinate covalent bond.
- Lewis base is a substance that can donate a pair of electron to form a coordinate covalent bond.
- Water is amphoteric in nature it behaves like an acid as well as base.
- Ionization constant for water is also called as ion product constant for water. Its value is 1×10^{-14} at 25° C.
- In pure water the $[H^+] = [OH^-] = 1\times10^{-7}$, that why water is neutral has pH=7.
- Acids have pH less than 7.
- Bases have pH greater than 7.
- pH of solution can be measured in several ways for e.g. by using litmus paper, universal indicator paper, indicators and by pH meter.
- Indicators are weak organic acid or base which change their color over small range of pH.
- A titration is a technique where a solution of known concentration is used to determine the concentration of an unknown solution. Typically, the titrant (the known solution) is added from a burette to a known quantity of the analyte (the unknown solution) until the reaction is complete.
- Salt is a product of acid base reaction. It's a combination of cation (from base) and anion (from acid).
- Neutralization is a reaction between acid and base to produce salt and water.
- Acidic salt contains one or more replaceable H atom.
- Buffer solution is solution which resists the change in pH of solution against the addition of small amount of acid or abase.

Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

Encircle the correct answer in each case.

1. Corrosive effect on skin is caused by:

(a) acid (b) base (c) salt (d) both a & b

2. Preservatives are used to preserve :

(a) acids (b) bases (c) food (d) water

3. Which of the following is not an Arrhenius acid:

(a)HCl (b) CO_2 (c) HNO_3 (d) H_2SO_4

4. NH_3 can be a base according to :

(a) Arrhenius theory (b) Bronsted- lowery theory

(c) Lewis theory (d) both b and c

5. Which of the following is a Lewis base?

(a) HNO_3 (b) CN^- (c) HCl (d) $AlCl_3$

6. A substance that can donate a pair of electron to form coordinate covalent bond:

(a) Lewis acid (b) Lewis base

(c) Bronsted- Lowery acid (d) Bronsteed-Lowery base

7. If pH value is greater than 7, then solution is :

(a) acidic (b) basic (c) amphoteric (d) neutral

8. Salt among following is :

(a) HCl (b) KCl (c) HNO_3 (d) H_2SO_4

9. Substances that react with both acids and bases are called :

(a) conjugate acids (b) conjugate bases

(c) amphoteric substances (d) Buffers

10. The reaction of acid and base to form salt and water is called :

(a) hydration (b) Neutralization (c) hydrolysis (d) both a & c

SECTION- B: SHORT QUESTIONS:

1. Discuss the properties of acid and base.
2. Elaborate the Arrhenius concept of acid and base with suitable example.
3. What is Bronsted –lowery acid- base theory?
4. What are conjugate acid base pairs? Explain with examples.
5. Classify the following solutions as acidic, basic or neutral.

   A solution that has $[H^+]=1\times10^{-4}$ mol. dm^{-3}

   A solution that has $[H^+]=1\times10^{-11}$ mol. dm^{-3}

   A solution that has $[OH^-]=1\times10^{-9}$ mol. dm^{-3}

   A solution that has $[OH^-]=1\times10^{-3}$ mol. dm^{-3}
6. Elaborate the ionization equation of water.
7. Define the following terms;

   (a) pH (b) Indicator (c) Neutralization (d) Titration
8. Define buffers. What is the composition of buffers? Discuss its importance in our daily life.

SECTION- C: DETAILED QUESTIONS:

1. Describe salts, preparation of salts and types of salts.
2. Explain in detail that how water ionization is related with pH of solution?
3. Discuss in detail how different solutions in aqueous system exhibit increase in acidity and increase in basicity on the basis of H^+ and OH^-?
4. What do you mean by balancing of neutralization reaction with the help of examples?
5. Write down the uses of salt in daily life.

SECTION- D: Numerical

1. Calculate pH of 5M solution of NaOH.
2. A solution of H_2SO_4 has pH of 1.05 calculate its pOH and $[H^+]$.
3. The hydrogen ion concentration of a solution is 1×10^{-8} mol. dm^{-3}. what is pH of the solution?

Chapter 3

Organic Chemistry

Time Allocation

Teaching periods = 15
Assessment period = 03
Weightage = 15%

MAJOR CONCEPTS:

3.1 Organic Compounds
3.2 Sources of Organic Compounds
3.4 Uses of Organic Compounds
3.5 Alkanes and Alkyl Radicals
3.6 Nomenclature of simple Alakne, Alkenes and Alkynes
3.7 Introduction to Functional Groups

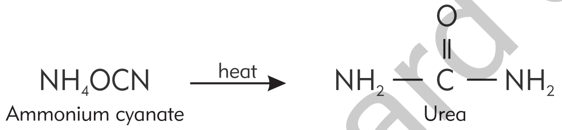
STUDENTS LEARNING OUT COMES (SLO'S)

- Recognize structural, condensed, and molecular formulas of the straight chain hydrocarbons up to ten carbon atoms. (Remembering)
- Identify some general characteristics of organic compounds. (Remembering)
- Explain the diversity and magnitude of organic compounds. (Understanding)
- List some sources of organic compounds (Remembering)
- List the uses of organic compounds (remembering)
- Recognize and identify a molecule's functional groups.(Remembering)
- Distinguish between saturated and unsaturated hydrocarbons. (Understanding)
- Name the alkanes up to decane, alkenes up to decene and alkynes up to decyne (Remembering)
- Modify alkanes into alkyl radicals. (Applying)
- Differentiate between alkanes and alkyl radicals. (Analyzing)
- Define functional group. (Remembering)
- Differentiate between different organic compounds on the basis of their functional groups. (Analyzing)
- Classify organic compounds into straight chain, branched chain and cyclic compounds. (Understanding)

Introduction

Mostly the products we use in our daily life such as computer, furniture, vehicles, food, cooking oil, soap, detergents, vinegar are made up of different organic compounds. Before 1828 it was believed that chemical compounds could be made only in the presence of vital force and that vital force theory was introduced by Berzelius in 1815. It states that "organic compounds can only be formed in the tissues of living organisms (plants and animals) and cannot be synthesized from inorganic substances in the laboratory".

In 1828 the German chemist Friedrich Wohler converted an inorganic compound ammonium cyanate into urea. Urea is an organic compound excreted in the urine of mammals. Wohler prepared urea in the absence of vital force.



$$\underset{\text{Ammonium cyanate}}{NH_4OCN} \xrightarrow{\text{heat}} \underset{\text{Urea}}{NH_2-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2}$$

This was the first synthesis of an organic compound in the laboratory. This reaction gave a big blow to the vital force theory and propose a proper definition of organic chemistry that "Organic chemistry is branch of chemistry which deals with the study of compounds of carbon and hydrogen (hydrocarbons) and their derivatives".As all organic compound contain carbon as an essential element.

3.1 Organic Compound:

Organic compounds are those that include one or more carbon atoms that are covalently linked to atoms of other elements, such as hydrogen, oxygen, nitrogen etc.

For example: Ethane, Alcohol, Amine, Polystyrene, Chloroform.

General Characteristics of organic compounds

Some general characteristics of organic compounds are given below:

(i) Source

Organic compounds are obtained from living things (animals and plants) and minerals.

(ii) Composition

Carbon is the key element in all organic compounds. After carbon, most frequently used element is hydrogen. Organic compounds may also contain halogens, oxygen, sulphur, nitrogen and phosphorus elements. Organic compounds contain both types of covalent bonds-polar and non polar bonds.

(iii) Solubility

According to like dissolve like rule, organic compounds are insoluble in water but soluble in organic solvents. Non-polar organic compounds are soluble in benzene, carbon disulphide, ether etc and polar compounds are soluble in alcohols.

(iv) Melting and boiling points

As covalent bond is weaker than ionic bond, so organic compounds have lower melting and boiling points.

(v) Rate of Reactivity

The rate of reactivity of organic compound is very slow and need specific conditions.

(vi) Electrical Conductivity

Generally, organic compounds are non-conductors of electricity because they consist of covalent molecules.

(vii) Combustion

All organic compounds are more combustible and burn in air due to high percentage of carbon. The common product produced in all cases is carbon dioxide.

(viii) Stability

Organic compounds are less stable on a high temperature as compare to inorganic compounds.

Representation of organic compound

Though carbon oxides such as carbon monoxide and carbon dioxide, as well as carbonates, bicarbonates, and carbides, are carbon compounds, they are not classified as organic molecules since their characteristics are fundamentally different. The formula for each chemical compound is unique.Organic compounds have four different sorts of formulae:

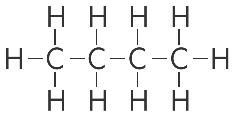
- Molecular formula
- Structural formula
- Condensed formula
- Dot and cross formula

Molecular Formula

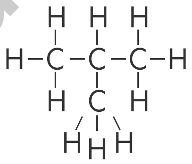
The molecular formula is the formula that indicates the exact number of atoms in one molecule of an organic compound; for example, the molecular formula of butane is C_4H_{10}. It demonstrates that butane is composed of carbon and hydrogen atoms. Butane has four carbon atoms and ten hydrogen atoms in each molecule.

Structural Formula

The exact arrangement of the individual atoms of various elements contained in a molecule of a substance is represented by the structural formula of a compound. Between the bonded atoms, a single bond is represented by a single line (-), a double bond by two lines (=), and a triple bond by three lines (≡). Organic compounds can have the same molecular formula but various structural formulas, such as butane C4H10, which has two the structural formulae:



n– Butane



isobutane

Condensed Formula

Condensed formula is the formula in which bond line to each carbon are omitted and each distinct structural unit is written with subscript numbers for multiple substituents including hydrogen.

$CH_3\,CH_2\,CH_2\,CH_3$

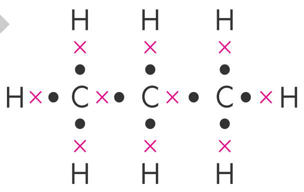
n– Butane

$CH_3\,CH(CH_3)\,CH_3$

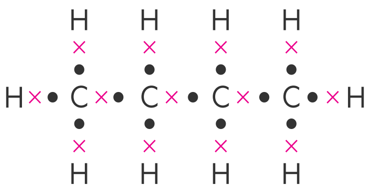
isobutane

Dot and Cross Formula (electronic)

The dot and cross formula, also known as the electronic formula, depicts the sharing of electrons between distinct atoms in a single molecule of an organic compound.



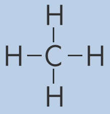
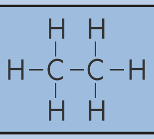
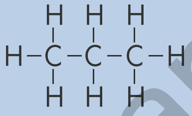
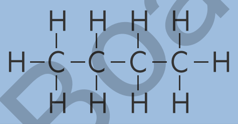
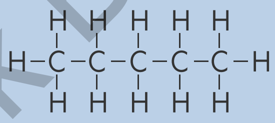
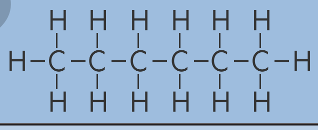
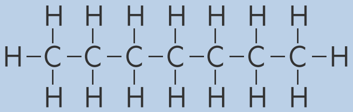
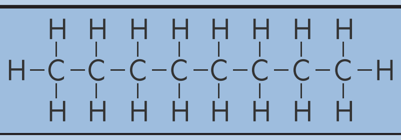
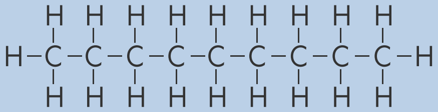
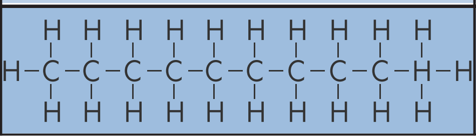
Propane



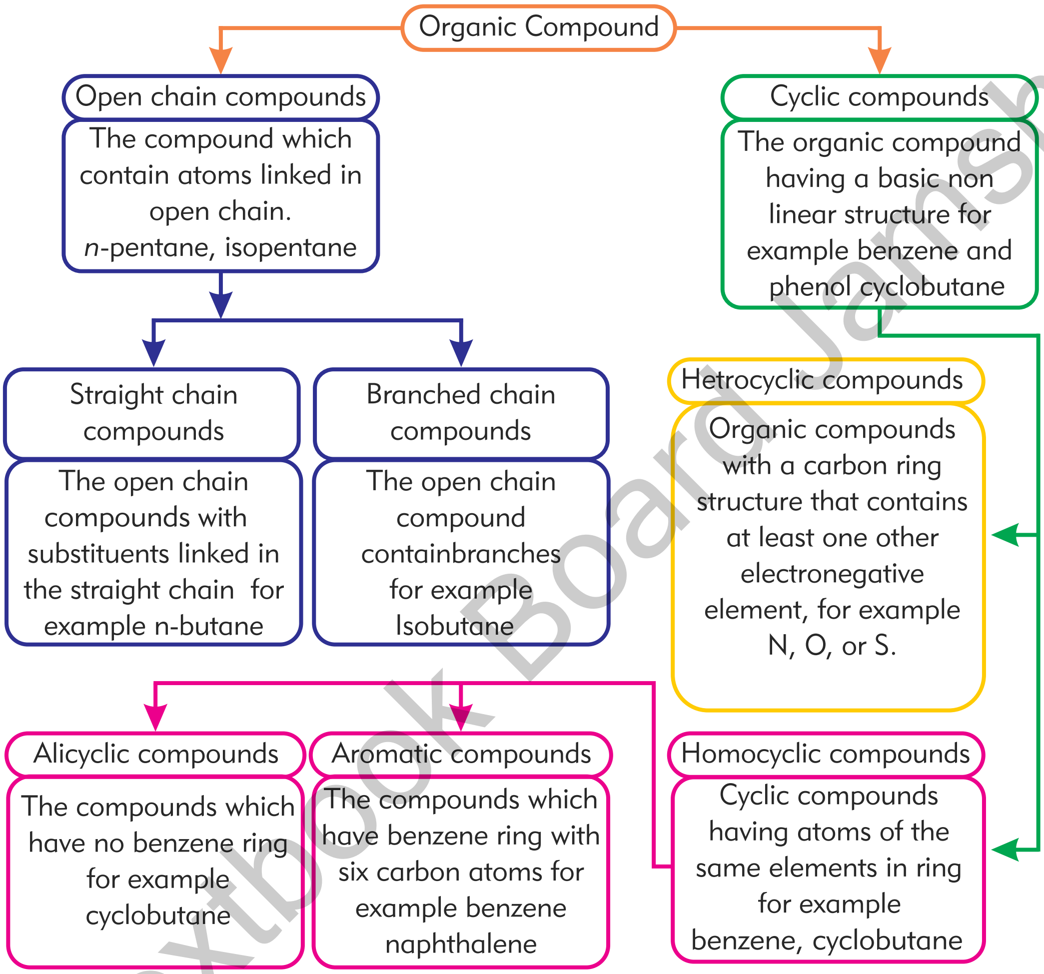
Butane

Table 3.1

Compound, Molecular, Structural and Condensed Formulae of first ten hydrocarbons

Compound	Molecular Formula	Structural Formula	Condensed form
Methane	CH_4	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	CH_4
Ethane	C_2H_6	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	H_3CCH_3
Propane	C_3H_8	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	$H_3CCH_2CH_3$
Butane	C_4H_{10}	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	$H_3C(CH_2)CH_3$
Pentane	C_5H_{12}	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	$H_3C(CH_2)_3CH_3$
Hexane	C_6H_{14}	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	$H_3C(CH_2)_4CH_3$
Heptane	C_7H_{16}	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	$H_3C(CH_2)_5CH_3$
Octane	C_8H_{18}	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	$H_3C(CH_2)_6CH_3$
Nonane	C_9H_{20}	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-H$	$H_3C(CH_2)_7CH_3$
Decane	$C_{10}H_{22}$	 $H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{H}}-H$	$H_3C(CH_2)_8CH_3$

Classification of Organic compounds



Organic Compound

Open chain compounds

The compound which contain atoms linked in open chain. *n*-pentane, isopentane

Cyclic compounds

The organic compound having a basic non linear structure for example benzene and phenol cyclobutane

Straight chain compounds

The open chain compounds with substituents linked in the straight chain for example n-butane

Branched chain compounds

The open chain compound containbranches for example Isobutane

Hetrocyclic compounds

Organic compounds with a carbon ring structure that contains at least one other electronegative element, for example N, O, or S.

Alicyclic compounds

The compounds which have no benzene ring for example cyclobutane

Aromatic compounds

The compounds which have benzene ring with six carbon atoms for example benzene naphthalene

Homocyclic compounds

Cyclic compounds having atoms of the same elements in ring for example benzene, cyclobutane

Diversity and magnitude of organic compound

There are total of 118 elements that are currently known. More than 10 million organic compound (carbon compounds) exist. This amount is significantly more than the total number of compounds formed by the other elements. The following factors contribute to the existence of such a great number of organic compounds:

1. Catenation:

The ability of carbon atoms to join with another via covalent bonds to create long chains or rings of carbon atoms is the primary cause for the formation of a vast number of organic compounds. Straight or branched chains are possible. Catenation is the capacity of atoms to build long chains and huge rings by linking with other similar atoms.

There are two main criteria for an element to show catenation:

1. The element should have a valency of two or more.

2. An element's bonds with its own atoms should be stronger than the element's bonds with other atoms, particularly oxygen.

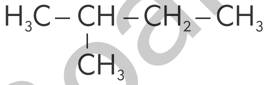
Although both silicon and carbon have comparable electrical structures, carbon exhibits more catenation whereas silicon exhibits very less. The reason for this is that C-C bonds are substantially stronger (355 kJ mol^{-1}) than Si-Si bonds (200 kJ mol^{-1}). Si-O bonds, on the other hand, are more stronger (452 kJ mol^{-1}) than C-O bonds (351 kJ mol^{-1}). As a result, silicon is found in nature as silica and silicates.

2. Isomerism:

The phenomena of isomerism is another cause for the abundance of organic molecules. If two compounds have the same molecular formula but distinct atom arrangements in their molecules or different structural formulas, they are said to be isomers. Isomerism increases the number of structures that may be expressed; for example, the chemical formula of pentane (C_5H_{12}) can be represented by three distinct structures. As a result, C_5H_{12} has three isomers, as indicated in the diagram below:

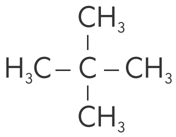
$$H_3C-CH_2-CH_2-CH_2-CH_3$$

n-pentane



$$H_3C-\underset{\underset{\displaystyle CH_3}{|}}{CH}-CH_2-CH_3$$

iso-pentane



$$H_3C-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}-CH_3$$

neopentane

The number of isomers increase as the number of carbon atoms in a chemical formula increases.

3. Carbon's covalent bond strength:

Because of its tiny size, carbon can make extremely strong covalent bonds with other carbon atoms, hydrogen, oxygen, nitrogen, and halogens. This allows it to make a vast number of different compounds.

4. Multiple bonding:

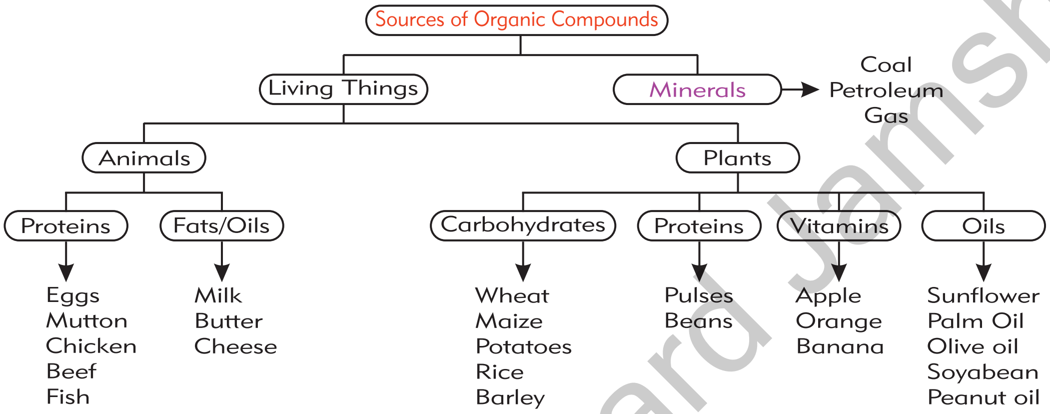
Carbon may form multiple bonds in order to meet its tetravalency (i.e., double and triple bonds). This increases the number of structures that can be built. A single covalent bond connects two carbons in ethane, a double covalent bond connects two carbons in ethylene, and a triple covalent bond connects two carbons in acetylene.

Test Yourself

1. Why number of compounds of Si are lesser than that of carbon compounds.
2. What is Rate of Reactivity of organic compound?

3.2 Source of organic compounds

There are two main sources of organic compounds namely living things and minerals. These sources are described as under.



3.2.1 Coal:

Coal is made up of a variety of hydrocarbons. It is an important source of solid fossil fuels for us. It can be found at various depths beneath the Earth's surface. Coal is formed in a variety of ways.Coal is said to have developed in nature 500 million years ago from the remnants of trees buried deep inside the soil. It was turned to peat as a result of bacterial and chemical processes on the wood. Peat was then converted into coal as a result of high temperature and pressure within the Earth's crust. Natural carbonization is the process of converting wood into coal. Wood has a carbon content of 40%.Four varieties of coal are created depending on the degree of carbonization.

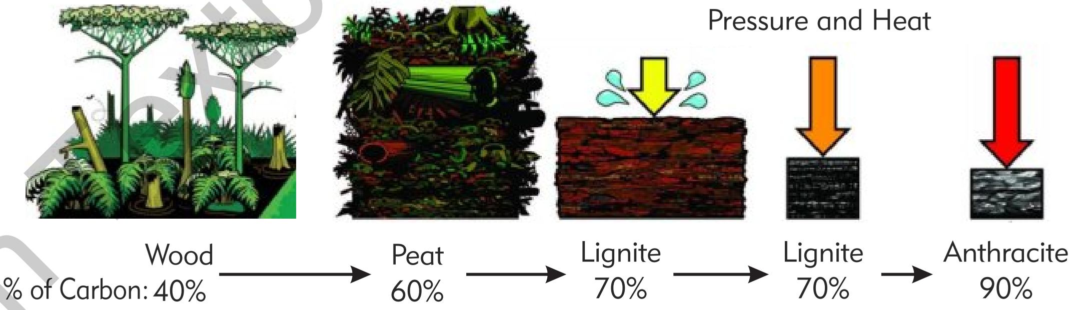


Figure 3.1 Formation of coal

China, the United States of America, Russia, the United Kingdom, Germany, Poland, Australia, and Pakistan are the world's top coal producers. In Sindh's Tharparkar area, Pakistan contains one of the world's biggest lignite deposits, estimated at more than 185 billion tonnes. Dighari-sor-Range, Kost-shahrig-Harnai (Balochistan), and Salt Range are the other active coal mines (Punjab).

3.2.2 Petroleum:

Petroleum is a thick dark brownish or greenish black liquid. It's a complicated combination of solid, liquid, and gaseous hydrocarbons, together with water, salts and earth particles.

Organic compounds are mostly derived from petroleum. It is made up of a variety of substances, the majority of which are hydrocarbons. Fractional distillation is used to separate these chemicals (separation of fractions or components from a liquid mixture depending upon their boiling point ranges is called fractional distillation). Each fraction contain single chemical compound, rather than multiple component.

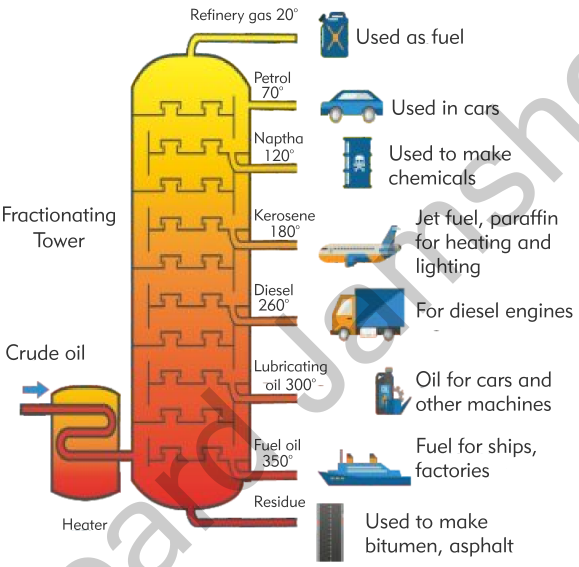


Figure 3.2 Fractional distillation

3.2.3 Natural Gas:

It's a mixture of hydrocarbons with low molecular weight. Methane, together with other gases such as ethane, propane, and butane, makes up around 85% of the mixture. It has a similar origin to coal and petroleum. As a result, it is discovered with their deposits. Natural gas is utilized as a fuel in both households and industries. Compressed natural gas (CNG) is utilized as a fuel in cars. Carbon black and fertilizers are also made from natural gas.

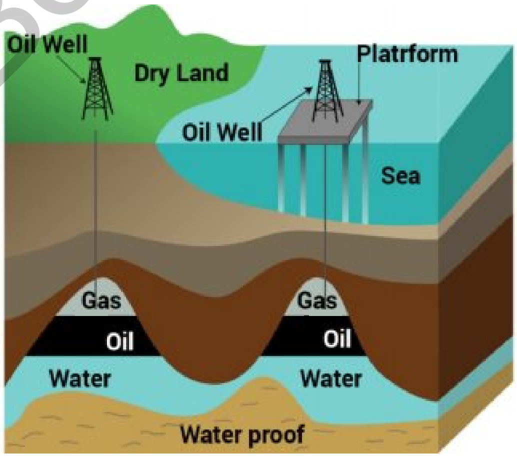


Figure 3.3 Drilling for Natural Gas

3.2.4 Plants:

Macromolecules, such as carbohydrates, proteins, lipids, and vitamins, are synthesized by living plants. Glucose is the fundamental unit of all carbohydrates, and it is produced by plants through photosynthesis. Starch, and cellulose are formed as glucose polymerizes further. Pulses and beans are high in protein. Proteins are made by nitrogen fixing bacteria that live on the roots of plants. Seeds from plants including sunflower, rapeseed, palm, coconut, and groundnut contain oils. Apples and citrus fruits are high in vitamins. Plants provide us with gums, rubber, medications, and other products in addition to these primary food staples.

3.2.5 Synthesis in Laboratory:

Only plants and animals, it was thought just over two centuries ago, could synthesize organic compounds because they possessed 'Vital Force,' which is required for organic compound synthesis. However, F.M. Wohler's laboratory synthesis of urea (NH_2CONH_2) in 1828 established the area of laboratory synthesis of organic molecules. More than 10 million organic molecules have been synthesized in laboratories till today. They range in complexity from simple to complicated.Drugs and medications, flavorings and scents, plastics and paints, synthetic fibers and rubber, cosmetics and toiletries, detergents, insecticides and pesticides, and other products include them.

Test Yourself

1. Name the Alkanes up to Decane?
2. Which type of bonding unsaturated Hydrocarbon possess?

3.3 Uses of organic compounds

Thousands of organic compounds are undoubtedly synthesized spontaneously by animals and plants, but scientists prepare millions of organic compounds in labs. These compounds are found in a wide range of products, from the food we consume to the many goods we use in our everyday lives to meet our requirements.

- Uses as Food: The foods we eat on a daily basis, such as milk, eggs, meat, vegetables, and so on, are all organic and contain carbohydrates, proteins, lipids, vitamins, and so on.
- Uses as Clothing: Natural (cotton, silk, wool, etc.) and synthetic (polyester, nylon, etc.) fibres are used in all forms of clothing (we wear, we use as bed sheets, etc). (nylon , dacron and acrylic, etc.) All of these substances are made up of organic components.
- Uses as a House: Wood is made mostly of cellulose (naturally synthesized organic compound). It's used to build anything from buildings to furnishings.
- Uses as Fuel: Coal, petroleum, and natural gas are the fuels we use in our cars and in our homes. These are referred to as fossil fuels. These are all organic compounds.
- Medical Applications: We employ a significant variety of organic compounds (naturally generated by plants) as medications. Antibiotics (which suppress or kill bacteria that cause infectious illnesses) and other life-saving medications and treatments are manufactured in laboratories.
- As a Raw Material: Organic compounds are used to make a wide range of products, including rubber, paper, ink, pharmaceuticals, dyes, paints, varnishes, insecticides, and more.

3.4 Alkanes and Alkyl Radicals

Saturated hydrocarbons or paraffins are alkanes (para means little, affin means affinity). C_nH_{2n+2} is their general formula, where 'n' is the number of carbon atoms. When it comes to alkanes, 'n' can range from 1 to 40. Alkanes are the most significant homologous sequence of compounds in this fashion.

Homologous Series

Organic substances are classified into classes based on their chemical characteristics. A homologous series is the name given to each group. Organic molecules belonging to the same homologous series have the following characteristics:

1. A general formula can be used to describe all members of a series. For example, the general formulas for alkanes, alkenes, and alkynes are C_nH_{2n+2} ,C_nH_{2n}, and C_nH_{2n-2}, respectively.
2. The relative molecular masses of successive members of the sequence differ by one unit of $^{-}CH_{2-}$ and 14 a.m.u.
3. They have chemical properties that are comparable (because they contain the same functional group).
4. Their physical properties evolve in a predictable pattern; melting and boiling points rise in lockstep with increasing molecule masses.
5. They can be prepared in a similar manner.

Hydrocarbons are organic substances that are considered to be the parents of other organic compounds. All other compounds are thought to be made by replacing one or more hydrogen atoms in a hydrocarbon with one or more reactive atoms or groups of atoms.

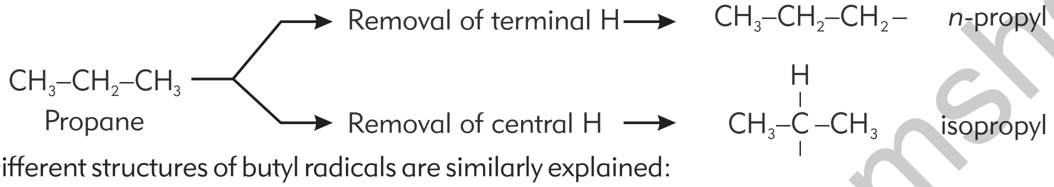
Formation of Alkyl Radical

Alkyl radicals are alkane derivatives. They are created by removing one of an alkane's hydrogen atoms and are symbolized by the letter 'R.' Their name is formed by substituting the letter "ane" in alkane with the letter "yl." The first 10 alkanes and their alkyl radicals are shown in Table. C_nH_{2n+1} is their general formula.

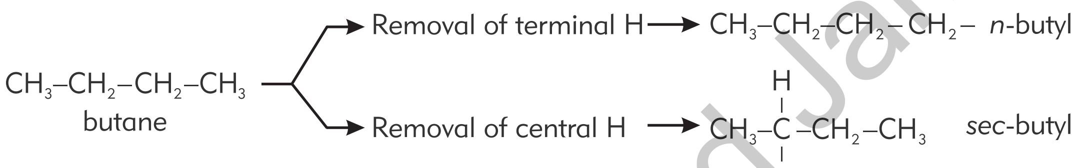
Table 3.2 Formation of Alkyl radical

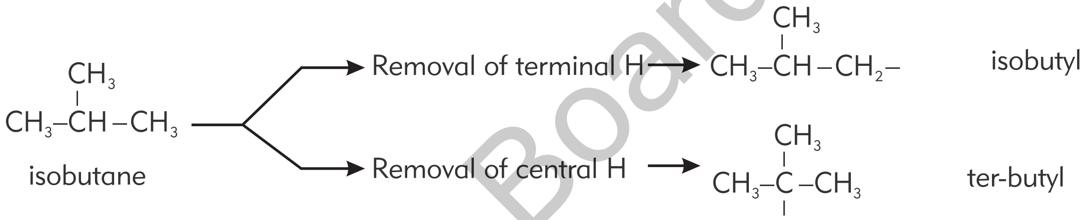
Alkane	Molecular Formula	Alkyl radical	Name
Methane	CH_4	CH_3-	Methyl
Ethane	C_2H_6	C_2H_5-	Ethyl
Propane	C_3H_8	C_3H_7-	Propyl
Butane	C_4H_{10}	C_4H_9-	Butyl
Pentane	C_5H_{12}	$C_5H_{11}-$	Pentyl
Hexane	C_6H_{14}	$C_6H_{13}-$	Hexyl
Heptane	C_7H_{16}	$C_7H_{15}-$	Heptyl
Octane	C_8H_{18}	$C_8H_{17}-$	Octyl
Nonane	C_9H_{20}	$C_9H_{19}-$	Nonyl
Decane	$C_{10}H_{22}$	$C_{10}H_{21}-$	Decyl

It's easier to discuss the many types of propane and butane radicals. Propane has a chain structure that is straight. It's termed as n-propyl when terminal H is removed. Isopropyl is formed when hydrogen from the middle carbon is removed, as stated below:



Different structures of butyl radicals are similarly explained:





Differentiation between saturated and unsaturated hydrocarbons:

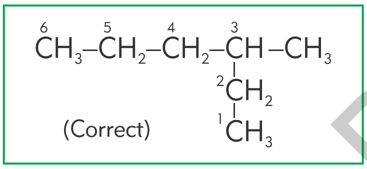
Saturated hydrocarbon:	Unsaturated hydrocarbon:
• Saturated hydrocarbons contain carbon carbon single bond.	• Unsaturated hydrocarbons contain carbon carbon double and tripple bonds.
• The valancies of all carbon atoms are fully satisfied through single bond.	• The valancies of all carbon atoms are fully satisfied through double and triple bond.
• Saturated hydrocarbons have a less amount of carbon and high amount of hydrogen.	• Unsaturated hydrocarbon have a less amount of hydrogen and high amount of carbon as compared to satured hydrocarbons.
• Saturated hydrocarbons are less reactive.	• Unsaturated hydrocarbons are more reactive.
• They burns with blue and non sooty flame in air.	• They burn with yellow and sooty flame in air.
• The compounds of saturated hydrocarbon are alkanes	• The compounds of unsaturated hydrocarbon are alkenes and alkynes.
• Alkanes are represented by general formula C_nH_{2n+2}.	• The general Formula of alkenes (C_nH_{2n}) and alkynes (C_nH_{2n-2}).
• Examples of alkanes are Ethane ($CH_3–CH_3$), Propane ($CH_3–CH_2–CH_3$).	• Examples of alkenes are Ethene ($CH_3=CH_3$), Propene ($CH_3–CH_2=CH_3$) and Example of alkynes, Ethyne ($CH\equiv CH$), Propyne ($CH_3–C\equiv CH$)

3.5 Nomenclature:

Organic compounds were once classified according to their sources. For example, methane as a marsh gas, methyl alcohol as a wood spirit, and acetic acid from vinegar (Latin: aceteum=vinegar) these are trivial names. Due to their fast rise, the number of organic compounds has increased, posing an issue in naming them. A symposium of top chemists was organized in Geneva to address the issue. In 1882, They developed a naming system known as the Geneva system. In Liege in 1930, the International Union of Chemistry (I.U.C.) changed this approach. The International Union of Pure and Applied Chemistry developed the I.U.C system even more. The I.U.P.A.C system of naming was created in 1960.even further. The I.U.P.A.C system of nomenclature was created in 1960.

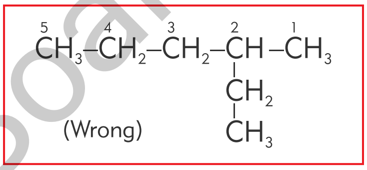
Rules for naming Alkanes:

1. Consider the parent alkane and select the longest possible continuous chain of carbon atoms, whether straight or branched.



$\overset{6}{C}H_3-\overset{5}{C}H_2-\overset{4}{C}H_2-\underset{\substack{|\\ {}^{2}CH_2\\ |\\ {}^{1}CH_3}}{\overset{3}{C}H}-CH_3$

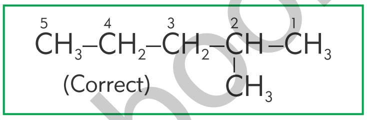
(Correct)



$\overset{5}{C}H_3-\overset{4}{C}H_2-\overset{3}{C}H_2-\underset{\substack{|\\ CH_2\\ |\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

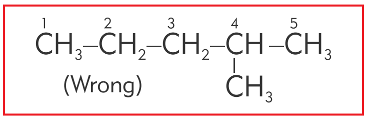
(Wrong)

2. Assign numbering on c-atoms of chain from that end to which branch or radical is nearer.



$\overset{5}{C}H_3-\overset{4}{C}H_2-\overset{3}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

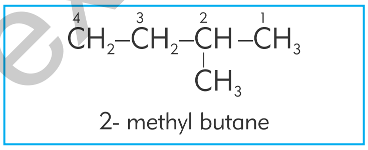
(Correct)



$\overset{1}{C}H_3-\overset{2}{C}H_2-\overset{3}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{4}{C}H}-\overset{5}{C}H_3$

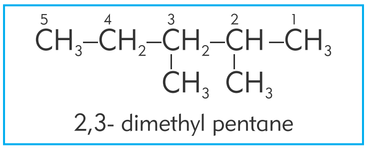
(Wrong)

3. Name the alkyl radical with its position.



$\overset{4}{C}H_2-\overset{3}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

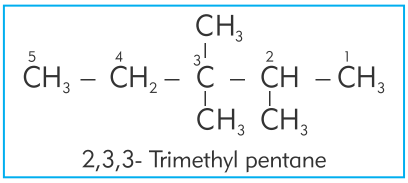
2- methyl butane



$\overset{5}{C}H_3-\overset{4}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{3}{C}H_2}-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

2,3- dimethyl pentane

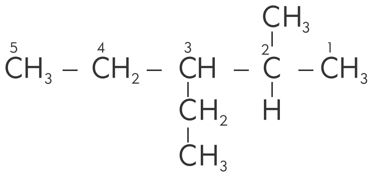
4. If the same radical appears more than once in the chain, the number of alkyl radicals is expressed by prefixing the name of the alkyl radical with di, tri, tetra, penta, and so on.



$\overset{5}{C}H_3-\overset{4}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{\substack{CH_3\\ |}}{{}^{3}C}}-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

2,3,3- Trimethyl pentane

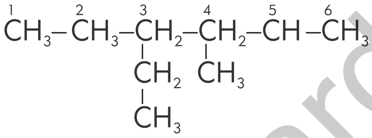
5. When there are two or more separate alkyl radicals in a chain, they are designated in alphabetical order, ethyl before methyl, methyl before propyl, and so on.



$$\overset{5}{C}H_3-\overset{4}{C}H_2-\underset{\begin{array}{c}|\\CH_2\\|\\CH_3\end{array}}{\overset{3}{C}H}-\underset{\begin{array}{c}|\\H\end{array}}{\overset{\begin{array}{c}CH_3\\|\\2\end{array}}{C}}-\overset{1}{C}H_3$$

3–ethyl, 2–methyl pentane

6. When separate alkyl radicals occur at the same location on a carbon atom from either end of the chain, the carbon chain is numbered from that end to which larger radical is nearer.



$$\overset{1}{C}H_3-\overset{2}{C}H_3-\underset{\begin{array}{c}|\\CH_2\\|\\CH_3\end{array}}{\overset{3}{C}H_2}-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{4}{C}H_2}-\overset{5}{C}H-\overset{6}{C}H_3$$

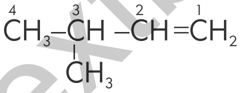
3–ethyl,4–methyl hexane

7. In the end name of parent chain is named as alkane w.r.t number of c-atoms.

Rules for naming Alkenes:

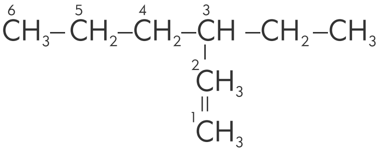
1. Choose the longest continuous chain of carbon atoms, which must include both double-bonded carbon atoms.

2. Regardless of alkyl radicals, the longest chain is numbered from the end closest to the carbon-carbon double bond.



$$\overset{4}{C}H_3-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{3}{C}H}-\overset{2}{C}H=\overset{1}{C}H_2$$

3– methyl, 1–butene



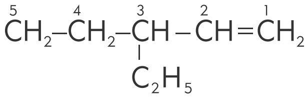
$$\overset{6}{C}H_3-\overset{5}{C}H_2-\overset{4}{C}H_2-\underset{\begin{array}{c}|\\{}^{2}CH_3\\||\\{}^{1}CH_3\end{array}}{\overset{3}{C}H}-CH_2-CH_3$$

3–ethyl, 1–hexene

3. The presence of a double bond in a compound is indicated by replacing the suffix "ane" of the corresponding alkane with "ene," as well as the location of the double bond in the chain.

$$\overset{6}{C}H_3-\overset{5}{C}H_2-\overset{4}{C}H-\overset{3}{C}H=\overset{2}{C}H-\overset{1}{C}H_3$$

2–hexene



$$\overset{5}{C}H_2-\overset{4}{C}H_2-\underset{\begin{array}{c}|\\C_2H_5\end{array}}{\overset{3}{C}H}-\overset{2}{C}H=\overset{1}{C}H_2$$

3–ethyl–1–pentene

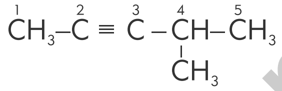
4. If there are two or more double bonds in the chain, the prefixes di, tri, tera, and so on are added before the suffix "ene" with its position.

$$\overset{6}{C}H_3-\overset{5}{C}H=\overset{4}{C}H-\overset{3}{C}H_2=\overset{2}{C}H-\overset{1}{C}H_2$$

2,4–hexadiene

Rules for naming Alkynes:

1. Choose the longest continuous chain of carbon atoms, which must include both triple-bonded carbon atoms.
2. Regardless of alkyl radical, the longest chain of carbon atoms is numbered from the end closest to the carbon-carbon triple bond.



$$\overset{1}{C}H_3-\overset{2}{C}\equiv\overset{3}{C}-\underset{\displaystyle CH_3}{\overset{4}{C}H}-\overset{5}{C}H_3$$

4–methyl–2–pentyne

3. The number of the carbon atom with the lowest value indicates the position of the triple bond.
4. By changing the suffix "ane" of the matching alkane to "yne," the triple bond in the compound is indicated.

$$\overset{4}{C}H_3-\overset{3}{C}H_2-\overset{2}{C}\equiv\overset{1}{C}H_3$$

1–butyne

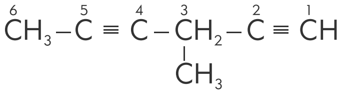
$$\overset{1}{C}H_3-\overset{2}{C}\equiv\overset{3}{C}-\overset{4}{C}H_2-\overset{5}{C}H_3$$

2–pentyne

5. When there are two or more triple bonds in the chain, the prefixes di, tri, and so on are added before the suffix-"yne" with its position.

$$\overset{5}{C}H_3-\overset{4}{C}\equiv\overset{3}{C}-\overset{2}{C}\equiv\overset{1}{C}H$$

1,3–pentadiyne



$$\overset{6}{C}H_3-\overset{5}{C}\equiv\overset{4}{C}-\underset{\displaystyle CH_3}{\overset{3}{C}H_2}-\overset{2}{C}\equiv\overset{1}{C}H$$

3–methyl–1, 4–hexadiyne

6. When both double and triple bonds are present at same locations in a chain of molecule, the double bond is given priority in numbering.

$$\overset{1}{C}H_2=\overset{4}{C}H-\overset{3}{C}H_2-\overset{4}{C}\equiv\overset{5}{C}H$$

1–penten–4–yne

$$\overset{1}{C}H_3-\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H_2-\overset{5}{C}\equiv\overset{6}{C}-\overset{7}{C}H_3$$

2–hepten–5–yne

7. When there are both double and triple bonds at various places in a chain, the numbering begins at the end where the double or triple bond is closest.

$$\overset{6}{C}H_3-\overset{5}{C}H=\overset{4}{C}H-\overset{3}{C}H_2-\overset{2}{C}\equiv\overset{1}{C}H$$

4–hexen–1–yne

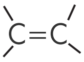
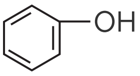
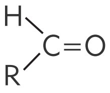
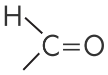
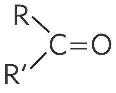
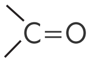
$$\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}H_2-\overset{4}{C}\equiv\overset{5}{C}-\overset{6}{C}H_3$$

1–hexen–4–yne

3.6 Functional groups:

The functional group, is an atom or group of atoms that is responsible for the features of organic molecules. Each functional group has its own distinct characteristics. As a result, a functional group is defined as an atom or group of atoms whose existence in an organic compound gives distinctive qualities to that compound. The structure of a certain family of organic molecules is also defined by the functional group. The functional group in alkyi halides (R–X) is the halogen atom (–X), while in alcohols (R–OH), the hydroxyl group (–OH) is the functional group. The functional group governs an organic compound's fundamental chemistry, whereas the alkyl group affects its physical properties. The polar hydroxyl group (–OH) in alcohols, for example, improves solubility. The non-polar alkyl group resists it in water. This opposing action is sufficiently higher for any alkyl groups larger than C4H9 (Butyl) to restrict a compound's solubility in water. Names of certain common functional groups, as well as the structures of organic compounds containing them, are listed in Table 3.3

Table 3.3 Functional Groups

S.#	Homologous Series	General Molecular Formula	Functional Group and its name
i.	Alkanes	C_nH_{2n+2} or R–H	———
ii.	Alkenes	C_nH_{2n}	 Double bond
iii.	Alkynes	C_nH_{2n-2}	$-C\equiv C-$ Triple bond
iv.	Haloalkanes	R–X (where X=F, Cl, Br, I) or $C_nH_{2n+1}X$	–X (Halide group)
v.	Alcohols	R–OH or C_nH_{2n+1} OH	–OH (Hydroxyl group)
vi.	Phenols	 or C_6H_5OH	–OH (Hydroxyl group)
vii.	Ethers	R–O–R′ or $C_nH_{2n+2}O$	–OR′ (Alkoxy group)
viii.	Aldehydes		 (Carbonyl group) or –CHO (aldehyde group)
ix.	Ketones		 (Carbonyl group) (kenotic group)

x.	Carboxylic Acids	$R–\overset{\overset{O}{\|}}{C}–OH$ or R–COOH	$–\overset{\overset{O}{\|}}{C}–OH$ (Carbonyl group) (Carboxylic group)
xi.	Esters	$R–\overset{\overset{O}{\|}}{C}–OR'$	$–\overset{\overset{O}{\|}}{C}–OR'$ (Alkoxy carbonyl group) or Ester group

3.6.1 Functional Groups Containing Carbon, Hydrogen and Oxygen

The organic compounds containing carbon, hydrogen and oxygen as functional groups are alcohols, ethers, aldehydes, ketones, carboxylic acids and esters. Their class name, functional group, class formula and examples are given in the Table 11.4.

(i) Alcoholic Group

The functional group of alcohol is -OH. Their general formula is ROH. Where R is any alkyl group.

$CH_3 – OH$	$CH_3 – CH_2 – OH$	$CH_3 – CH_2 – CH_2 – OH$
Methyl alcohol	Ethyl alcohol	n-Propyl alcohol

(ii) Ether Linkage

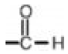
The functional group of ether is C - O - C. Their general formula is R - O - R` where R and R' are alkyl groups.

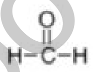
R and R' may be same or different, such as:

$H_3C - O - CH_3$ Dimethyl ether, $C_2H_5 - O - C_2H_5$, Diethyl ether $H_3C - O - C_2H_5$, Ethyl methyl ether

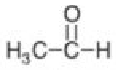
(iii) Aldehydic Group

Aldehyde family consists of carbonyl functional group. Their general formula is RCHO. Where R stands for H or some alkyl groups, such as:


$–\overset{\overset{O}{\|}}{C}–H$


$H–\overset{\overset{O}{\|}}{C}–H$

Formaldehyde


$H_3C–\overset{\overset{O}{\|}}{C}–H$

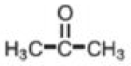
Acetaldehyde

(iv) Ketonic Group

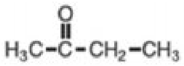
Compounds containing the functional group $>C=O$ are called ketones.

They have the general formula $R–\overset{\overset{O}{\|}}{C}–R'$ where R and R' are alkyl groups.

They may be same or different, such as:


$H_3C–\overset{\overset{O}{\|}}{C}–CH_3$

Acetone (Dimethyl ketone)

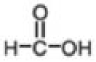

$H_3C–\overset{\overset{O}{\|}}{C}–CH_2–CH_3$

Ethyl methyl ketone

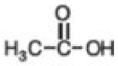
(v) Carboxyl Group

Compounds containing functional group $–\overset{\overset{O}{\|}}{C}–OH$ are called carboxylic acids.

Their general formula is $R–\overset{\overset{O}{\|}}{C}–OH$ where R stands for — H or some alkyl groups. Such as:


$H–\overset{\overset{O}{\|}}{C}–OH$

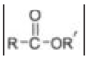
Formic acid


$H_3C–\overset{\overset{O}{\|}}{C}–OH$

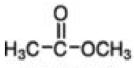
Acetic acid

(vi) Ester Linkage

Organic compounds consisting of RCOOR' functional group are called esters.

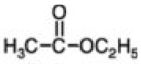
Their general formula is where  $R-\overset{O}{\overset{\|}{C}}-OR'$ R and R'are alkyl groups.

They may be same or different, such as:



$H_3C-\overset{O}{\overset{\|}{C}}-OCH_3$

Methyl acetate



$H_3C-\overset{O}{\overset{\|}{C}}-OC_2H_5$

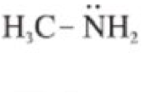
Ethyl acetate

Table 3.4 Functional groups containing carbon, hydrogen and oxygen

Class Name	Functional Group	Class Formula	Examples
Alcohols			
Primary	$-CH_2-OH$	$R-CH_2-OH$	CH_3-CH_2-OH
Secondary	$>CH-OH$	$\begin{matrix}R\\R\end{matrix}>CH-OH$	$\begin{matrix}H_3C\\H_3C\end{matrix}>CH-OH$
Tertiary	$\begin{matrix}\|\\-C-OH\\\|\end{matrix}$	$\begin{matrix}R\\\|\\R-C-OH\\\|\\R\end{matrix}$	$\begin{matrix}CH_3\\\|\\H_3C-C-OH\\\|\\CH_3\end{matrix}$
Ethers	$-O-$	$R-O-R$	$H_3C-O-CH_3$
Aldehydes	$-\overset{O}{\overset{\|}{C}}-H$	$R-\overset{O}{\overset{\|}{C}}-H$	$H_3C-\overset{O}{\overset{\|}{C}}-H$
Ketones	$-\overset{O}{\overset{\|}{C}}-$	$R-\overset{O}{\overset{\|}{C}}-R$	$H_3C-\overset{O}{\overset{\|}{C}}-CH_3$
Carboxylic acids	$-\overset{O}{\overset{\|}{C}}-OH$	$R-\overset{O}{\overset{\|}{C}}-OH$	$H_3C-\overset{O}{\overset{\|}{C}}-OH$
Esters	$-\overset{O}{\overset{\|}{C}}-OR$	$R-\overset{O}{\overset{\|}{C}}-OR$	$H_3C-\overset{O}{\overset{\|}{C}}-OC_2H_5$

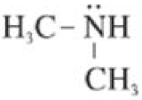
3.6.2 Functional Group Containing Carbon, Hydrogen and Nitrogen:

The organic compounds containing carbon, hydrogen and nitrogen as functional group are called as amines. Their functional group is $-NH_2$ and their general formula is $R-NH_2$. Examples of amines are:



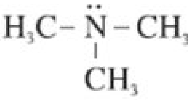
$H_3C-\ddot{N}H_2$

Methylamine



$H_3C-\underset{CH_3}{\underset{|}{\ddot{N}H}}$

Dimethylamine



$H_3C-\underset{CH_3}{\underset{|}{\ddot{N}}}-CH_3$

Trimethylamine

3.6.3 Functional Group Containing Carbon, Hydrogen and Halogens:

The organic compounds having functional group containing carbon, hydrogen and halogens are called alkyl halides. Their functional group is R-X. 'X' may be F, Cl, Br or I.

Table 3.5 Functional group containing carbon, hydrogen and halogens

Class Name	Functional Group	Class Formula	Examples	
Alkyl Halides				
a. Primary	$-CH_2-X$	$R-CH_2-X$	H_3C-CH_2-X	Ethyl halide
b. Secondary	$>CH-X$	$\begin{array}{l}R\\R\end{array}\!>CH-X$	$\begin{array}{l}H_3C\\H_3C\end{array}\!>CH-X$	*sec-* Propyl halide
c. Tertiary	$-\overset{\vert}{\underset{\vert}{C}}-X$	$R-\overset{R}{\underset{R}{C}}-X$	$H_3C-\overset{CH_3}{\underset{CH_3}{C}}-X$	*ter-* Butyl halide

3.6.4 Double and Triple Bond:

Hydrocarbon consisting of double bonds between two carbon atoms in their molecules are called as alkenes, such as:

$H_2C=CH_2$ Ethene

$H_3C-HC=CH_2$ Propene

Hydrocarbon consisting of triple bonds between two carbon atoms in their molecules are called as alkynes, such as:

$HC\equiv HC$ Ethyne (Acetylene)

$H_3C-C\equiv CH$ Propyne

Test Yourself

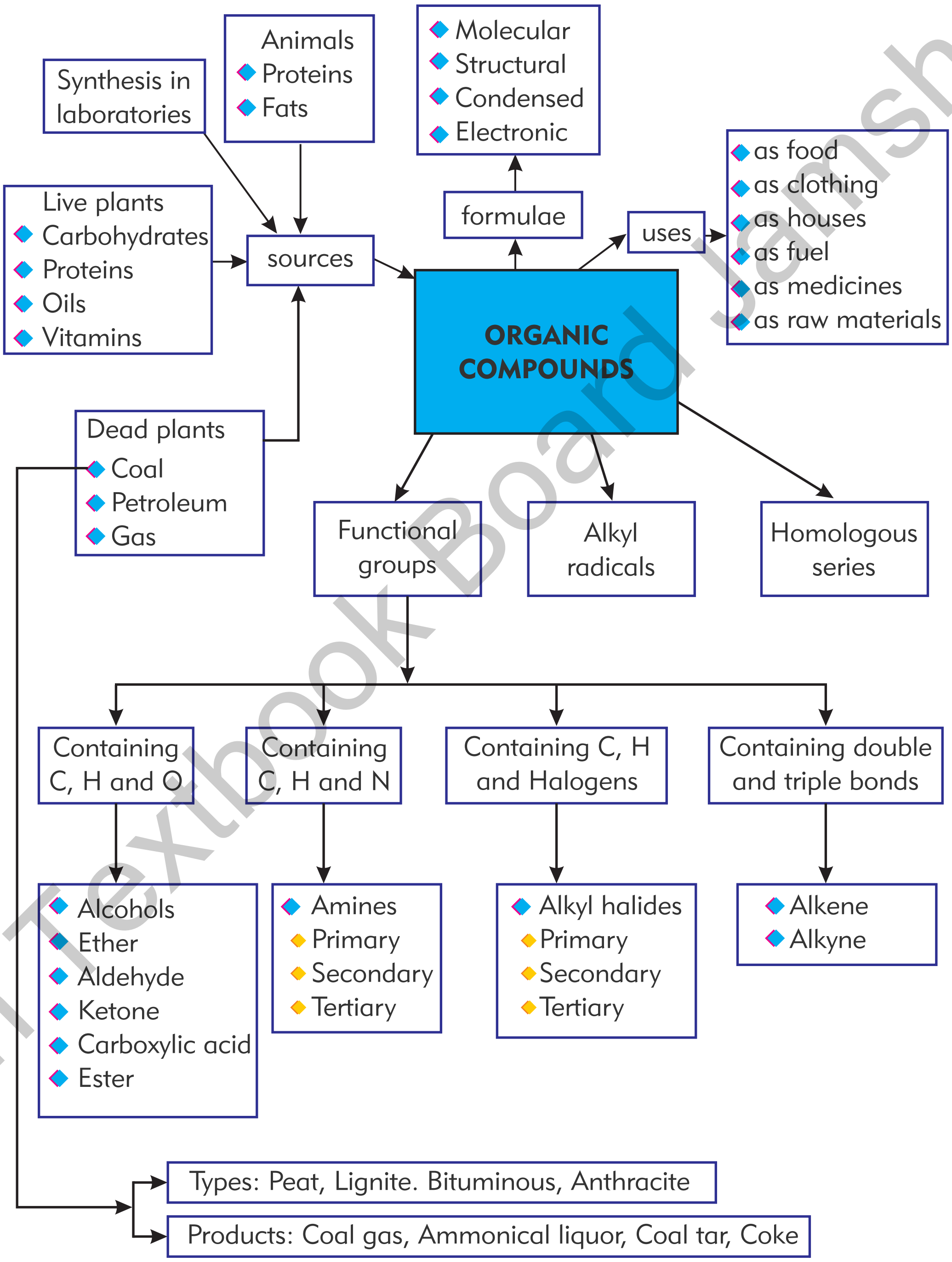
1. Identify functional group in the given compounds: CH_3CH_2OH, CH_3OCH_3, CH_3CHO
2. If we dip a blue litmus paper in a solution and it changes to red color which functional group does the solution have?

Society, Technology and Science

Role of pharmaceutical chemist in the synthesis of effective new drugs

The pharmaceutical chemist plays an important role in the pharmaceutical industry by laboratory analysis, quality assurance, quality control and production of new effective drugs. Pharmaceutical chemist prepare and select appropriate compounds for biological evolutions and decide its active implementation for diseases. The chemist plays the most critical role in the drug development process and serve as the backbone to framework for the drug discovery .

CONCEPT DIAGRAM



Summary

- First time Berzelius used the word organic compound for those compounds which were obtained from animals and plants.
- According to Vital Force Theory, organic compounds can only be prepared in living tissues by vital force.
- Urea is the first synthesized organic compound and it was prepared by Wohler in 1828.
- Carbon is an essential element in all natural and synthesized organic compounds.
- Hydrocarbons are composed of hydrogen and carbon atoms.
- The study of hydrocarbons and their derivatives is modern definition of organic chemistry.
- Self-linking property of carbon is called catenation.
- The compounds having same molecular formula but different structures are termed as isomers.
- Due to catenation and isomerization millions of organic compounds are existed in the universe.
- On the basis of chains organic compounds are divided into main two classes- open chain and closed chain (cyclic) compounds.
- Saturated hydrocarbons contain carbon-carbon single bonds. Alkanes are saturated hydrocarbons.
- Unsaturated hydrocarbons contain carbon-carbon double and triple bonds. Alkenes ($C=C$) and alkynes are ($C\equiv C$) unsaturated hydrocarbons.
- Organic compounds are soluble in organic solvents like benzene, carbon disulphide, ether alcohols etc.
- Organic compounds have weaker bonding than ionic compounds so they have lower melting and boiling points.
- Organic compounds have slow rate of reactions.
- On combustion, all organic compounds produce one of the common product carbon dioxide.
- The members of homologous series have same functional group.
- Coal is also called black gold.
- In Pakistan the name sui gas is used for natural gas.
- The name of organic compound is composed of two parts: Prefix + suffix. Prefix tells thenumber of carbon atoms and suffix functional group in each molecule.
- Alkyl radicals are formed by the removal of hydrogen from alkanes.
- A functional group is an atom or group of atoms that gives a molecule its characteristic properties.
- On the basis of functional groups organic compounds are divided into different families.
- Many organic compounds are used in perfumes, scents, paints, dyes and drugs.

Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

1. Encircle the correct answer:

(i) The branch of chemistry which deals with the hydrocarbons and their derivatives is known as:

(a) Organic chemistry (b) Inorganic chemistry (c) Biochemistry (d) Physical chemistry

(ii) The general formula for alkanes is:

(a) C_nH_{2n} (b) C_nH_{2n+1} (c) C_nH_{2n+2} (d) C_nH_{2n-2}

(iii) Which of the following is an alcohol?

(a) CH_3CHO (b) CH_3-CH_2-O-CH_3 (c) CH_3-OH (d) HCOOH

(iv) Which of the following is saturated hydrocarbon?

(a) $CH_3CH{=}CH_2$ (b) CH_3-CH_2-CH_3 (c) CH_3-C≡CH (d) CH_2=CH-C≡CH

(v) The prefix 'hept' stands for the .... carbon atoms.

(a) 2 (b) 5 (c) 7 (d) 9

(vi) The functional group –COOH is used for:

(a) Alkynes (b) alcohols (c) Phenols (d) Carboxylic acids

(vii) Polyethene is:

(a) oil (b) paper (c) plastic (d) wood

(viii) Acetic acid is obtained from:

(a) Banana (b) Dates (c) Garlic (d) Vinegar

(ix) Alkenes:

(a) show same general formula as alkynes.
(b) have carbon carbon triple bond.
(c) have carbon carbon double bond.
(d) are saturated hydrocarbons.

(x) CH_3-CH_2- is ... radical.

(a) Methyl (b) Ethyl (c) n-propyl (d) Isopropyl

SECTION- B: SHORT QUESTIONS:

(i) Define Vital Force Theory.
(ii) Explain how petroleum is source of organic compounds?
(iii) Define the functional group. Write the functional groups which contain carbon, hydrogen and oxygen.

(iv) Define the alkyl radicals with suitable examples.
(v) What is homologous series? Name the some common homologous series.

(vi) Identify the functional groups in the following compounds.

(a) CH_3-CHO (b) CH_3-CH_2-CH_2-OH (c) CH_3-CO-CH_3

(d) CH_3-COOH (e) CH_2=CH-CH_3

(vii) Write the condensed and structural formulae of the pentane and octane.

(viii) What is catenation? Give any two examples of catenation of carbon atoms.

SECTION- C: DETAILED QUESTIONS:

(i) Give the important characteristics of organic compounds.
(ii) Differentiate between saturated and unsaturated hydrocarbons.

(iii) What are the main sources of organic compound? mention with special reference of coal, petroleum and natural gas.

(iv) Describe the uses of organic compound.

(iv) Name the alkenes and alkynes having the following formula.

(i)	C_2H_4	(ii)	C_3H_4	(iii)	C_3H_6	(iv)	C_6H_{12}
(v)	C_5H_8	(vi)	C_8H_{16}	(vii)	C_7H_{12}	(viii)	C_6H_{10}

(v) Define nomenclature and describe the I.U.P.A.C nomenclature rules for alkynes.

(vi) What do you mean by diversity and magnitude of organic compounds?

Chapter
4

Biochemistry

Time Allocation

Teaching periods	= 11
Assessment period	= 02
Weightage	= 11%

MAJOR CONCEPTS:

4.1 Carbohydrates
4.2 Proteins
4.3 Lipids
4.4 Nucleic acids
4.5 Vitamins

STUDENTS LEARNING OUT COMES (SLO'S)

Students will be able to:

- Describe the composition of carbohydrates.
- Distinguish between mono-, di- and trisacchrides.
- Describe the bonding in protein molecule.
- Describe the sources and uses of carbohydrates, proteins and lipids.
- Differentiate between fats and oils.
- Describe the importance of nucleic acids.
- Explain the types of nucleic acids [deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)].
- Define and explain the vitamins and their importance.

Introduction:

The word Biochemistry (Bio=Life + Chemistry) means chemistry of life. This branch of chemistry deals with the study of chemical and physical processes inside living system which involve chemical compounds such as carbohydrates, vitamins, proteins, lipids and nucleic acids. It focuses on what is happening inside our cells and looks at how cells communicate with each other. Thus biochemistry can be defined as, The branch of chemistry which deals with the study of chemical substances and processes that occur in living organisms (plants and animals) is known as biochemistry.

The history of biochemistry may be considered from Ancient Greeks.
However, biochemistry as a specific discipline was accepted a little before 19th century. First time the word biochemistry was used by a German chemist Carl Neuberg in 1903.

Do You Know?

Food is essential for life on Earth and is a complex mixture of chemical substances. Food fuels metabolic processes. In living beings, certain complex organic molecules are broken down into simpler ones to provide energy (catabolism), while others are transformed into complex organic compounds to store energy (anabolism), such as starch and glycogen. Both biology and chemistry cope with these opposing processes. Thus a new science was introduced called biochemistry.

4.1 Carbohydrates

Carbohydrates are naturally occurring organic compounds and are important component of our food. Generally they contain elements like carbon, hydrogen and oxygen. Mostly carbohydrates are represented by general formula $Cx(H_2O)y$ because in these compounds hydrogen and oxygen are in the ratio as in H_2O. Actually these compounds do not contain water molecules.

The structural analysis shows that these compounds contain aldehyde group (-CHO), ketone group (>C=O) along with alcoholic hydroxyl groups (-OH). Thus carbohydrates are defined as, "polyhydroxy aldehydes or poly hydroxy ketones or large molecules that produce these compounds on hydrolysis". The carbohydrates which contain aldehyde group are generally termed as aldoses and those which contain ketone group are termed as ketoses.

Majority of carbohydrates are sweet in taste so they are also called Sacchrides (Latin, saccharum = sugar). Carbohydrates also have property to rotate the plane polarized light.

Do You Know?

Those carbohydrates which rotate plane polarized light to clock wise are known as dextrorotatory (indicated by D or +) while those which rotate anti-clock wise are known as levorotatary (indicated by L or -).

Classification of carbohydrates

On the basis of hydrolysis, there are three types of carbohydrates.

4.1.1 Monosacchrides (Greek mono = one)

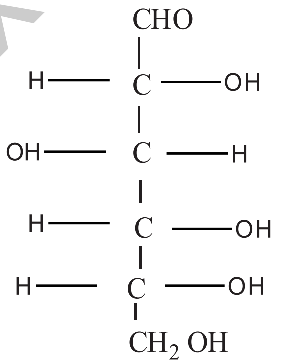
These are also called simple sugars. These carbohydrates cannot be further simplified on hydrolysis. Monosacchrides contain 3 to 10 carbon atoms and may be subdivided into trioses, tetroses, pentoses, hexoses etc depending upon the number of carbon atoms they possess. Glucose (grape sugar) belongs to aldoses and fructose (honey) to ketoses are examples of monosacchrides.

$$\text{Monosacchride} + \text{water} \xrightarrow{\text{Hydrolysis}} \text{No reaction}$$

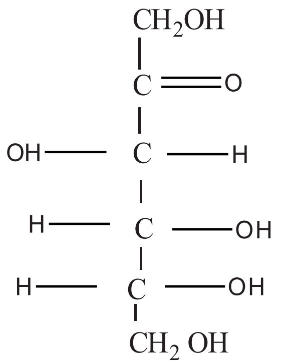
$$C_6H_{12}O_6 + \text{water} \xrightarrow{\text{Hydrolysis}} \text{No reaction}$$

Glucose is obtained naturally as dextrorotatory and is present in most delicious foods, such as grapes (20-30 percent). It can also be found in honey. It may be found in the combined state in cane sugar, cellulose, and starch. Photosynthesis is how plants synthesize glucose. Glucose is generated when carbon dioxide reacts with water in the presence of sunlight and chlorophyll (catalyst). Plants also use glucose to make starch and cellulose. Because glucose is a necessary component of human blood, it is also known as blood sugar. The normal range for blood glucose is 65-110 mg (0.06-0.1%) per 100 mL. Glucose is commonly thought to be a rapid source of energy for patients.

Fructose (Latin fructus = fruit) occurs in ripe fruits, honey, cane sugar etc.



Glucose
(It is an aldose sugar)



Fructose
(It is ketose sugar)

Monosacchrides are crystalline solids, sweet in taste and are soluble in water.

4.1.2 Oligosacchrides (Greek oligo = few)

These carbohydrates produce 2 to 10 monosacchride's on hydrolysis. The oligosaccharides which contain two monosacchrides are called disaccharides and those which contain three are known as trisacchrides and so on.

$$\text{Oligosacchrides} + \text{water} \xrightarrow{\text{Hydrolysis}} \text{2-10 monosacchrides}$$

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + \underset{\text{Water}}{H_2O} \xrightarrow{\text{Hydrolysis}} \underset{\text{Glucose}}{C_6H_{12}H_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

In oligosaccharides, monosacchrides are connected with each other by glycosidic bond/ linkage. Sucrose, maltose, lactose (milk sugar) etc are important members of oligosaccharides. Like monosacchrides, oligosaccharides are crystalline solids, sweet in taste and soluble in water.

4.1.3 Polysacchrides (Greek poly = many)

These carbohydrates produce more than ten monosacchrides on hydrolysis. These are also called polymeric carbohydrates. In these carbohydrates, monosacchrides are connected by glycosidic linkage.

$$\text{Polysacchrides} + \text{water} \longrightarrow \text{More than10 monosacchrides}$$

$$\underset{\text{Cellulose or starch}}{(C_6H_{10}O_5)_n} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Glucose}}{n\,(C_6H_{12}H_6)}$$

Cellulose, starch (plant origin), glycogen (animal origin), amylose etc are common polysaccharides. Cellulose is found in the cell walls, wood, linen, paper, cotton etc. Cotton contains 95% cellulose. Starch occurs in cereals like wheat, rice barley etc and roots of potatoes. Glycogen is also called animal starch, found in muscles and liver of animals.

Unlike monosacchrides and oligosaccharides, polysaccharides are amorphous solids, tasteless and insoluble in water.

4.1.4 Sources and uses of carbohydrates

Carbohydrates are important food factor and obtained from various sources like fruits, vegetables and dairy products.

Table 4.1 carbohydrates and their sources

Carbohydrates	Sources
Monosacchrides **Glucose** **Fructose**	Grapes, honey, guava, molasses ,honey etc
Oligosacchrides **Sucrose** **Lactose** **Maltose** **Raffinose**	Sugarcane , sugar beet, beet root, carrots, maple, pine apple etc Milk Wheat, barley etc Legumes
Polysacchrides **Cellulose** **Starch** **Glycogen (also called animal starch)**	Cell wall of all land plants, cotton etc Cereal foods (Wheat, barley), potato, legumes, small amount in root vegetables Liver, muscles etc

Figure 4.1 Sources of carbohydrate

Do You Know?

Insulin is hormone which enables our body to use glucose obtained from food or glycogen (stored food) for the production of energy. If body lacks insulin, the glucose level will be increased in blood which leads to the diabates.

Uses of carbohydrates

1. They are required as a energy source for the survival of both plants and animals.
2. They sustain structure of plants.
3. Carbohydrates, in the form of starch in plants and glucose in mammals, serve as energy storage.
4. They keep our blood sugar levels in check.
5. Sucrose is a food additive. It's found in confectioneries, condensed milk, canned fruits, jams, and jellies, among other things.
6. Carbohydrate fiber helps in cholesterol reduction and blood pressure regulation.
7. Carbohydrates coexist with a variety of proteins and lipids in biosystems.
8. Celluloses provide food its bulk and fibre. It promotes peristalsis in the intestine.
9. Cellulose is used as a raw material in a variety of industries, including textiles and paper.
10. Starch is used to improve the writing characteristics of paper by coating and sizing it.
11. Starch is utilized in the production of ethanol and in laundries.

Test Yourself

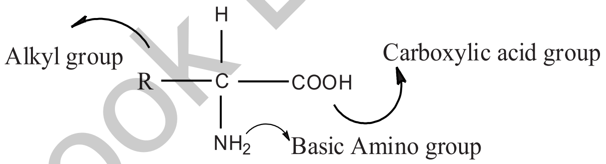
1. What are the carbohydrates?
2. What is the difference between monosacchrides and oligosacchrides?

4.2 Proteins

The word protein is taken from Greek Proteios means first. These are nitrogenous macro-molecules found in all the cells of living organisms. Proteins have central position in architecture and functioning of living matter. They are composed of carbon, hydrogen, nitrogen, oxygen and very rarely sulphur and phosphorus. Proteins are defined as: The polymers (macro-molecules formed of simple units called monomers) of amino acids are called proteins.

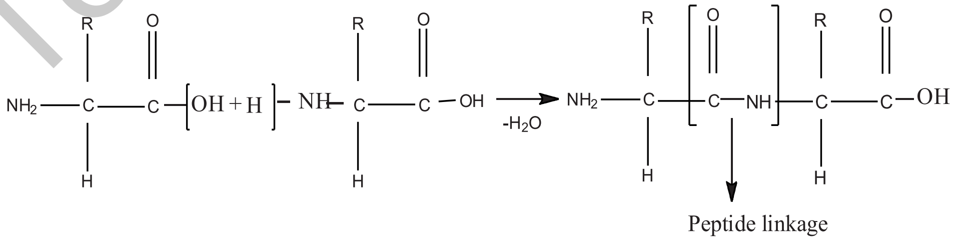
4.2.1 Amino acids as a monomers or building blocks of proteins

Amino acids are building blocks of proteins. They are bi-functional compounds and contain basic amino (-NH_2) and acidic carboxyl group (-COOH) groups. Upto twenty amino acids have been found in nature, ten are essential and remaining ten non-essential. Body can only synthesize non-essential ten amino acids. The general formula for amino acids is:



$$\mathrm{R-\underset{NH_2}{\overset{H}{C}}-COOH}$$

Where 'R' is the chain of carbon atoms. During the condensation of amino acids, –OH (from carboxyl group) of one amino acid and H (from amino group) of another amino acid are combined and eliminated as water (H_2O) molecule. Thus a new linkage is formed between two amino acid units known as peptide linkage/ bond. Due to this linkage protein is formed.



Proteins may contain 60 to 6000 amino acid molecules. A protein molecule is formed with two amino acids is termed as dipeptide, with three tripeptide and so on. Generally the molecular weight of proteins ranges from 43000 – 50,000,000 daltons (1dalton =1a.m.u).

4.2.3 Sources and uses of proteins

The important sources of proteins are eggs, meat, pulses, nuts, edible seeds, beans, peas, cheese etc.

Uses of proteins:

1. Animal proteins can be found in meat, mutton, poultry, fish, and eggs. Humans consume them as food since they are required for protoplasm production.
2. Enzymes are proteins generated by living organisms. They help to stimulate chemical processes in our body. They are highly specialized and extremely efficient. Many enzymes are utilized in pharmaceuticals. They cure blood cancer as well as decrease bleeding.
3. Proteins are hides. These are used in the tanning process to create leather. Leather is used to produce shoes, coats, and sports equipment, among other things.
4. Bones are rich in proteins. When bones are cooked, gelatin is produced. Bakery goods are made with gelatin.
5. Plants, such as pulses, beans, and other legumes, manufacture proteins as well. These are utilized as a source of food.

Figure 4.2 Sources of protiens

4.3 Lipids

A group of naturally occurring heterogeneous organic compounds which includes fats, oils, waxes and are insoluble in water means hydrophobic (water repellent) but easily soluble in Bloor's reagent (mixture of diethyl ether and ethyl alcohol in the ratio of 2:1) and organic solvents like ether, benzene, acetone, carbon tetra chloride and chloroform. Generally lipids are composed of elements like carbon, hydrogen and oxygen, but there are some lipids which contain nitrogen and phosphorous too. Lipids are the building blocks of cells.

Figure 4.3 Sources of lipids

Do You Know?

How vegetable oil is converted into saturated fat (ghee)? The chemical process used for this is hydrogenation, in this process vegetable oil (unsaturated organic compound) is treated with molecular hydrogen (H_2) in the presence of catalyst nickel (Ni) or palladium (Pd). Thus fat is formed by addition reaction of H_2 with oil.

4.3.1 Fatty Acids

Fatty acids are lipids' building components. They're carboxylic acids with a lengthy chain, either saturated or unsaturated. For example:

$C_{15}H_{31}COOH$	Palmitic acid
$C_{17}H_{35}COOH$	Stearic acid

In the presence of mineral acids, these acids produce esters (oils or fats) with glycerol.

Table 4.2 Differentiate between fats and oils.

S.No	Fats	Oils
1	These are solids at ordinary room temperature.	These are liquids at ordinary room temperature.
2	They are obtained mainly from animals.	They are obtained mainly from plants.
3	These are saturated compounds.	These are unsaturated compounds.
4	They have high melting points.	They have low melting points.
5	They increase cholesterol level in body.	They maintain cholesterol level in body.

4.3.2 Sources and uses of lipids

Sources of lipids

Animals:

Marine animals like salmon and whales are rich sources of lipids. Butter, ghee, cheese are obtained from animals.

Plants:

Sun flower, coconut, ground nuts, corn, cotton seed, olive etc are important plant sources of lipids.

Uses of lipids:

(i) They act as transporter of fatty acids and fat soluble vitamins (vitamin A, D, E & K) in body.

(ii) Some lipids reduce cholesterol level in body.

(iii) Fats and oils are used for cooking and frying of food.

(iv) Fats and oils are used in detergents, soaps, cosmetic, polishes and paints.

(v) They activate the enzymes.

(vi) Animal fats are found in adipose tissue cells. Animals secrete milk from which butter and ghee is obtained. Butter and ghee are used for cooking and frying of food, for preparing bakery products and sweets.

4.4 Nucleic acids

The name nucleic acid implies that they generally occur in nuclei of the cells. But some nucleic acids are also present in cytoplasm. Like proteins, nucleic acids are biopolymers. They are most important of all biomolecules because they store and transmit hereditary information from parents to children. In living organisms, even single fertilized egg carries the information for making the different organs like heart, liver, eyes, kidneys, hands, legs, heads etc. They contain elements like carbon, hydrogen, oxygen, nitrogen and rarely phosphorous etc. Nucleic acids are simply defined as, “The macromolecules which are formed by the polymerization of nucleotides (monomers) are called nucleic acid“. Each nucleotide is composed of:

(i) Pentose sugar

(ii) Phosphate group

(iii) Nitrogenous base (purines and pyrimidines)

4.4.1 Types of nucleic acids

There are two types of nucleic acids. These both types of nucleic acids are present in all animals and plants.

Deoxyribonucleic acid (DNA)

Deoxyribose sugar is found in DNA. J. Watson and F. Crick identified its structure in 1953. It's a two-chained double-stranded molecule with a considerable length. Sugar, phosphate, and a base make up each chain. The backbone of the chains is made up of sugar and phosphate groups, and two chains are joined by bases. Figure 4.4 shows how the chains are wrapped around each other in a double helix shape.

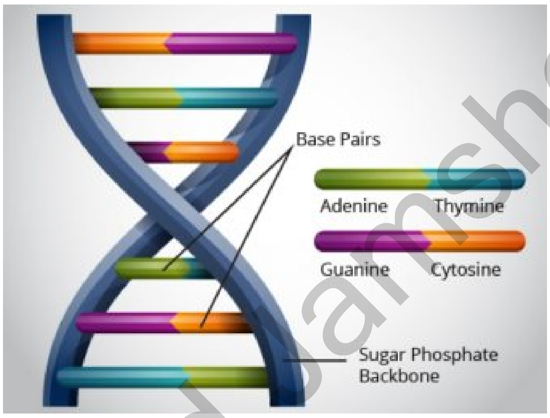


Figure 4.4 Structure of DNA

In the nucleus of a cell, DNA is the permanent storage site for genetic information. It transports and stores all of the cell's genetic information. It conveys these instructions on how to build certain proteins from amino acids from generation to generation. These instructions are referred to as the "genetic code of life." They decide whether a cell is a nerve cell or a muscle cell, and if an organism is a man, a tree, or a buffalo.

Protein formation in new cells is determined by the sequence of nitrogenous bases in DNA. The purpose of DNA's double helix construction is to ensure that there is no disorder. DNA contains genes that regulate RNA production. Errors in the genes cause incorrect RNA to be produced. It makes defective proteins that don't work the way they're meant to. Genetic disorders are caused by this ailment.

Ribonucleic acid (RNA)

It is made up of ribose sugar. It's a molecule with only one strand. It is in charge of putting genetic information to work in the cell in order to produce proteins. Its function is similar to that of a messenger.

DNA produces RNA in order to convey genetic information. The information sent to RNA is received, read, decoded, and used to build new proteins. As a result, RNA is in charge of guiding the production of new proteins.

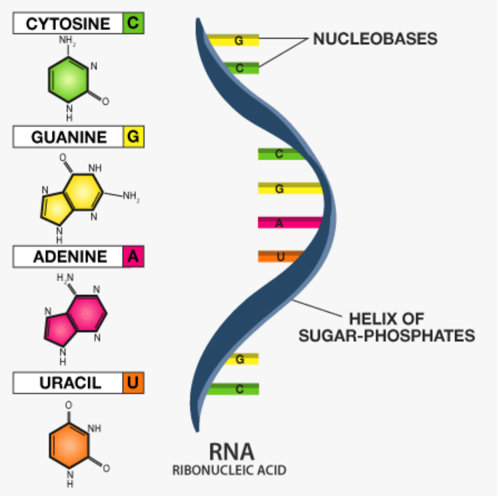


Figure 4.5 Structure of RNA

4.4.2 Importance of Nucleic Acid

1. Nucleic acid are the most vital ,material for cell functioning.
2. Nucleic acids are the storage of genetic information
3. Nucleic acid work for mutation to save the cells and body from threatening diseases.
4. Nucleic acids transfer heredity characters from one generation to another generation.
5. Nucleic acids serve as source of energy in the form of ATP.

4.5 Vitamins

Hopkins discovered in 1912 that there are other nutrients required for optimal development in addition to carbohydrates, proteins, and lipids. Despite the fact that these compounds were only required in modest amounts, they were considered Accessory Growth Factors. These compounds were later given the name Vitamin by Funk. Vitamin B_1 (Thiamin) was discovered by him.

4.5.1 Types of vitamins

On the basis of solubility, there are two types of vitamins.

(i) Water soluble vitamins

Those vitamins which are soluble in water are called water soluble vitamins. These vitamins are obtained from cereals and fruits. Generally, vitamin B (complex) and vitamin C are water soluble vitamins. These vitamins are not stored in body. If we take these vitamins in excess, they cannot harm us. Further, these vitamins are easily excreted from our body.


Figure 4.6 Beriberi affected child
(Deficiency of vitamin B)

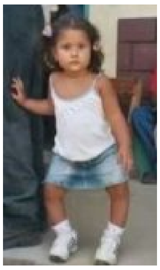


Figure 4.7 Rickets affected child
(Deficiency of vitamin D)

(ii) Fat soluble vitamins

Those vitamins which are soluble in fats and organic solvents are called fat soluble vitamins. Vitamins A, D (sunshine vitamin), E and K are fat soluble vitamins and are stored in the body for long period of time. These vitamins are obtained from lipids. If we take over doses of vitamins, they may harm us and cause diseases. For example excess of vitamin A causes irritation and head ache, vitamin D calcification and pain in bones, vitamin E fatigue and headache and vitamin K liver and kidney diseases.

Table 4.3 Vitamins, their sources, importance and deficiency caused diseases

S.No	Vitamins	Sources	importance	Deficiency diseases
1.	A	Butter, fish, eggs, milk, cheese, carrots etc. It may be obtained from the coloring matter of green and yellow vegetables.	Eyes (form visual pigments), skin	Night blindness (an inability to see in dim light), Xerophthalmia (tear glands cease to function), dryness of skin etc.
2.	B (complex)	Wheat, rice, eggs, milk, meat, liver, nuts, yeast etc.	Nerves, skin	Beriberi (causes inflammation of nerves and heart failure), Dermatitis (red and swollen skin), loss of hairs, tongue inflammation, inflammation of lips, burning of eyes, thickening of skin etc
3.	C (Ascorbic acid)	Oranges, lemon, tomatoes, green peepers etc.	Heal wounds, prevent gum bleeding and cold.	Scurvy (swelling gums and opening of healed wounds).
4.	D (Anthracitic vitamin)	Fish, Milk, butter, mushrooms sunshine etc.	Bones, teeth (controls the metabolism of calcium and phosphorus in body).	Rickets (softening and weakening of bones in children).
5.	E (Sometimes it is called fertility factor)	Plant oils like wheat germ oil, cotton seed oil, corn germ oil, soyabean oil, peanut oil etc. It also occurs in green leafy vegetables.	Maintain cell membrane and proper functioning of reproductive system.	Sterility, haemolysis (fragility of R.B.C) etc.
6.	K	Green vegetables like spinach, alfalfa, cabbage, cereals etc.	Form blood clotting factor.	Hemorrhage (increase blood clotting time).

Society, Technology and Science

Commercial uses of enzymes

On a commercial basis, enzymes are used for a variety of applications. The following are some examples of enzymes and their use in industry:

Commercially, yeast enzymes are utilized in the fermentation of molasses and starch to make alcohol (Ethanol). Diastase, invertase, and zymase are the enzymes in question.

Detergents include microbial enzymes (powder or liquid). Lipases are enzymes that break down fats into more water-soluble molecules. Amylase is a starch-based stain remover. Cellulase breaks down cellulose into glucose, which is a water-soluble substance. Protein stains on garments are broken down by bacterial proteases. As a result, enzyme-based detergents efficiently clean and eliminate all stains and grime.

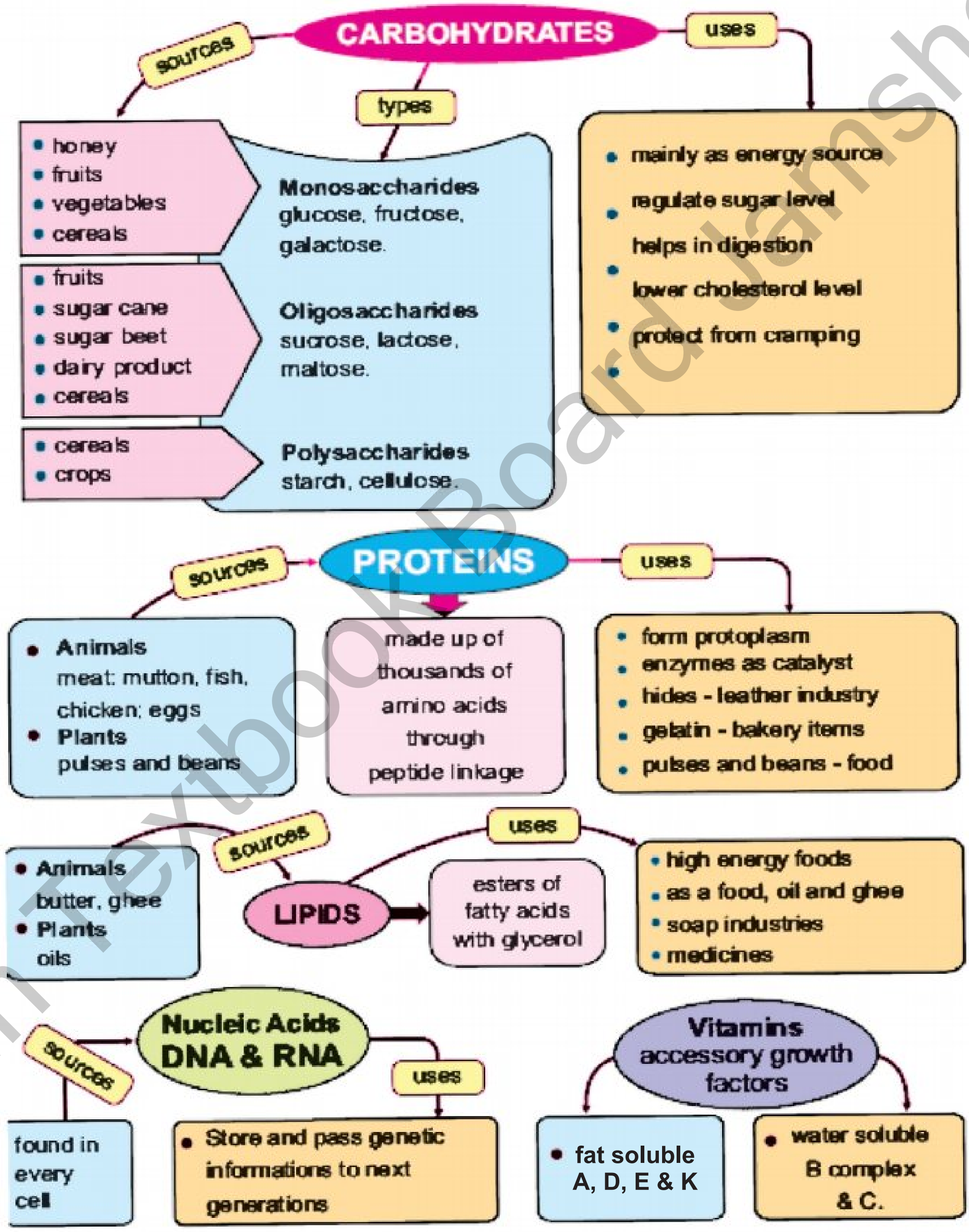
Fruit juices are purified with the help of enzymes. They're used in fruit that's been crushed, such as grapes. By eliminating suspended particles, the yield of the juice produced is increased. It also helps to enhance the color of the fruit skins.

Amylase enzymes are utilized in the production of bread because they can increase the amount of starch in the flour. Even they are capable of converting starch to sugary glucose syrup. This may be used as a sweetener in cuisine as well as in the baking of bread.

The lactase enzyme is used to make ice cream sweeter. Lactose is broken down in milk to galactose and glucose, both of which are sweeter than lactose.

Enzymes are used in the dairy sector to make cheeses, yogurt, and other dairy products, while others are employed to improve the texture or flavor of the product.

CONCEPT DIAGRAM



CARBOHYDRATES

sources

- honey
- fruits
- vegetables
- cereals

- fruits
- sugar cane
- sugar beet
- dairy product
- cereals

- cereals
- crops

types

Monosaccharides
glucose, fructose, galactose.

Oligosaccharides
sucrose, lactose, maltose.

Polysaccharides
starch, cellulose.

uses

- mainly as energy source
- regulate sugar level
- helps in digestion
- lower cholesterol level
- protect from cramping

PROTEINS

sources

- **Animals**
  meat: mutton, fish, chicken; eggs
- **Plants**
  pulses and beans

made up of thousands of amino acids through peptide linkage

uses

- form protoplasm
- enzymes as catalyst
- hides - leather industry
- gelatin - bakery items
- pulses and beans - food

LIPIDS

sources

- **Animals**
  butter, ghee
- **Plants**
  oils

esters of fatty acids with glycerol

uses

- high energy foods
- as a food, oil and ghee
- soap industries
- medicines

Nucleic Acids DNA & RNA

sources

found in every cell

uses

- Store and pass genetic informations to next generations

Vitamins accessory growth factors

- fat soluble A, D, E & K
- water soluble B complex & C.

Summary

- Biochemistry deals with the study of chemical reactions taking place in the living organisms.
- In 1903, first time Carl Neuberg used the word 'Biochemistry'.
- Carbohydrates contain aldehyde group (-CHO) or ketone group (>C=O) along with many hydroxyl groups (-OH).
- The general formula for carbohydrates is $C_x(H_2O)_y$.

  Aldoses, a family of carbohydrates, contain aldehyde group and many hydroxyl groups.

  Ketoses, a family of carbohydrates, contain ketone group and many hydroxyl groups
- On the basis of hydrolysis, carbohydrates are divided into main three types-mono-, di- and trisacchrides.
- Carbohydrates provide 2 to 10 monosacchrides on hydrolysis are called oligosaccharides.
- Carbohydrates provide more than 10 monosacchride's on hydrolysis are called polysaccharides.
- Cellulose and starch are the common plant origin polysaccharides.
- Proteins are the polymers of amino acids.
- Through peptide bonds amino acids are connected with each other in proteins.
- A protein may contain 60 to 6000 amino acid molecules.
- Proteins are building blocks of body.
- Enzymes are proteins which catalyze the biological reactions. Enzymes are also called biocatalysts.
- Haemoglobin is a protein which transports the oxygen to various parts of body.
- Fats are solids at room temperature and increase the cholesterol level in body.
- Nucleic acids are biomolecules which store and transmit hereditary information from parents to children.
- Nucleotides are the monomers of nucleic acids.
- DNA is store house of information. It encodes genetic information and transfers it to generation to generation.
- RNA receives, decodes, reads and uses the information obtained from DNA.
- Vitamin B complex and vitamin C are water soluble vitamins. Excess of these vitamins cannot harm us.
- Fat soluble vitamins (A, D, E and K) are stored in the body. If quantity of these vitamins exceeds, body is affected by various diseases like vitamin A causes irritation and head ache; vitamin D calcification and pain in bones; vitamin E fatigue and headache; vitamin K liver and kidney diseases.

Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

(i) **Glucose is:**
(a) vitamin (b) protein (c) carbohydrate (d) lipid

(ii) **The deficiency of vitamin D causes:**
(a) beriberi (b) rickets (c) scurvy (d) haemorhage

(iii) **….. encodes a genetic information.**
(a) R.N.A (b) D.N.A (c) progesterone (d) cholesterol

(iv) **The carbohydrates which contain aldehyde group are called:**
(a) sacchrides (b) ketoses (c) pentoses (d) aldoses

(v) **Amino acids are building blocks of:**
(a) nucleic acids (b) protein (c) vitamins (d) lipid

(vi) **Which one of the following is polysacchride.**
(a) Fructose (b) maltose (c) starch (d) None of these

(vii) **Lactose is:**
(a) Grape sugar (b) honey sugar
(c) milk sugar (d) cane sugar

(viii) **What is true about a peptide?**
(a) It is a protein
(b) It is an anhydride of a carboxylic acids
(c) It is an anhydride of an amine
(d) It is a polyamide.

(ix) **Fats are solids at:**
(a) ordinary room temperature (b) high temperature
(c) higher than 50°C temperature (d) None of these

(x) **Cotton contains … cellulose.**
(a) 30% (b) 65% (c) 85% (d) 95%

SECTION- B: SHORT QUESTIONS:

(i) What are the proteins?

(ii) Define the importance of deoxyribose nucleic acid (DNA).

(iii) Differentiate between fats and oils.

(iv) What are the polysaccharides? How monosaccharides are produced from polysaccharides?

(v) What is peptide bond? How it is formed? And also explain dipeptides and tripeptides.

(vi) Enumerate the important uses of lipids.

(vii) What are the amino acids and give their general structure?

(viii) What is vitamin D? Give its sources and importance.

(ix) Distinguish between fat soluble and water soluble vitamins.

SECTION- C: DETAILED QUESTIONS:

(i) What are the carbohydrates? Explain sources and uses of carbohydrates.

(ii) What are lipids? Write down the sources and uses of lipids.

(iii) Describe vitamins and types of vitamins.

(iv) Describe in detail nucleic acids, RNA and DNA.

(v) How you can justify that deficiency of different types of vitamins causes diseases in human beings

Chapter
5

Environmental Chemistry-1
The Atmosphere

Time Allocation

Teaching periods	= 10
Assessment period	= 02
Weightage	= 10%

MAJOR CONCEPTS:

5.1 Composition of Atmosphere
5.2 Layers of Atmosphere
5.3 Pollutants
5.4 Acid rain and its effects
5.5 Ozone depletion and its effects
5.6 Green house effect

STUDENTS LEARNING OUT COMES (SLO'S)

- Define atmosphere. (Remembering)
- Explain composition of atmosphere. (Understanding)
- Differentiate between stratosphere and troposphere (Analyzing)
- Summarize the components of stratosphere and troposphere (Understanding)
- Describe major air pollutants. (Understanding)
- Describe source and effects of air pollutants. (Understanding)
- Explain ozone formation (Understanding)
- Describe acid rain and its effects (Understanding)
- Describe the ozone depletion and its effects (Understanding)
- Describe global warming (Understanding)

Introduction:

The scientific study of chemical and biological events that occur in natural settings is known as environmental chemistry. It is the study of chemical species' origins, interactions, movement, impacts, and destinies in the air, soil, and water environments, as well as the impact of human and biological activities on these. Environmental chemistry is an interdisciplinary subject that encompasses atmospheric, water, and soil chemistry, as well as depending significantly on analytical chemistry and being linked to other fields of study.

A material or energy which is present in excess of the natural concentration and produce an adverse effect upon the environment is known as pollutant and the phenomena is known as pollution. This pollution creates harmful effects on atmosphere which we will discuss in detail in this chapter.

What is atmosphere?

The earth is surrounded by a layer of gases called the atmosphere. The atmosphere protects Earth like a big blanket of insulation. It absorbs the heat from the Sun and keeps the heat inside the atmosphere helping the Earth to stay warm. This big blanket also helps to form our weather patterns and climate. All of these things are important for life and the Earth's ecology. The atmosphere does not end at a specific place. The higher above the Earth something is, the thinner the atmosphere around it is. There is no clear border between the atmosphere and outer space.

5.1 Composition of atmosphere

The atmosphere is the air that plants and animals breathe to survive. It is made up of nitrogen (78.09 %) and oxygen (20.95%), with small amounts of argon (0.93%), carbon dioxide (0.03 %), water vapor, and other gases. There are lots of other gases like neon, helium, hydrogen that are part of the atmosphere, but in much smaller amounts. Solid particulate, including ash, dust, volcanic ash, etc. are also small parts of atmosphere. They are important in making clouds and fog.

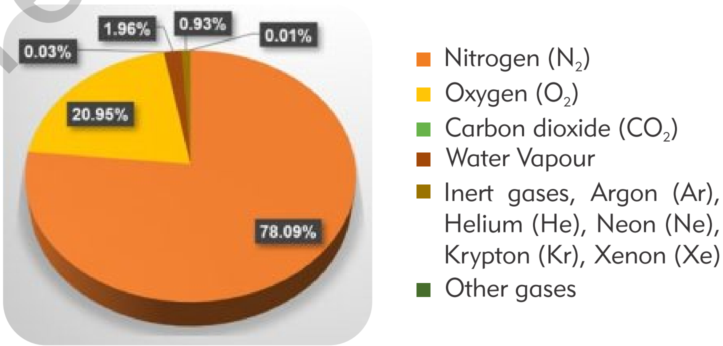
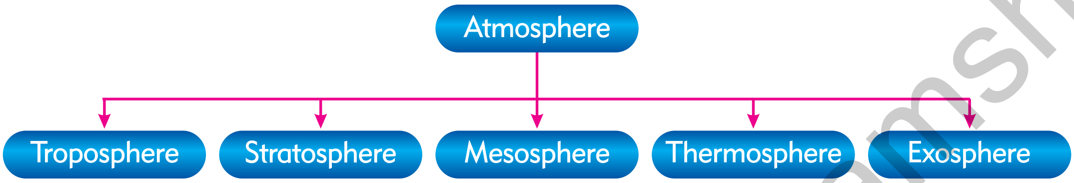


Figure 5.1 Composition of atmosphere

5.2 Layers of Atmosphere

The Earth's atmosphere is divided up into 5 major layers. These layers are classified on the bases of temperature and density with respect to earth surface; following are the layers of the atmosphere, starting from the ground to upward:



Here we will only discuss following two layers of atmosphere

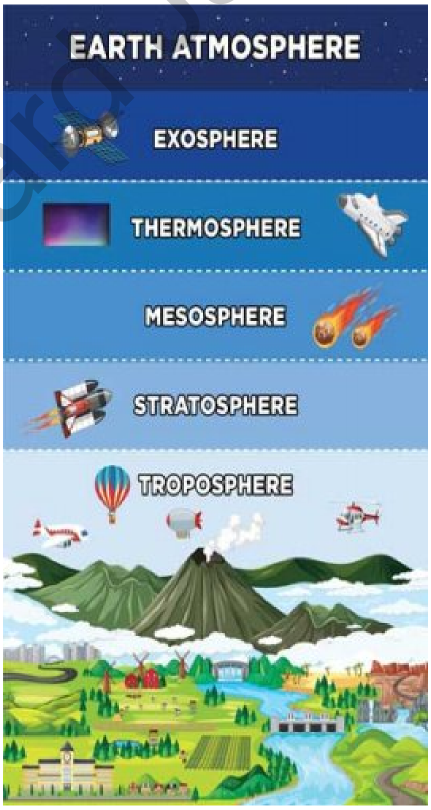


Figure 5.2 Earth atmosphere

Troposphere: The troposphere is the lowest layer of Earth's atmosphere. It extends from Earth's surface to an average height of about 12 km, although this altitude varies from about 9 to 17 kilometers (9 km at the poles, 17 km at the Equator) above earth's surface. This is where we live and even where planes fly mostly. Weather in this layer affects our daily life. Around 80% of the mass of the atmosphere is in the troposphere.

Stratosphere: The stratosphere is the second-lowest layer of Earth's atmosphere. It lies above the troposphere and is separated from it by the tropopause. This layer extends from the top of the troposphere at roughly 12 km above Earth's surface to the stratosphere at an altitude of about 50 to 55 km. The higher the altitude the hotter is the atmosphere. Unlike the troposphere the stratosphere gets its heat by the Ozone Layer absorbing radiation from the sun. As a result, it gets warmer the further away you get from the Earth. There are less water vapors and other substances in this layer. Weather balloons go as high as the stratosphere.

Do You Know?

The higher you go in troposphere, the colder it is. Since At high altitude, atmospheric pressure is lower than that at sea level. It is this lower pressure at higher altitudes that causes the temperature to be colder on top of a mountain than at sea level.

Distinguish between Troposphere and Stratosphere

Troposphere	Stratosphere
1. It is the lowest point on the earth's surface.	1. It is the uppermost layer of the atmosphere after the troposphere.
2. It stands at a height of around 11 kilometers above sea level.	2. It rises up to 50 kilometers above sea level.
3. The troposphere makes up around 75% of the mass of the atmosphere.	3. The stratosphere has a far less amount of atmosphere than the troposphere.
4. As you climb higher in this sphere, the temperature drops steadily. It ranges in temperature from 15°C to -56°C.	4. The temperature fluctuates somewhat with height and usually the higher the altitude the hotter it gets.
5. Ozone, which is found here, is a polluting gas.	5. The presence of ozone here shields the planet from ultraviolet radiation.
6. There is a lot of movement of the air, and this area is part of an active weather system.	6. There is a lack of air movement in this area.
7. Almost all planes pass through this layer.	7. Airplanes are not permitted in this layer.
8. N_2, O_2, CO_2, and water vapours are the most essential gases in this sphere.	8. In this layer water vapours and gases are quite low in quantity.

Test Yourself

- What Is Atmosphere?
- From which gases our atmosphere is made up of?
- How would you differentiate between stratosphere and troposphere?

5.3 Pollutants

A waste material that pollutes the air, water, or land is referred to as a pollutant. A pollutant's severity is determined by three factors: its chemical type, concentration, and persistence. Human activities produce and release these contaminants into the environment. They endanger human life by polluting the environment (air, water, and soil). Pollutants are chemicals that pollute the environment. Contaminants, on the other hand, are things that make something impure. Air pollutants are hazardous compounds found in the atmosphere. Pollutants in the air alter the weather, have a negative impact on human health, harm vegetation, and cause the destruction of structures.

Types of Pollutants

There are seven types of pollutants
- Air pollutants
- Water pollutants
- Soil pollutants
- Thermal pollutants
- Radioactive pollutants
- Noise pollutants
- Light pollutants

But in this chapter we will only discuss air pollutants and air pollution.

5.3.1 Major air pollutants

Primary and secondary pollutants are the two types of major air pollutants. The waste or exhaust products produced by the burning of fossil fuels and organic materials are referred to as primary pollutants. Sulfur oxide (SO_2), carbon oxides (CO_2 and CO), nitrogen oxides (especially nitric oxide NO), hydrocarbons (CH_4), ammonia, and fluorine compounds are among them. Primary pollutants create secondary pollutants through a variety of processes. Sulphuric acid, carbonic acid, nitric acid, hydrofluoric acid, ozone, and peroxy acetyl nitrate (PAN) are secondary pollutants.

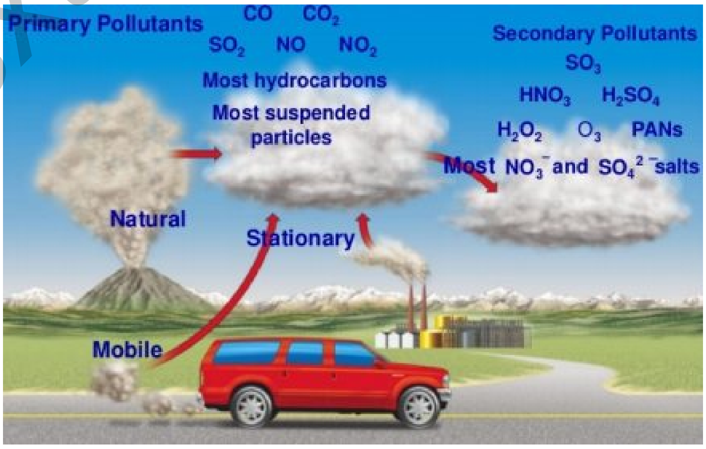
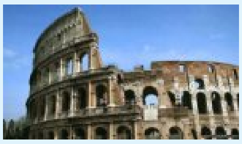


Figure 5.3 Major air pollutants

Pollutant	Sources	Environmental risks	Human health risks
Carbon monoxide (CO)	Emissions from automobiles, fires, and industrial operations	causes the production of smog 	In healthy persons, it can increase symptoms of cardiac disease, such as chest discomfort; it can also cause visual difficulties and diminish physical and mental skills.
Nitrogen oxides (NO and NO_2)	Emissions from automobiles, electrical generation, and industrial operations	It causes harm to the plants and helps to the creation of pollution. 	Inflammation and irritation of the respiratory tract.
Sulfur dioxide (SO_2)	Electricity generation, fossil-fuel burning, industrial activities, and automotive emissions are all examples of pollution sources.	Key contributor to the creation of acid rain, which destroys flora, buildings, and monuments; interacts to generate particulate matter 	Having trouble breathing, especially if you have asthma or heart problems
Ozone (O_3)	NOx and VOCs from industrial and car emissions, gasoline vapours, chemical solvents, and electrical utilities are all sources of ozone.	Interferes with certain plants' capacity to breathe, making them more vulnerable to other environmental stresses (e.g., disease, harsh weather) 	Lung function is impaired, and breathing passageways are irritated and inflamed.

Particulate matter	Fires, smokestacks, building sites, and unpaved roads are examples of primary particle sources; interactions between gaseous compounds released by power plants and cars are examples of secondary particle sources.	Contributes to the creation of haze and acid rain, which alters the pH balance of streams and harms vegetation, buildings, and monuments 	breathing passage discomfort, asthma exacerbation, irregular heartbeat
Lead (Pb)	Metal processing, garbage incineration, and fossil-fuel burning are all examples of industrial processes.	Biodiversity loss, reduced reproduction, and neurological difficulties in vertebrates are all issues that need to be addressed. 	When young children are exposed, it can have negative effects on numerous body systems and can lead to learning problems. Adults' cardiovascular consequences.

5.4 Acid rain and its effects

As you know, burning fossil fuels releases sulphur and nitrogen oxides into the atmosphere. SO_2 is converted to H_2SO_4 by rainwater, while NOx is converted to HNO_2 and HNO_3 by rainwater. Rainwater is somewhat acidic because it contains dissolved CO_2 from the atmosphere. It has a pH of 5.6 to 6. Rainwater, on the other hand, becomes increasingly acidic as a result of dissolving air pollutants (acids), and its pH drops to 4. Acid rain is created when rainwater dissolves acidic air pollutants like sulphur dioxide and nitrogen dioxide. The conversion of sulphur and nitrogen oxides into acids is seen in Figure. Acid rain causing harm to soil, animals, plants, and aquatic life.

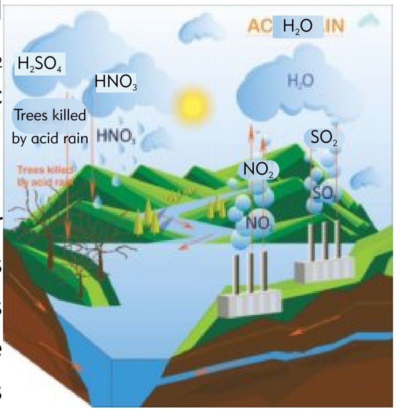


Figure 5.4
Acid rain

Effects of acid rain

1. Acid rain leaches heavy metals (Al, Hg, Pb, Cr, etc.) from soil and rocks and discharges them into rivers and lakes. Humans consume this water as a source of drinking water. These metals build up to hazardous levels in the human body. The aquatic life in lakes, on the other hand, suffers as a result of the high concentration of these metals. The fish gills become clogged when there is a very high concentration of aluminum ions. It causes fish to suffocate and die as a result.
2. Acid rain eats away the calcium carbonate in marble and limestone, which is found in many structures and monuments. As a result, these structures are becoming increasingly drab and degraded.
3. Acid rain makes the soil more acidic. Many crops and plants are unable to thrive in such conditions. It also raises the levels of hazardous metals in the soil, which damage the plants. Because of the acidity of the soil, even elderly trees are impacted. Their development is slowed. They wilt and perish as a result of the dryness.
4. Acid rain causes direct harm to tree and plant leaves, restricting their development. Plant development may be impeded depending on the severity of the injury. Plants' capacity to withstand cold or illnesses deteriorates, and they eventually perish.

5.5 Ozone Depletion and its Effects

Ozone Formation:

Three oxygen atoms make up ozone (O_3), a highly reactive gas. It is a natural and man-made substance that occurs in the higher atmosphere of the Earth (stratosphere).

Ozone has a positive or negative impact on life on Earth depending on its location in the atmosphere.

The interaction of solar ultraviolet (UV) light with molecular oxygen produces stratospheric ozone (O_3). The "ozone layer," which is located about 6 to 30 miles above the Earth's surface, decreases the quantity of dangerous UV light that reaches the earth surface.

Photochemical interactions between two primary groups of air pollutants, volatile organic compounds (VOC) and nitrogen oxides, produce tropospheric or ground-level ozone, in which humans breathe.

Ozone Depletion:

Three oxygen atoms make up ozone, which is an allotropic form of oxygen. It is created in the atmosphere when an oxygen atom joins an oxygen molecule in the mid-stratosphere.

Ozone is found in all parts of the atmosphere. However, its highest concentration, known as the ozone layer, is found in the stratosphere, roughly 25 to 30 kilometers above the Earth's surface. This layer surrounds the Earth and acts as a screen against damaging UV radiation. UV rays would induce skin cancer if ozone layer were not present. As a result, the ozone layer in the stratosphere is advantageous to life on earth.

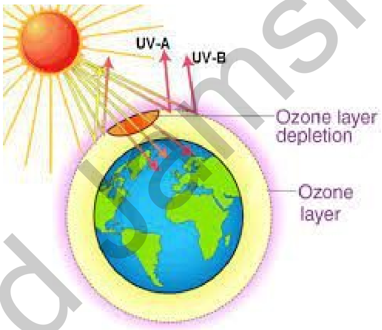


Figure 5.5
Ozone depletion

Ozone concentration in the stratosphere is essentially constant under normal conditions due to a series of complicated atmospheric interactions.

However, different chemical interactions are depleting the ozone layer. such as, chlorofluorocarbons (CFCs), which are utilized as refrigerants in air conditioners and refrigerators, are a major contributor to ozone depletion. These substances leak in some way and disperse into the stratosphere. The C-Cl bond in $CFCl_3$ is broken by ultraviolet light, resulting in chlorine free radicals.

These free radicals have a high level of reactivity. They react with ozone to produce oxygen in the following way:

$$O_{3(g)} + Cl^{\bullet} \longrightarrow O_{2(g)} + OCl^{\bullet}$$

$$OCl^{\bullet} \longrightarrow O^{\bullet} + Cl^{\bullet}$$

$$O^{\bullet} + O^{\bullet} \longrightarrow O_{2(g)}$$

A single chlorine free radical produced by the breakdown of CFCs has the potential to damage millions of ozone molecules. The ozone hole is a location where the ozone layer is depleted.

The first signs of ozone depletion were seen over Antarctica in the 1980s. Depletion has also been seen in the Arctic during the 1990s.

Effect of ozone depletion

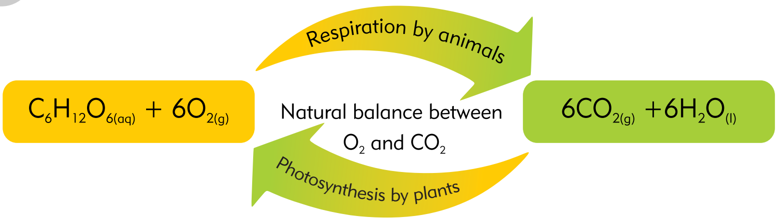
Even slight ozone depletion issues might have significant consequences.

1. Ozone depletion allows UV light from the Sun to reach the Earth, which can cause skin cancer in humans and other animals.
2. As the ozone layer gets thinner, infectious illnesses such as malaria become more prevalent.
3. It has the potential to disrupt the food chain by altering plant life cycles.
4. It has the ability to alter wind patterns, resulting in global climate shifts. Asia and the Pacific, in particular, would be the most impacted regions, as a result of the human migration issue caused by climate change.

5.6 Green House Effect (Global Warming)

CO_2 produces an envelope-like layer surrounding the Earth. It permits the Sun's heat rays to flow through it and reach the Earth's surface. These rays are reflected off the Earth's surface and return to the upper atmosphere. The normal CO_2 layer concentration maintains enough heat to keep the atmosphere warm. As a result, maintaining a normal CO_2 content is both required and advantageous for maintaining a comfortable temperature. The Earth would have been uninhabitable otherwise. Instead of the current average temperature of 15°C, the Earth's average temperature would be around -20°C. CO_2 is not a contaminant of the atmosphere. Rather, it is a necessary gas for plants, just as O_2 is for mammals. Photosynthesis consumes CO_2 and produces O_2 in plants.

Animals consume O_2 in their breathing and emit CO_2. As a result, a natural equilibrium between these important gases exists, as seen above. However, as a result of various human activities spewing more and more CO_2 into the air, this equilibrium is being disrupted.



Despite the fact that CO_2 is not a harmful gas, its rising concentration as a result of the combustion of fossil fuels in various human activities is concerning. CO_2 in the atmosphere works as a greenhouse's glass wall. It permits UV and IR radiations to pass through, but not the other way around. Some of the infrared light released by the Earth is trapped by it.

As a result, higher CO_2 concentration absorbs infrared radiation generated by the Earth's surface, preventing heat energy from exiting the atmosphere. It aids in preventing the surface from cooling down at night. As CO_2 concentrations in the atmosphere rises, less thermal energy is lost from the Earth's surface. As a result, the surface's average temperature progressively rises. This is known as the greenhouse effect. The quantity of CO_2 in the air has a direct relationship with this impact. The greater the amount of CO_2, the greater the heat trapping or warming. This phenomena is also known as global warming because of the increased temperature. Primary green house gases in the earth's atmosphere are, water vapors, CO_2, CH_4, N_2O and ozone.

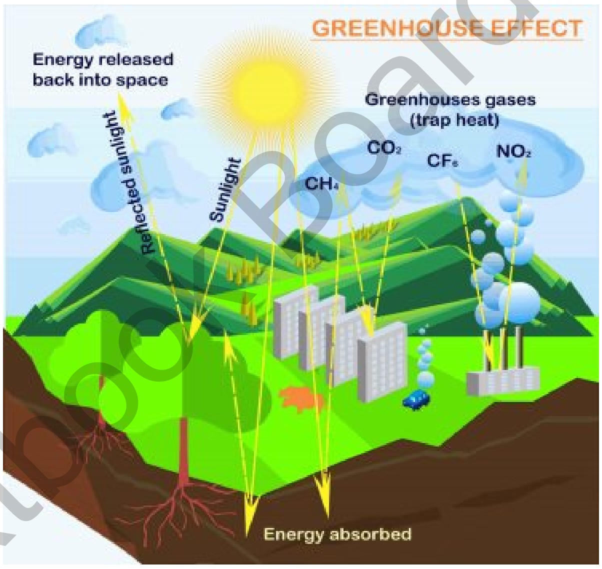
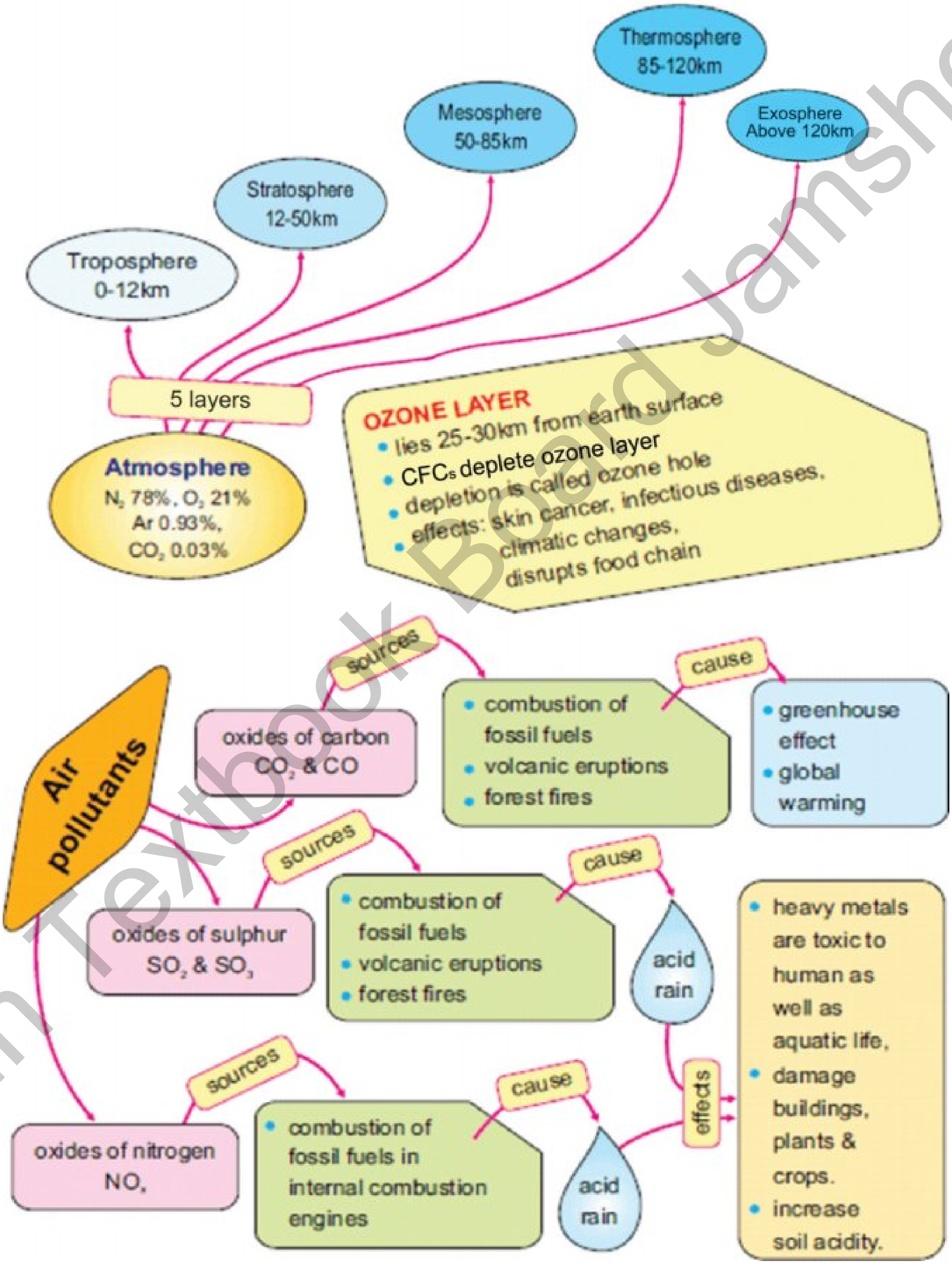


Figure 5.6 Green house effect

Effect of Global Warming

1. The accumulation of carbon dioxide in the atmosphere causes an annual increase in atmospheric temperature of roughly 0.05 degrees Celsius.
2. It's producing significant shifts in weather patterns. Extreme weather events are occurring more frequently and with more intensity than in the past.
3. It melts glaciers and snow caps, increasing the danger of flooding and intensifying tropical cyclones.
4. As the sea level rises, low-lying regions are more likely to be submerged, rendering previously populous places uninhabitable.

CONCEPT DIAGRAM



Summary

- The earth is surrounded by a layer of gases called the atmosphere.
- The earth's atmosphere is made up of nitrogen (78.09%) and oxygen (20.95%), with small amounts of argon (0.93%), carbon dioxide (0.03%), water vapors, and other gases.
- The Earth's atmosphere is divided into 5 major layers, namely: Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere.
- Air pollution occurs when harmful or excessive quantities of substances including gases, particulates, and biological molecules are introduced into Earth's atmosphere.
- Major air pollutants are Carbon monoxide, Nitrogen dioxide, sulfur dioxide, lead, particulate matter and greenhouse gases.
- Acid rain is the precipitation of acidic components, such as sulfuric or nitric acid that fall to the ground from the atmosphere in wet or dry forms.
- Ozone is a gas majorly found in the lower stratosphere consisting of three oxygen atoms: O_3
- The major causes of ozone depletion are CFC's.
- The greenhouse effect is a warming of Earth's surface and the air above it.

Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

1. Second highest layer of Earth's atmosphere is

(a). stratosphere (b). mesosphere (c). troposphere (d). thermosphere

2. Aeroplanes fly in:

(a). Troposphere (b). Stratosphere (c). Mesosphere (d). Thermosphere

3. Atmospheric pressure decreases with the

(a). increase in longitude (b). decrease in altitude

(c). increase in altitude (d). increase in latitude

4. Layer of atmosphere which separates stratosphere and troposphere is known as

(a). tropo-pause (b). mesopause (c). thermopause (d). stratopause

5. Ozone layer is part of

(a). mesosphere (b). stratosphere (c). thermosphere (d). troposphere

6. Which is not part of greenhouse gases

(a). carbon dioxide (b). methane (c). nitrous oxide (d). oxygen

7. Second most abundant constituent of dry air in terms of volume after nitrogen is

(a). nitrogen (b). oxygen (c). carbon dioxide (d). helium

8. Which of the following is the reason of global warming

(a) Presence of sulphite
(b) Rise in CO_2 concentration.
(c) Oxides of nitrogen
(d) Formtion of ozone

9. The altitude on stratosphere is:

(a). 40 to 45 km (b). 50 to 55 km (c). 60 to 65 km (d). 70 to 75 km

10. Ozone is a gas found in the ____________ layer:

(a) Troposphere
(b) Mesosphere
(c) Stratosphere
(d) Exosphere

SECTION- B: SHORT QUESTIONS:

1. Enlist major air pollutants and their sources.
2. Describe the effects of some air pollutants on human health?
3. What is the cause of acid rain?
4. Justify that Green house effect leads to global warming.
5. List down the layers of atmosphere.
6. Write down the effects of acid rain.
7. Justify that change in altitude change the temperature of atmosphere
8. What are primary and secondary air pollutants.

SECTION- C: DETAILED QUESTIONS:

1. Define atmosphere and explain its composition.
2. Differentiate between stratosphere and troposphere.
3. Describe that how different air pollutants effects environment and human health.
4. Describe Global Warming.

Chapter 6

Environmental Chemistry II: Water

Time Allocation

Teaching periods	= 10
Assessment period	= 02
Weightage	= 10%

MAJOR CONCEPTS:

6.1 Water
6.2 Soft and Hard Water
6.3 Water Pollutants
6.4 Water Borne Diseases

STUDENTS LEARNING OUT COMES (SLO'S)

- Describe the occurrence of water and its importance in the environment including Industry. (Analyzing)
- Review our dependence on water and the importance of maintaining its quality. (Analyzing)
- Describe the composition and properties of water. (Understanding)
- Differentiate among soft, temporary and permanent hard water (Analyzing)
- Describe methods for eliminating temporary and permanent hardness of water. (Applying)
- Identify water pollutants. (Analyzing)
- Describe the industrial wastes and household wastes as water pollutants. (Understanding)
- Describe the effects of water pollutants on life. (Understanding)
- Describe the various types of water borne diseases (Understanding)

Introduction:

Water is the most abundant compound on earth. It doesn't have odor, color and smell. the chemical formula of water is H_2O. A person can live no more than 4 to 5 days without water, and we rely on it for drinking, cooking, bathing, washing clothes, growing food, recreation, industry, and mining, as well as generation of electric power.

6.1 Water

Occurrence of water

Water makes up around one third of the earth's surface. Oceans, rivers, glaciers, lakes, wells, and groundwater are the primary sources of water. Water covers around 70% of the earth's surface, while land covers the remaining 30%. The majority of the water on Earth (about 97 percent) is salt water, largely found in the seas, with only 3 percent being fresh water. Fresh water accessible for human needs accounts for less than 1% of the total quantity on the planet. The issue is that fresh water is not distributed equitably across the globe.

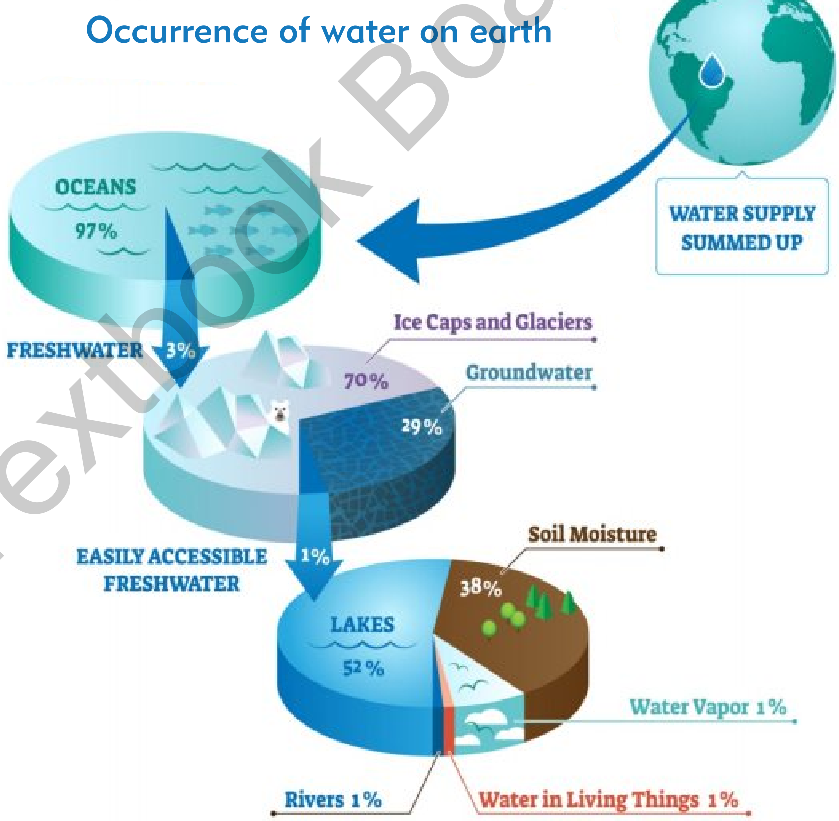


Figure 6.1 Occurrence of water

Importance of water

1. Our organs need water to work properly and toxins are removed from our body through urine.
2. Fatigue is also caused by dehydration, therefore water prevents fatigue.
3. It is necessary for washing and sanitation.
4. It is used in cooking.
5. It is used for growing food (Agriculture).
6. Thermal power plants use water for the production of energy (electricity).
7. In many medicinal procedures water act as an important component e.g: In dialysis, water containing fluid is used to remove waste from blood.
8. Fatal diseases are prevented by clean water e.g cholera, typhoid etc.

Figure 6.2 Importance of water

6.1.1 Properties of water

Pure water is a transparent, colorless, odorless, and tasteless liquid possessing the attributes listed below:

1. It is litmus-neutral.
2. At sea level, it has a freezing point of 0°C and a boiling point of 100°C.
3. At 4°C, its maximum density is 1 g.cm^{-3}.
4. It's a great solvent for both ionic and molecular substances.
5. It has a very high heat capacity of 4.2 J.Kg^{-1}.K^{-1}, which is almost six times that of rocks.
6. This feature of water is responsible for maintaining the Earth's temperature within reasonable bounds. Otherwise, the temperature during the day would have been too hot to handle, and the temperature during the night would have been too cold to freeze everything.
7. It has a lot of surface tension. Water's remarkable capillary strength is due to its one-of-a-kind action. The mechanism by which water rises from the roots of plants to the leaves is known as capillary action. The survival of terrestrial plants depends on this mechanism.

Composition of water

Water molecule is made up of one atom of oxygen and two atoms of hydrogen connected by covalent bond. Rain water is considered as purest form of water. Drinking water contain ions necessary for our body i.e. Na^{+}, Cl^{-}, K^{+} ,Mg^{2+} etc water is a polar molecule due to difference in electronegativity b/w H and O.

Structure of Water

Water is a simple molecule consisting of one oxygen atom bonded to two different hydrogen atoms. Because of the higher electro negativity of the oxygen atom, the bonds are polar covalent (polar bonds). The oxygen atom attracts the shared electrons of the covalent bonds to a significantly greater extent than the hydrogen atoms. As a result, the oxygen atom requires a partial negative charge (δ^{-}), while the hydrogen atoms each acquire a partial positive charge (δ^{+}).

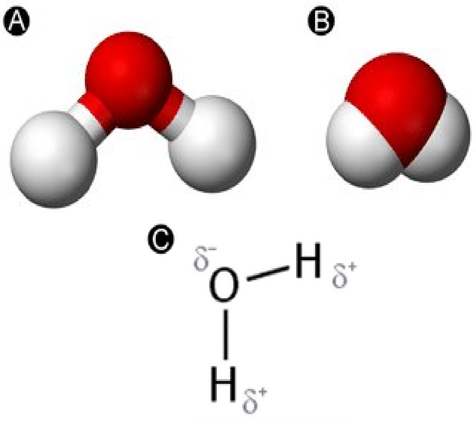


Figure 6.3 Molecular structure of water

6.1.2 Water as a solvent

Water can dissolve practically all minerals, water is known as the universal solvent. Water's capacity to dissolve compounds is due to two distinct qualities of the molecule:

1. Polar nature of water
2. Extensive hydrogen bonding ability.

Polar nature of water

The water molecule has a polar structure because of the electro negativity difference between oxygen and hydrogen atoms, which means one end of the molecule is partially positive and the other end is partially negative.

Water dissolves all other polar compounds because the positive end of the substance is drawn to the water's negative end ($O^{\delta-}$) and the negative end is attracted to the water's positive end ($H^{\delta+}$). The ion-dipole forces of attraction between ions and water molecules overcome the electrostatic interactions among the ions. The positive and negative ions of the compounds are separated in this manner. These oppositely charged ions are eventually enveloped by water molecules, which keeps them separated in solution. Most salts, such as NaCl, KCl, Na_2SO_4, and others, are soluble in water. Water molecules, on the other hand, are not attracted to numerous covalent compounds that lack polar ends or links, such as benzene, ether, oil and petrol. Non-polar chemicals do not dissolve in water as a result.

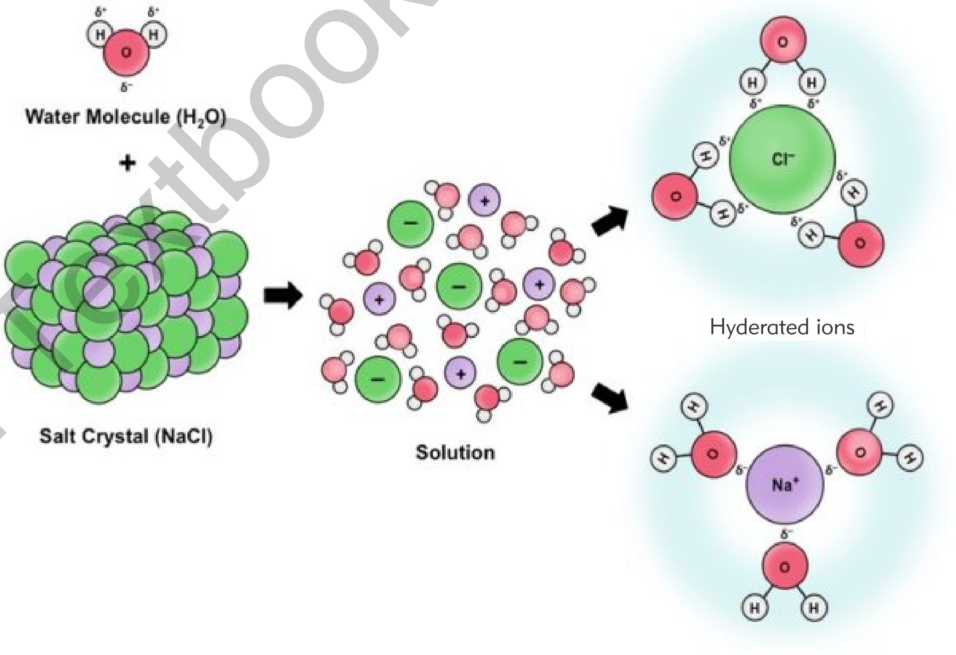


Figure 6.4 Polar structure of water

Extensive hydrogen bonding ability

The oxygen and hydrogen atoms make up the water molecule. One H_2O molecule can create hydrogen bonds with maximum four additional H_2O molecules stacked tetrahedrally around the H_2O molecule due to two O—H bonds and two lone pairs.
By establishing hydrogen bonds with various polar non-ionic molecules containing hydroxyl groups (-OH), such as alcohols, organic acids, glucose, sugar, and so on, water is able to dissolve them.

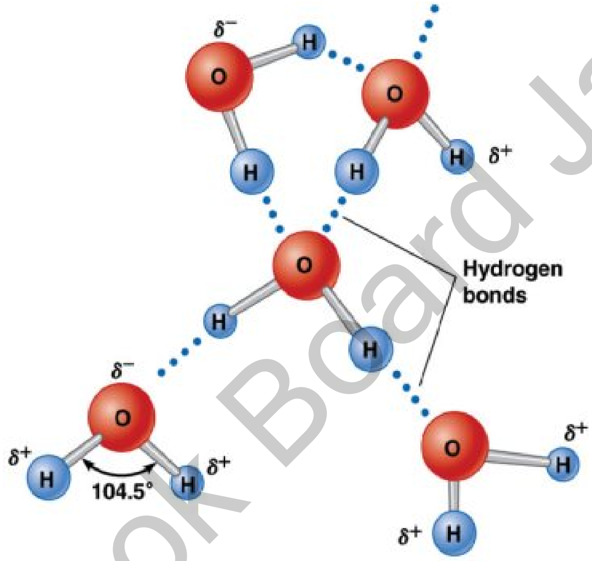


Figure 6.5 Hydrogen bonding

6.2 Soft and Hard water

Soft water

Soft water is water that generates an excellent lather when used with soap. It contain dissolved impurities but in small quantity.

Hard water

Hard water is defined as water that does not lather with soap. Hardness in water is caused by a variety of factors. Rainwater collects carbon dioxide from the atmosphere as it falls. When water combined with carbon dioxide flows through the soil layers, insoluble calcium and magnesium carbonates are converted to soluble bicarbonates. It may also dissolve calcium and magnesium chlorides and sulphates. The hardness of the water is caused by these minerals.

$$CaCO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \longrightarrow Ca(HCO_3)_{2\,(aq)}$$

$$MgCO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \longrightarrow Mg(HCO_3)_{2\,(aq)}$$

6.2.1 Types of Hardness of water

Water which cannot form lather with soap called hard water. A hard water has large amount of saline or dissolve salts such as calcium magnesium and other heavier metals. Hard water scaling the pipes and other in domestic alliance. Sea and ocean are the sources of hard water. There are two types of hard water:

1. Temporary hardness of water
2. Permanent hardness of water

Temporary hardness of water

Temporary hardness is caused by excessive amount of dissolved salt of calcium bicarbonate $Ca(HCO_3)_2$ and magnesium bicarbonate $Mg(HCO_3)_2$. A temporary hardness can be removed by boiling the water.

Permanent hardness of water

Permanent hardness of water is caused by the excessive amount of dissolved salts of chlorides and sulfates of Magnesium, Calcium, and Aluminum $CaCl_2$, $MgCl_2$, $CaSO_4$, $MgSO_4$, $FeSO_4$, $Al_2(SO_3)_3$. Permanent hardness of water cannot be removed by boiling. The sum of temporary and permanent hardness is referred as total hardness of water.

Degree of hardness of water on the basis of dissolved calcium (Ca^{2+})ion (mg,L^{-1})	
Soft water	0-16.1 mg/liter
Slightly hard water	16.1-60 mg/liter
Moderate hard water	61-120 mg/liter
Hard water	121-180 mg/liter
Very hard water	More than 180 mg/liter

Although hardness of water is never presence in the form of $CaCO_3$ as it is insoluble in water hardness of water is conveniently expressed in terms of equivalents of $CaCO_3$.

6.2.2 Methods of removing Hardness

Water softening is the process of removing the ions Mg^{2+} and Ca^{2+} that cause hardness.

1. Removal of temporary hardness

(a) Boiling Water

With a temporary hardness can be readily eliminated by boiling it. When calcium bicarbonate, $Ca(HCO_3)_2$, is heated, it decomposes into insoluble calcium carbonate, which precipitates out of the solution.

$$Ca(HCO_3)_{2(aq)} \xrightarrow{\Delta} CaCO_{3(s)} + H_2O + CO_{2(g)}$$

(b) Clark's method

The addition of slaked lime $Ca(OH)_2$ is a chemical approach for removing temporary hardness. Temporary hard water is treated using a determined amount of lime water. As a result of the precipitation of magnesium and calcium ions, water becomes soft.

$$Mg(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow MgCO_{3(s)} + CaCO_{3(s)} + 2H_2O_{(1)}$$

$$Ca(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow 2CaCO_{3(s)} + 2H_2O_{(1)}$$

2. Removal of permanent hardness

Chemicals are the only way to get rid of permanent hardness. Adding washing soda (Na_2CO_3) or sodium zeolite removes calcium (Ca^{2+}) and magnesium (Mg^{2+}) as insoluble salts.

Using washing soda:

Adding washing soda to the calcium and magnesium ions results in the formation of insoluble calcium and magnesium carbonates.

$$Na_2CO_{3(aq)} + CaSO_{4(aq)} \longrightarrow CaCO_{3(s)} + Na_2SO_{4(aq)}$$

$$Na_2CO_{3(aq)} + MgSO_{4(aq)} \longrightarrow MgCO_{3(s)} + Na_2SO_{4(aq)}$$

6.2.3 Disadvantages of water hardness

Lather Formation:

When you wash your clothing in hard water, the soap generates a white precipitate instead of lather. The scum is the white precipitate. Without the development of lather, your garments will not be cleansed.

Stains:

Hard water leaves stains on your clothes. They fade the colors of your garments. Calcium scum also causes your garments to become rough.

Bath tiles, glass, and fixtures are also stained by hard water. Calcium deposits on bath fittings may build a very difficult to remove coating if not cleaned frequently. The cloud-like watermarks on the kitchenware are caused only by hard water.

Effects on hair:

If you continue to wash your hair with hard water, you will continue to have awful hair days. Your hair becomes dry and scratchy when you wash it with hard water. This is due to the extra minerals found in hard water, which turn into a curd-like material that adheres to your hair. As a consequence, you may feel compelled to wash your hair, but this will just make it frizzier.

Effects on skin:

Bathing with hard water causes your skin to become dry and irritated. It's because the soap residue left behind adheres to your skin. Eczema-like symptoms are caused by the remaining residue. Children are more likely to have such a problem.

Reduces the life of Appliances:

If you continue to use hard water with your household equipment, the lifespan of the appliances will be dramatically reduced. The appliances steadily deteriorate due to the hard water, and they finally fail. In addition, the presence of minerals in hard water affects the machine's performance. A dishwasher has a ten-year life expectancy. If you run it with hard water, though, the life expectancy drops to seven years. A faucet should also run for nine years. With hard water, though, it will only last five years. That's how much hard water degrades your appliances.

Corrosion of pipes:

Hard water deposits may corrode pipes as well as obstruct them. As a result, the amount of water that can flow through the pipe is limited. And all that this does is slow down the flow of water. Pipe corrosion can also cause metals to leak into the water, making it unsafe to drink.

6.3 Water Pollutants

The polluting of water bodies is known as water pollution (e.g. lakes, rivers, oceans and ground water). Pollutants are dumped directly or indirectly into water bodies without proper treatment to eliminate dangerous substances, resulting in water pollution.

6.3.1 Industrial waste

Industrial units are erected to create the needed substances (chemicals, textile, leather products, paper, plastic items, petrochemicals, and rubber items) on a commercial scale. However, all industrial units, sadly, release their wastes (chemicals and solid materials) into the open land or into waterways. The term for this is industrial wastewater. Organic compounds, inorganic salts, heavy metals, mineral acids, oil and greases, and other very poisonous substances may be found in industrial waste. Water used as a cleaning agent in industries, on the other hand, is released immediately. This water is contaminated with a variety of harmful chemicals and detergents.

These effluents and used water either dissolve or float suspended in water when they reach lakes, streams, rivers, or oceans. As a result, water contamination occurs, i.e.

1. They degrade the quality of water.
2. They lower the amount of dissolved oxygen in the water, which has an impact on aquatic life and ecosystems.
3. They can also leak into the groundwater and influence the deposits.They pollute the water reserves. When this water is used by humans, it causes significant illnesses such as cancer and gastroenteritis. Soil, crops, plants, and animals are all harmed by this filthy water.
4. Heavy metals such as cadmium, lead, and mercury are harmful to humans and pose a health risk. Acute cadmium poisoning results in elevated blood pressure, renal damage, and red blood cell disintegration. Kidney, liver, brain, central nervous system, and reproductive system malfunction are all symptoms of acute lead

poisoning. Mercury toxicity damages the nervous system.

Figure 6.6 Industrial waste

6.3.2 Household waste

The usage of detergents for cleaning purposes in homes and businesses is growing by the day. It's because detergents, even in hard water, have a stronger cleaning activity than soap. They can even work in acidic environments. However, they have a significant disadvantage over soaps in that certain detergents are non-biodegradable (cannot be decomposed by microorganisms like bacteria). Water contamination occurs when domestic water containing these detergents is dumped into streams, ponds, lakes, and rivers.

The detergent lingers in the water for an extended period of time, rendering it unsuitable for aquatic life. Detergents include phosphate salts, which allow algae to develop quickly in water bodies and float on the surface. It is known as Eutrophication. These plants eventually die and decompose. Because decaying plants are biodegradable, they absorb oxygen gas in the water. As a result, aquatic life dies due to a lack of oxygen.

A wide range of dissolved and suspended pollutants can be found in domestic sewage. Food and vegetable waste, rubbish, cans, bottles, chemical soaps, washing powder, and other items are among them. It also has disease-causing bacteria in it. All of these things pollute the water.

Figure 6.7 Household waste

Do You Know?

- Less than 1 % of the earth's total water supply is suitable for drinking.
- Polluted water kills 5,000 children per day and 3 million per year globally. (UN, 2006)

6.3.3 Agricultural waste

The usage of fertilizers and pesticides causes water contamination owing to agricultural waste. Fertilizers are used to compensate for soil deficiencies in nitrogen, phosphorus, and other nutrients caused by intense crop cultivation in recent years.Pesticides, on the other hand, are used to either kill or control the growth of pests. Weeds, insects, fungus, viruses, and other pests are examples. They all harm crops and spread illnesses to both humans and animals.

Agricultural effluents have a two-fold impact:

1. Chemicals from fertilizers and pesticides leak into groundwater as a result of rain and intensive crop production, a process known as leaching. Irrigation run-off from agricultural fields is the primary source of excessive nitrate levels in ground water.
2. Runoff from agricultural land (which has been treated with fertilizers and pesticides) reaches ponds, streams, and rivers. Nitrate (NO_3^-) and phosphate (PO_4^{3-}) salts are present in this water. These compounds cause algae to develop quickly and float on the water's surface. They block the passage of sunshine and oxygen to aquatic life. When algae dies, microorganisms eat oxygen from the water to help the algae decompose. As a result, the water loses oxygen. Due to a lack of oxygen, aquatic creatures experience asphyxia and eventually perish.

Figure 6.8 Agriculture waste

Effects of water pollutants on life

Following are the effects of water pollutants:

1. It is harmful to people's health. Cholera, typhoid, and diarrhea can all be caused by drinking contaminated water.
2. The use of dirty water is harmful not only to humans, but also to animals and birds.

3. It promotes algae to develop quickly. The death and breakdown of algae results in a lack of oxygen in the water, which impacts aquatic organisms.
4. It harms aquatic life, causing a food chain link to be broken.
5. It degrades the appearance of lakes and rivers.
6. It is not suitable for cleaning or washing.

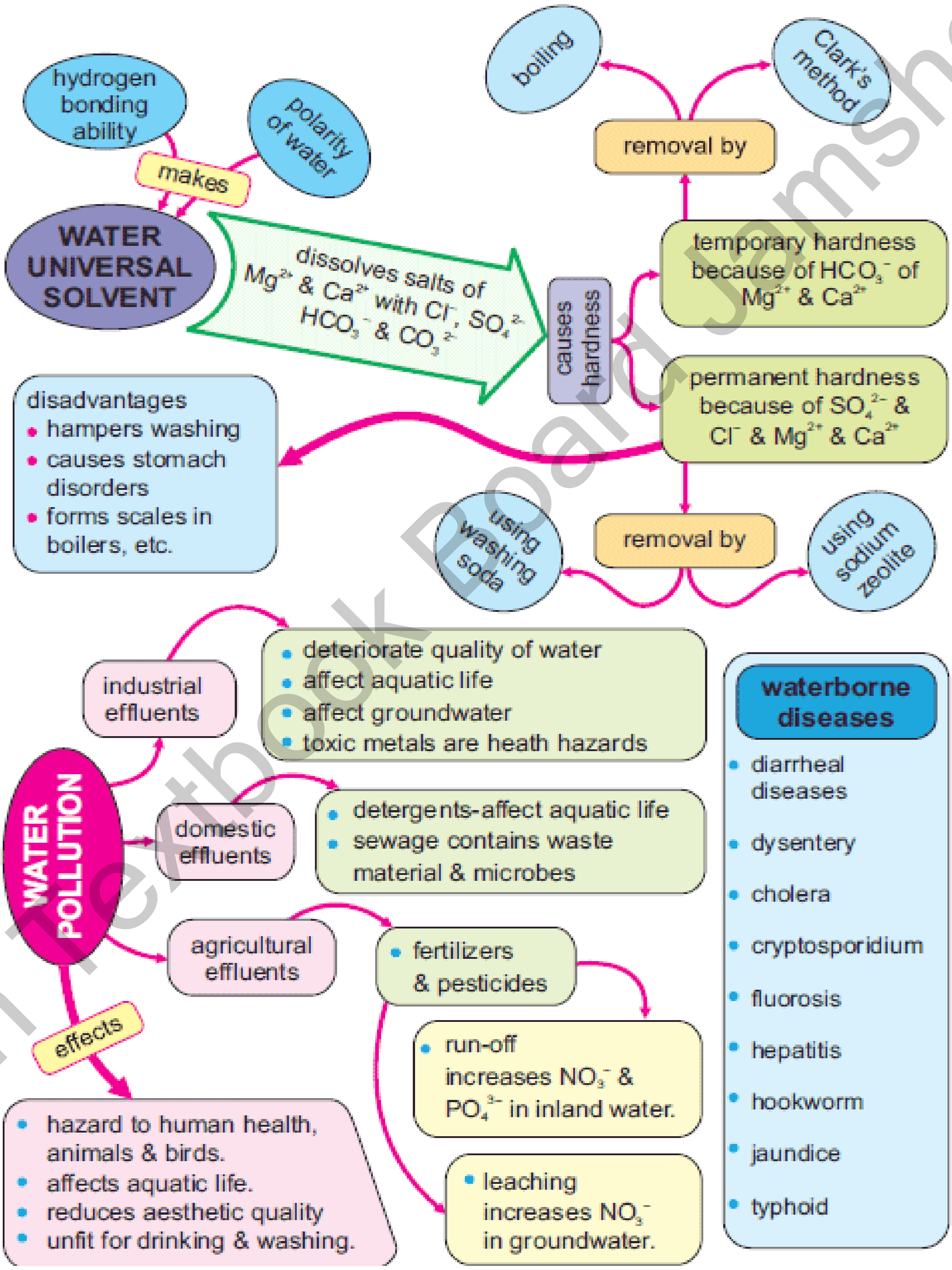
6.4 Water Borne diseases

Waterborne infectious illnesses are diseases that spread by drinking dirty water or eating food prepared with polluted water. Toxins or bacteria can cause water contamination. Arsenic, mercury, calcium, lead, and a variety of organic substances are examples of toxins. Viruses, bacteria, protozoa, and worms are examples of microorganisms.

The major reason of quickly spreading waterborne illnesses is a lack of sufficient sanitary facilities. Following are of the most frequent illnesses:

1. Diarrheal diseases
   Intestinal illnesses that can lead to serious dehydration, such as cholera. Viruses, bacteria, and parasites all can cause diarrhea.
2. Dysentery
   Dysentery is a kind of gastrointestinal infection caused by bacteria or parasites. It's characterized by severe diarrhea, which may include blood or mucus.
3. Cholera
   The bacteria Vibrios cholerae, which may be found in water tainted by human feces, causes cholera. Cholera is a disease that produces severe diarrhea and is potentially lethal.
4. Cryptosporidium
   Cryptosporidiosis is a gastrointestinal ailment caused by a waterborne microbe (protozoa) that causes diarrhea and vomiting. Surface water sources such as reservoirs, lakes, and rivers contain these microscopic germs
5. Fluorosis
   Fluorosis is a condition caused by too much fluoride in the body. Fluorosis can harm your bones and teeth.
6. Hepatitis
   Hepatitis A, B, C, D, and E are the five viruses that often cause liver inflammation. Viruses like hepatitis A and E can be spread through polluted water.
7. Hookworm
   Hookworm is a parasitic worm that lives in the small intestine and causes disease. Anemia and slowed development in children can occur in severe situations. Hookworm larvae enter the body via the skin, most commonly through the feet. Hookworms, which are spread by unsanitary settings, infect nearly one billion individuals each year throughout the world.
8. Jaundice
   An excess of bile pigments in the blood causes jaundice. The liver stops working, and the eyes turn yellow. The patient is weak and tired.
9. Typhoid
   A severe bacterial illness spreads often through polluted water or food cooked with contaminated water.

CONCEPT DIAGRAM



Summary

- Water is the most abundant compound on earth. Its main sources are rain, river, lakes, canal, ground and sea water.
- 97.5 percent water is saline and rest of water is fresh and able to use.
- Water is composed of two atoms of hydrogen and one atom of oxygen.
- Water is considered as a universal solvent oxygen form one fifth part of the water.
- The maximum density of water is at 4°C. While its freezing point is 0°C and boiling point is 100°C.
- Water shows the anomalous behavior due to the hydrogen bonding so it freezes at 0°C.
- Water quality is important for the ecological process even that our own life is depends on quality of water such as watering stock, drinking, fishing and recreation, and to meet cultural and spiritual needs.
- Drinking water can proceed in to several steps such as creeks, dams, canal, treatment plants, pipes and then in taps.
- Water which have the less amount of soluble salt is known as soft water.
- If the saline salt is soluble in excess quantity than hard water is formed.
- There are two types of hardness in water: temporary and permanent hardness.
- Temporary hardness formed by the bicarbonates salt of Ca and Mg and can be removed by boiling of water.
- Permanent hardness is formed by the salt of sulfate and chloride with Ca and Mg.
- The main sources of water pollutants are sewage water causes by households and industries which effect the main pollutants in water.
- Water pollutants may be physical chemical and in microorganism.
- Diseases which are caused by contamination called the waterborne diseases.
- water borne diseases are also caused by virus, bacteria and protozoa.
- Diarrhea and cholera are the main waterborne diseases.

Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

1. Which of the following water borne diseases is of viral origin.
(a) Typhoid fever (b) Polio (c) Dysentery (d) diarrhea

2. How much percentage (%) of the Earth's Surface is covered with water?
(a)70% (b) 60% (c) 90% (d) 75%

3. Which type of bond is formed between H_2O molecules:
(a) Hydrogen bond (b) ionic bond (c) covalent bond (d) all of these

4. The permanent hardness of water is due to presence of:
(a) $MgSO_4$ (b) $Mg(HCO_3)_2$ (c) $Ca(HCO_3)_2$ (d) all of these

5. How much fresh water is present on earth:
(a) 0.3% (b) 3% (c) 0.2% (d) 2%

6. Which salts are excessively dissolved to make temporary hard water:
(a) $CaSO_4$ and $CaCl_2$ (b) KNO_3 and KOH
(c) $CaCO_3$ and $Ca(OH)_2$ (d) $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$

7. Water is a:
(a) Polar solvent (b) Non polar solvent
(c) Amphipathic solvent (d) Non polar charged solvent

8. The taste of water is:
(a) Sour (b) Bitter (c) Sweet (d) Tasteless

9. Which of the following is helpful for removal of permenant hardness:
(a) Na_2CO_3 (b) $Ca(OH)_2$ (c) $CaCO_3$ (d) Na_2SO_4

SECTION- B: SHORT QUESTIONS:

1. Describe composition of water.
2. Define hard and soft water
3. Describe water pollutant.
4. How we can remove temporary hardness of water?
5. List down the diseases due to polluted drinking water.
6. Differentiate between hard and soft water.

SECTION- C: DETAILED QUESTIONS:

1. Write down the methods for removal of permanent hardness of water.
2. Describe the water pollutants in industries.
3. Justify that "Water is solvent".
4. Describe disadvantages of hard water?
5. Explain in detail Water borne diseases.

Chapter 7

Analytical Chemistry

Time Allocation

Teaching periods = 12
Assessment period = 03
Weightage = 12%

MAJOR CONCEPTS:

7.1 Qualitative and Quantitative Analysis
7.2 Important Parameters
7.3 Classical Methods
7.4 Advanced Instrumental Methods

STUDENTS LEARNING OUT COMES (SLO'S)

- Explain the basic concepts of Analytical Chemistry.(Remembering)
- Define the Qualitative and Quantitative analysis.(Understanding)
- Study the important Parameters, errors, accuracy and precision.(Analyzing)
- Differentiate the classical and instrumental methods.(Analyzing)
- Define the Spectroscopic methods such as Ultra-violet and visible Spectroscopy, infrared spectroscopy.(Understanding)
- Define Chromatographic methods such as high performance liquid chromatography and gas Chromatography.(Understanding)
- Define Electrochemical methods such as Potentiometric and conductometry.(Understanding)
- Understand new methods, scientific investigations.
- Communicate their findings using a variety of conventional and advanced technology in the field of analytical chemistry.

Introduction

As we know that chemistry is usually known as natural science because it is concerned with the knowledge of natural world and how it works. There is a range of knowledge, theories and applications for human beings in chemistry such as plastic, synthetic fibers, rubber, soaps, medicines, paints, insecticides, pesticides and petrochemical products. Today chemistry has a wide scope in all aspects of life and serving humanity. Chemists are working hard to investigate material and creating chemical material by combining and blending substances. There are many challenges like food problem, environmental protection, biochemical processes, population problems and new resources of energy being faced and solved by chemistry, all of these issues and processes are based on analysis of different substances. These analysis and separation of sample to detect and estimate its components through various techniques and instruments is known as Analytical Chemistry.

7.1A What is Analytical chemistry?

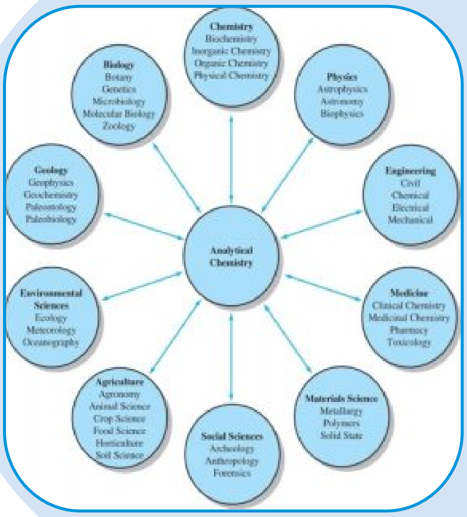
The analytical chemistry provide the methods and tools needed to insight our material World and answer the basic questions about a material

- What?
- Where?
- How much?
- What structure/arrangement/form?

The Analytical Chemistry deals with instruments and methods to separate, identify and quantify the matter. The main objective of analytical chemistry is to develop an understanding of analysis of elements and compound for measurement and problem solving with the help of analytical methods.

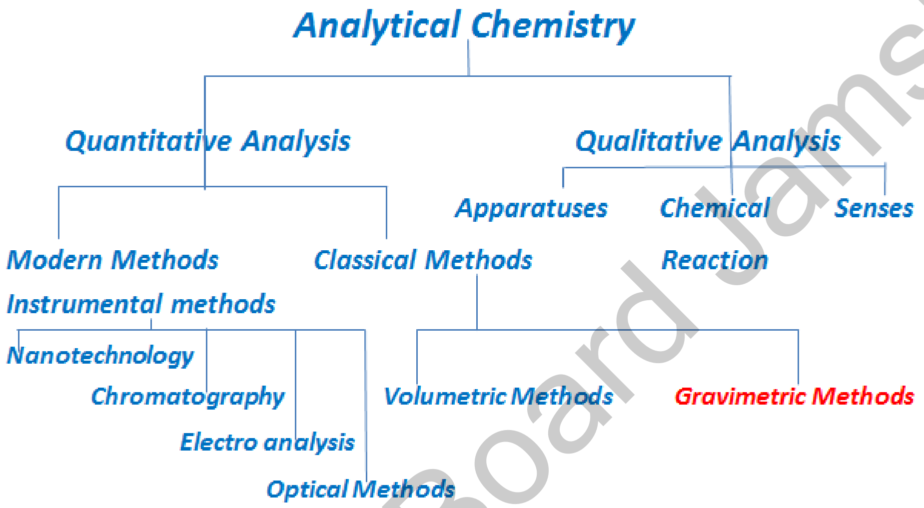
The Analytical Chemistry is applied in all fields of chemistry such as Medicine, Clinical laboratories, industries, Agriculture ,food contamination and environmental protection.

Do You Know?



7.1B Types of Analytical chemistry:

Classification of Analytical Chemistry



The analytical chemistry consist of two main types of analysis which are as follows

(1) Qualitative Analysis:

The identification of elements, ions or compounds present in sample is called qualitative analysis. The sample may be solid, liquid, gas or a mixture. Qualitative analysis does not measure the quantity of substance but measure the quality of that material. Qualitative analysis is performed by selective chemical reactions or with the use of instrumentation. For example: chemical test and flame test.

Qualitative analysis further divided on the basis of chemical test are as follows

(i) Organic qualitative analysis:

It deals with the identification of presence of different classes of organic compounds or functional groups by producing colors in chemical reactions. For example: formation of white precipitate by adding silver nitrate ($AgNO_3$) in dilute nitric acid (HNO_3) indicate the presence of halide (X=F, Cl, Br, I) . as shown in figure (7.1)

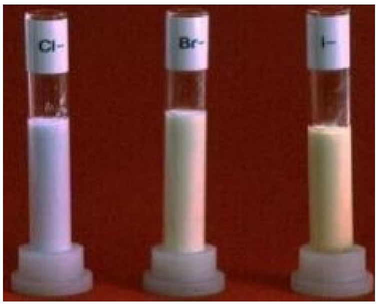


Figure 7.1
Organic qualitative Analysis

(ii) Inorganic qualitative analysis:

It deals with the identification of elements. For example: flame test of copper halide which shows bluish-green color due to presence of copper. Some other flame test of halide are given below in picture (7.2)

LiCl (Red flame)

NaCl (Yellow flame)

KCl (Light lilac flame)

RbCl (Violet flame)

$CaCl_2$ (Orange Red flame)

$SrCl_2$ (Red or crimson flame)

$BaCl_2$ (Light green flame)

$CuCl_2$ (Blue/Green flame)

Figure 7.2 Flame test

(2) Quantitative Analysis:

The determination of how much amount or quantity of one or more substance present in compound or sample is called quantitative analysis. It deals with large number of quantifying methods which are classified as physical or chemical.

Physical methods measure physical properties such as density, temperature, absorption of light, magnetic influences, color, and texture. The physical methods used to measure these properties are Fourier transform infrared spectroscopy (FTIR), Atomic emission spectroscopy (AES), trace element analysis and energy dispersive X –ray spectroscopy (EDS).

Physical methods and instruments are shared in pictures

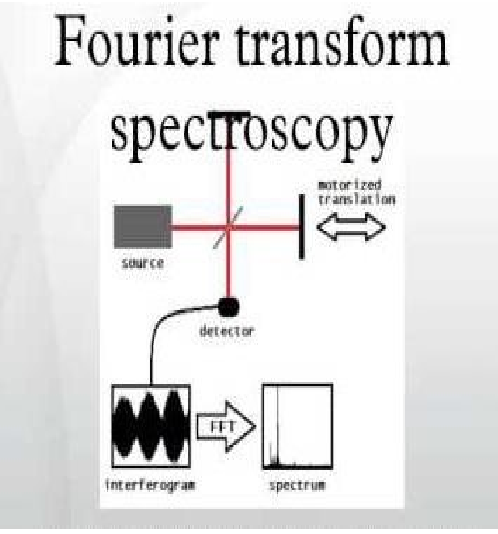


Figure 7.3
Fourier transform spectroscopy

Figure 7.4
Atomic emission spectroscopy

Figure 7.5
Trace element analyzing instrument

Figure 7.6
Energy dispersive X-ray spectroscopy

Chemical methods measure chemical reactions such as precipitation, oxidation or neutralization and measured by volumetric analysis, gravimetric analysis and combustion analysis.

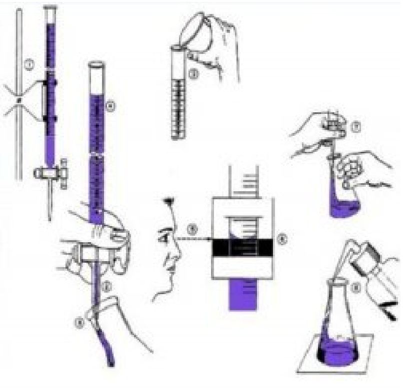


Figure 7.7
Volumetric Analysis

Figure 7.8
Gravimetric Analysis

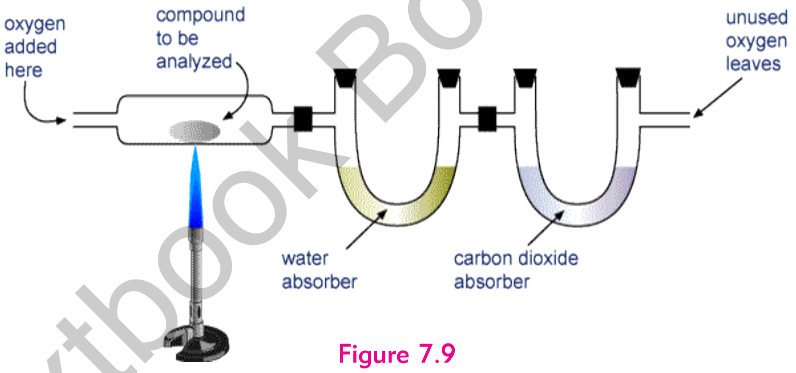


Figure 7.9
Combustion Analysis

Always remember that whenever any chemist start working to quantify any sample first of all qualify that sample to identify the compounds in sample then apply quantitative analysis procedures to determine quantity of compounds in sample.

Test Yourself

- Define analytical chemistry?
- Prove that analytical chemistry is a part of all types of chemistry?
- Justify that qualifying is the first step to quantify any sample?
- Discuss which method deals with physical properties of substances?
- Differentiate between quantitative and qualitative analysis?

7.2 Important Parameters

The parameter is measureable factor or boundary which define performance and quality of analytical methods. The validation of any analytical method is observed by parameters and various parameters of validation are selectivity, linearity, range,accuracy, precision and error.

In this chapter we will discuss about the three most important parameters

- Error
- Accuracy
- Precision

7.2.1 ERROR

We know that in all type of analytical methods or experiments we observe many errors and deviations. These errors are due to 13% equipment failure, 13% human error, 16% sample preparation and 10% wrong calibration. so we can say that factors which produce the error are defect in instrument, lack in handling the apparatus or improper functioning of the instrument.

Error can be defined as numerical difference between observed value and true value.

Errors in analytical chemistry are classified as systematic and random errors.

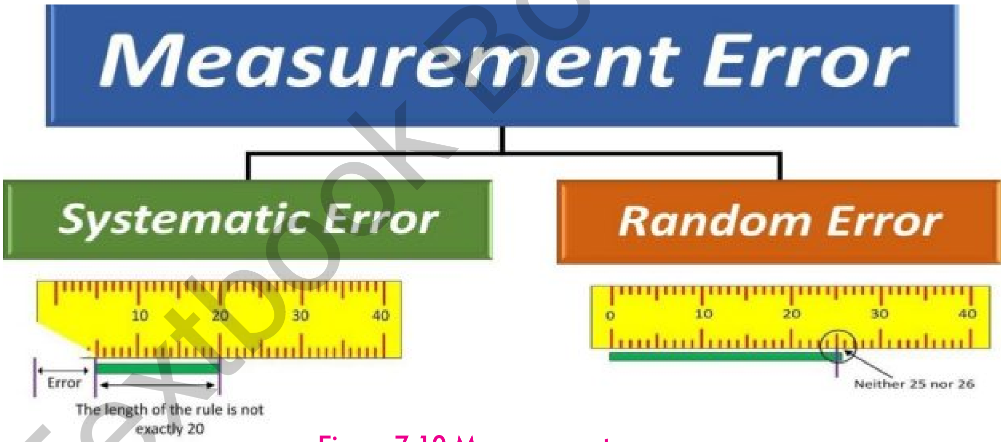


Figure 7.10 Measurement errors

Systematic errors are also known as determinate error and caused by defect in the analytical method or improper functioning of instrument. Systematic error may be instrumental, observational, environmental and theoretical. For example a thermometer, peppet , burette ,analytical balance and volumetric ware shows error in measurement. There is no any specific definition of systematic error because it's different for different experiments.

For example: in acid base titration if pH indicator is not properly prepared then color change will appear before equivalence point or if burette is not properly cleaned or rinsed will cause of systematic error.

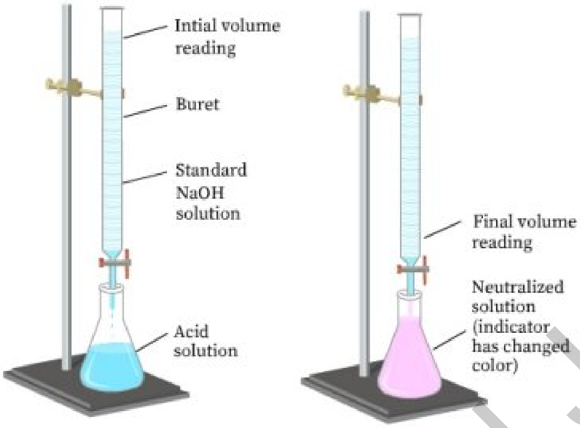


Figure 7.11 Titration

A systematic error can be estimated and eliminated but there is always some uncertainty in every physical measurement and mostly avoided.

Random errors are also known as indeterminate error and caused by variations of procedure, environmental factors and limitations of instrumentation. Random error are unavoidable and may be positive and negative. Measuring a mass of a sample on analytical balance may produce different reading due to effect of air or water on sample or analytical balance.

For example: in acid base titration we are using 50cm^3 burette we can read accurately only to nearest 0.1cm^3. as we discuss random error may be positive and negative and cannot be eliminated from experiment due to this reason we take many reading and average them.

7.2.2 Accuracy

The accuracy of analytical method is the closeness of obtained value to the true value of a sample, for example if you obtain weight 2.5mg of sample or substance but actual or known weight of sample is 10mg then your measurement is not accurate. Accuracy is the most difficult parameter to validate. Accuracy is degree of agreement between the measured value and true value. An absolute true value is very rarely obtained due to this more realistic definition of accuracy is an agreement between a measured value and the accepted true value.

Always remember that accuracy is not dependent on precisions. for example when measuring the density of copper and its true value is 8.99 g/ml and results of measurement are 10.0, 8.0 and 9.3 g/ml and their average is 9.1g/ml which is nearest accepted value and consider as accurate value.

7.2.3 Precision

The Precision is defined as the degree of agreement between replicate measurements of the same quantity. It is repeatability of a result and known as degree of exactness. Precision is measured how much detailed information is given and how much exactly measurement was taken.

A measurement can be precise but not accurate, accurate but not precise, neither or both. A measurement system is valid if it is both precise and accurate.

For example four students are performing an experiment to measure the density of aluminum (2.7g/ml) and note down the following data which shows different aspects of precision and accuracy, such as measurement of student number 1 is precise because 2.9 is repeating overall but not accurate because it is not closest to true value. Measurement of student number 2 is not precise and not accurate because values are not closest to true value and not repeatable .In the same manner measurement of student number 3 is not precise but accurate due to closeness of measurement with true value ,while measurement of student number 4 is precise and accurate which may consider a valid measurement system.

Student 1	Student 2	Student 3	Student 4
2.924 g/ml	2.316 g/ml	2.649 g/ml	2.701 g/ml
2.923 g/ml	2.527 g/ml	2.731 g/ml	2.699 g/ml
2.925 g/ml	2.941 g/ml	2.695 g/ml	2.702 g/ml
2.926 g/ml	2.136 g/ml	2.742 g/ml	2.698 g/ml
Precise	Not Precise	Not Precise	Precise
Not accurate	Not accurate	Accurate	Accurate

The above example shows that good precision does not assure good accuracy but a valid measurement system needs good precision as well as accuracy.

Test Yourself

- Prove that improper functioning of acid base titration is a systematic error?
- Distinguish between accuracy and precision?

7.3 Classical Method

The classical methods are the fundamental laboratory practicing techniques. It is a traditional method of chemical analysis and also known as wet chemical method. Classical methods are those analytical techniques which does not use any mechanical or electronic instrument rather than weighing balance. This method basically related with the chemical reactions between analyte and reagents.

The classical methods posses' qualititative as well as quantitative analysis. Such as chemical and flame tests are qualitative and titrimatic and gravimetric analysis are quantitative analysis.

7.3.1 Titrimetric Analysis

The titrimetric analysis is used to determine the volume of a solution with known concentration which react with the measured volume of solution of a substance quantitatively .The Titrimetric analysis is also known as volumetric analysis in which general rule of titration is applied in which volumetric measurement of a reagent takes place which is known as titrant and this titrant complete its chemical reaction with analyte .The general chemical reaction for titrimetric analysis is as follows

$$aA + tT \longrightarrow \text{Product}$$

Where **a** is number of moles of analyte **A** contain in the sample reacts with **t** moles of the titrant **T** in the titrant solution and this process is known as Titration. This reaction is carried out in a flask containing dissolved analyte while burette contains titrant solution which volumetrically delivered to the flask for reaction .The Titration is complete when sufficient amount of titrant added with analyte for chemical reaction and an equivalance point reached. An indicator is also added in flask to show the end point of whole reaction. We can also define Titration as

The comparison of volume of a solution of known concentration with the volume of solution of unknown concentration is called Titration.

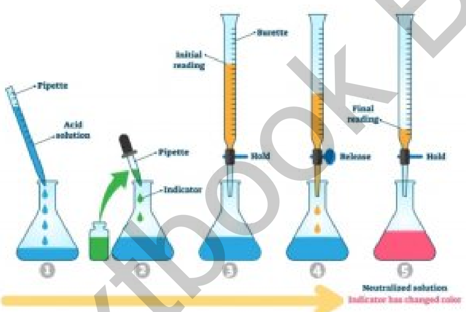


Figure 7.12 Titration

Do You Know?

What is titrant?

A titrant is a solution of known concentration that is added to another solution to determine the concentration of a second chemical species.for example NaOH ,HCl

What is analyte?

A chemical substance that is subject of chemical analysis or constituent going to be measure. For example 24 karat gold, NaCl , water etc

What is indicator?

Indicator is a substance which change the color with acidic and alkaline solution.

Eg:Litmus, Phenolphthalein, Methyl orange

7.3.2 Gravimetric Analysis

Gravimetric analysis is the oldest and important technique for quantitative estimation in chemical analysis .This technique involve determination of constituent by weight, it is one of the most accurate analytical method for quantitative estimation. In this analysis an amount of analyte is determined by converting the analyte to some product and then weighing it. For example you want to determine the amount of chlorine (Cl) present in solution of AgCl then you have to go through following 4 steps for gravimetric analysis.

(1) Preparation of a solution with known weight of sample (AgCl).
(2) Separation of the desired constituent (Cl).
(3) Weighing Separated constituent.
(4) Computation of amount of separated constituent in the sample.

The gravimetric calculation based on gravimetric factor which convert the grams of the compound in to grams of the single element.

There are four types of gravimetric analysis which are Physical, Thermo, Precompetitive and Electro gravimetric analysis.

Test Yourself

- Explain Titration and which apparatus used in it?
- Explore Why we use indicator in titration?
- List down the steps of gravimetric analysis.

7.4 Advanced Instrumental Methods

Analytical chemistry consists of many advanced methods , which involves use of instrument for analysis and separation of mixtures and compounds. The methods used as quantitative and qualitative analysis .These analytical advanced instrumental methods includes spectroscopy ,chromatography , electrochemical methods ,ultra violet and visible spectroscopy, infrared spectroscopy ,HPLC, gas chromatography, potentiomatric and conductometry. We will discuss these advanced instrumental methods in this chapter in detail.

7.4.1 Spectroscopic Methods

Spectroscopy is the interaction of light with matter. light is composed of electromagnetic waves so interaction of matter with radiative energy as function of wavelength or frequency is called spectroscopy. Spectroscopy used in physical and analytical chemistry for the identification of substances through the emission or absorption spectrum. Interaction of light with matter is shown in figure:

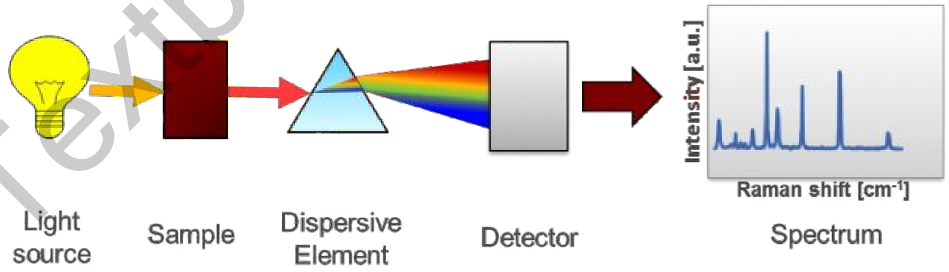


Figure 7.13 Spectroscopic methods

The spectroscopy used to assess concentration or amount of given chemical (atomic, molecular or ionic) and the instruments used for measurement are called spectrometer, spectrophotometer, spectrograph. There are a large number of atomic and molecular spectroscopic methods which depends upon the emission and absorption spectrum , but here we will discuss two main spectroscopic methods of ultraviolet and infrared spectroscopic methods in detail.

7.4.1.1 Ultraviolet and visible spectroscopy

The ultraviolet and visible spectroscopy is also known as electronic spectroscopy. It is a quantitative technique which measure how much a chemical compound absorb light. This is done by measuring the intensity of light passing through the sample .The basic principal of this spectroscopy is interaction between light and matter but here light wavelength is ultraviolet and process is formation of spectrum due to absorption of ultra violet light to the chemical compound or sample.

The wavelength range of ultraviolet and visible spectroscopy is 192 to 900nm.

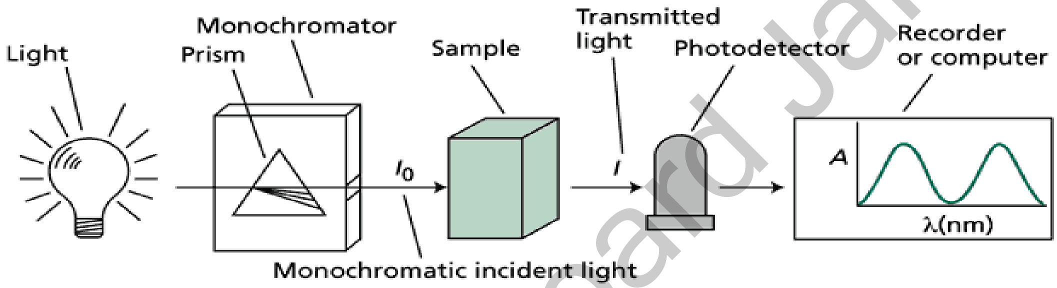


Figure 7.14 Ultraviolet and visible spectroscopy

7.4.1.2 Infrared Spectroscopy

The Infrared spectroscopy is analytical technique introduced in 1950, which qualify and quantify the information about samples in less time and cost effective .it is non hazardous because no any polluting chemical is required for this analysis. It is basically used for specification of functional groups in food products, polymers and industries now a days. It is an effective tool for quality control in different industries.

Electromagnetic radiations lower in energy than visible radiations are called infra- red radiation. The ordinary IR region extends from 2.5 μm(wavelength)to 15 μm(wavelength) or 4000 to 625 cm^{-1} (wave number).

When IR radiations passed through an organic molecule, the energy absorbed by the molecule is sufficient to produce vibrations in the molecules and the energy which is not absorbed is transmitted through the sample .It is also known as Vibrational spectroscopy.

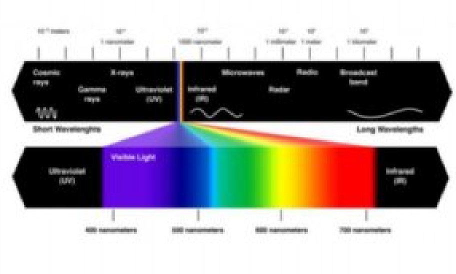


Figure 7.15 Spectrum

Figure 7.16 Spectrophotometer

7.4.2 Chromatographic Methods

Chromatography is the modern analytical technique which is used for separation of compounds . It also facilitate the purification ,isolation and comparision of components of mixture.It may be employed with all kinds of Voltile and soluble substance,organic and inorganic , polar and non polar etc.

Chromatography process starts with the mobile phase in which solutes are dissolved in substance and carry to next stationary phase. The different components of mixture travel from mobile to stationary phase with different speed and retention time.

The main types of chromatography are gas chromatography and liquid chromatography which are discussed below with detail of advanced instruments of chromatography.

7.4.2.1 High Performance Liquid Chromatography (HPLC)

What is HPLC?

The HPLC stands for high performance liquid chromatography, sometimes it also consider as high pressure liquid chromatography. It is the technique to separate out the substances. HPLC instrument is consisting of reservoir of mobile phase, a pump, an Injector, a separation column, a detector and data acquisition computer .The mobile liquid phase is pumped through the column packed with the absorbent, hence separation becomes more rapid. The pressure mechanical pump ensures the rapid solvent flow. The flow rate of solvent affects the resolution of sample components. As each component passes through the column, the detector notes its elution and gives signal to the recorder.

Do You Know?

What is mobile phase ?

Moving fluid stream of liquid containing sample up to stationary phase is called mobile phase .

What is stationary phase?

Stationary phase is not moveable.

What is retention time ?

The time taken for separation of components in compound from start to the elution or exit is called retention time. this retention time helps to identify the components of compounds.

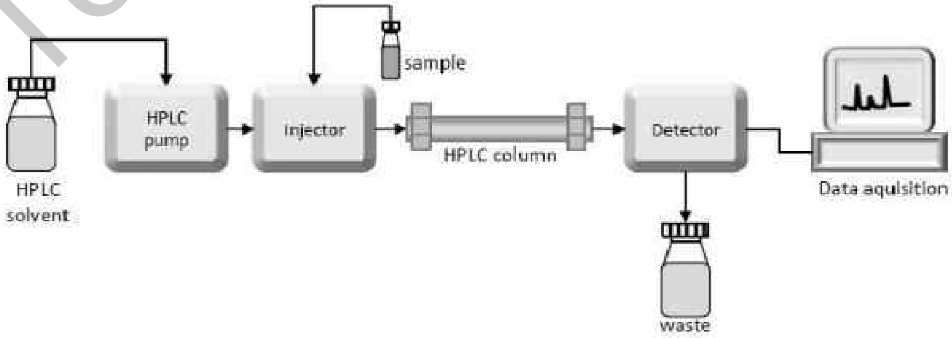


Figure 7.17 HPLC

These instruments are used in drug discovery, clinical analysis, cosmetic analysis, pharmaceutical, enviormental chemistry and biochemical genetics.

7.4.2.2 Gas Chromatography

What is Gas Chromatography?

A gas chromatography is a technique used in analytical chemistry for the separation of volatile compounds. The word gas chromatography is clear from its word that it is used for the separation of gases and volatile liquids in gaseous state.

The separation takes place by the exchange between a mobile gas phase and a liquid or solid stationary phase. The first gas chromatograph was introduced by noble prize winner John Porter Martin in 1950 and considered as father of modern gas chromatography.

Do You Know?

What are volatile compounds? Volatile compound are those organic compounds which have high vapor pressure and low water solubility and emits gases from certain solids and liquids. such as benzene, formaldehyde, xylene, toluene

The instrument of Gas chromatography is consisting of Gas cylinder, sample injector, Gas chromatograph, detector and data collection device. Where Gas is mobile phase and Gas cylinder controls the gas passage up to sample injector, which proceeds toward two columned gas chromatograph it is a stationary phase with uniform temperature. When compound reach the detector it detect the elution and send signals to data collection device (computer).

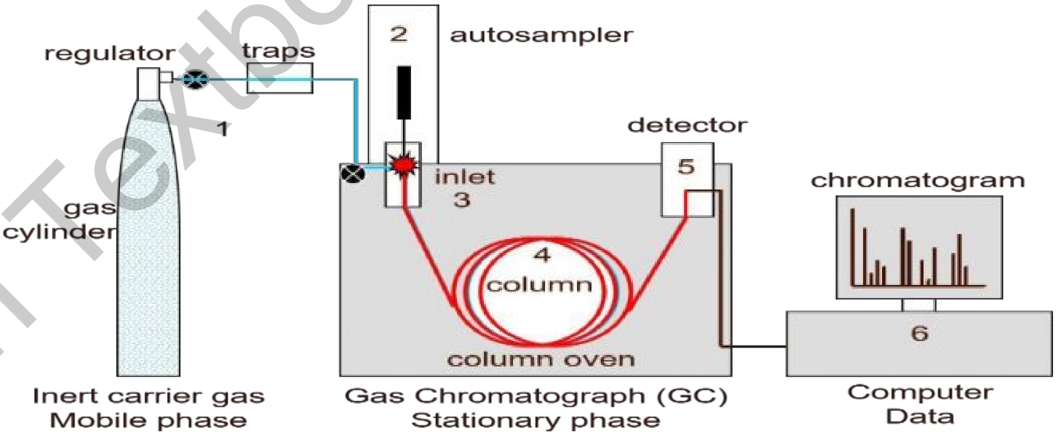


Figure 7.18 Gas chromatography

The gas chromatography used in analysis of inorganic compound, carbohydrates, proteins, lipids, vitamins, pollutants like benzene, plastic materials and dairy product.

7.4.3 Electrochemical Methods

The electrochemical method is an analytical technique which deal with measurement of potential, charge, electrical quantity or property of a solution .the measurement carried out by the use of certain instrument due to this known as advanced instrumental methods. These methods are useful because of consuming less time and without any suitable indicators.

The electrochemical analytical method is carried out with the help of electrochemical cell which is shown in the following figure, generally it consist of electrodes named as anode and cathode. Anode posses negative sign due to liberation of electrons in oxidation reaction and cathode posses positive sign due to consumption of electrons in reduction reaction.

The electrochemical cells consists of two half cells, both are connected with an electrode (anode and Cathode) and each electrode is dipped in electrolytic solution which is $ZnSO_4$ at Anode and $CuSO_4$ at cathode.

The half cells are connected by means of salt bridge (NaCl) which provides a platform for ionic connectivity without mixing, as we discuss that one of half cell losses electron due to oxidation and other half gains electrons in reduction process. Always remember that when equilibrium phase comes in both half cells the net voltage become zero and production of electricity by cell will stop.

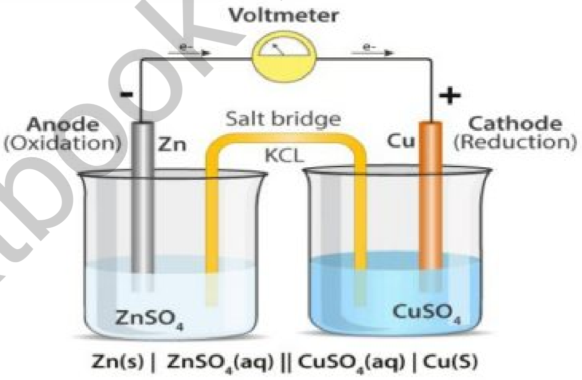


Figure 7.19 Electrochemical cell

7.4.3.1 Potentiometry

Potentiometry is method used in electroanalytical chemistry to find the concentration of solute in solution in potentiometric measurement. The potential between two electrodes is measured by voltmeter. There is no any flow of current.

Potentiometric analysis is used in analysis of pollutant in water, pharmaceutical and drugs, quality control in food industry and clinical chemistry.

Figure 7.20 The voltmeter

7.4.3.2 Conductometry

Conductometry is one of the important analytical technique which is used in physico – chemical analysis. It can be defined as a technique of analysis which is based on the measurement of electrical conductance.

It is done by the help of conductivity meter.

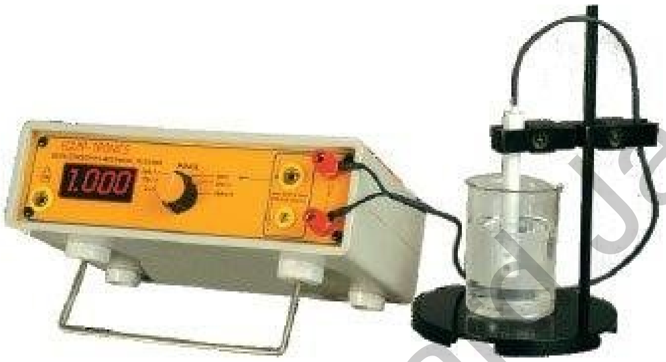


Figure 7.21 Conductometry

Applications of conductometry:

- Degree of dissociation constant can be determined.
- Solubility of a sparingly soluble salt can be determined.
- Rate constant of a reaction can be studied.
- End point of titration can be determined.

Distinguish Between Classical and Instrumental Methods

Classical Method	Instrumental Method
1. Procedure is simple and accurate.	1 Procedure is sensitive and technical.
2. Equipment needed is cheap.	2 Equipment needed is expensive
3. Methods are based on absolute measurement.	3 Methods are based on reliable measurement.
4 Specialized training is not required.	4 Specialized training is required.
5 Accuracy decreases by decreasing amount.	5 Accuracy depends upon instruments.
6 Determination is slow.	6 Determination is very fast.
7 Large amount of sample is needed.	7 Small amount of samples can be used.

Summary

- The analysis and separation of sample to detect and estimate its components through various techniques and instruments is known as Analytical Chemistry.
- The analytical chemistry answer the basic questions of What, Where, How much about material.
- The Analytical Chemistry is applied in all fields of chemistry such as Medicine, Clinical laborites, industries, Agriculture, food contamination and environmental protection.
- The Analytical Chemistry is consisting of two types Qualitative Analysis and Quantitative Analysis.
- Qualitative analysis is concerned with identification of elements, ions or compounds present in sample and only measure quality, qualitative analysis subdivided in two inorganic qualitative analysis and organic qualitative analysis.
- Quantitative analysis is concerned with the estimation of amount of a chemical substance present either alone or in a simple or complex mixture of other substances. quantitative analysis subdivided in physical quantitative analysis and chemical quantitative analysis.
- Error is a numerical difference between observed value and true value. Errors are classified as systematic and random errors.
- The accuracy of analytical method is the closeness of obtained value to the true value of a sample.
- Precision is defined as the degree of agreement between replicate measurements of the same quantity.
- The classical methods posses' qualititative as well as quantitative analysis. Such as chemical and flame tests are qualitative and titrimatic and gravimetric analysis are quantitative analysis.
- Instrumental methods includes spectroscopy ,chromatography , electrochemical methods ,ultra violet and visible spectroscopy ,infra red spectroscopy ,HPLC, gas chromatography, potentiomatric and conductometry.

Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

1. Encircle the correct answer:

1. The Analytical Chemistry deals with instruments and methods to ________, identify and quantify the matter.
   (a) MIx (b) Separate (c) Differentiate (d) Manipulate
2. The sample may be solid, liquid, gas or a ________ in qualitative analysis.
   (a) Mixture (b) Compound (c) Substance (d) None of these
3. Analysis deals with the identification of presence of functional groups in compounds is.
   (a) Physical qualitative analysis (b) Analytical qualitative analysis
   (c) Organic qualitative analysis (d) Inorganic qualitative analysis
4. Flame test of Copper Halide with bluish-green color identify the presence of.
   (a) Halogen (b) Hydrogen (c) Copper (d) b and c
5. The physical methods used to measure physical properties is called
   (a) Combustion analysis method (b) Atomic emission spectroscopy method
   (c) Volumetric analysis method (d) Gravimetric analysis method
6. The error caused by improper functioning of instrument is:
   (a) Determinant Error (b) In determinant Error
   (c) Systematic Error (d) Both a & c
7. An agreement between a measured value and the accepted true value.
   (a) Error (b) Accuracy (c) Precision (d) All of these
8. Spectroscopy is the interaction of light with :
   (a) Liquid (b) Solid (c) Gas (d) Matter
9. The Gas is mobile phase in:
   (a) Liquid chromatography (b) Solid chromatography
   (c) Gas chromatography (d) None of these
10. It used to assess concentration or amount of given atomic, molecular or ionic chemical.
    (a) Chromatography (b) Spectroscopy
    (c) Conductometry (d) Potentiometry

SECTION- B: SHORT QUESTIONS:

1. What do you think which method is faster classical or instrumental?
2. How will you compare the analytical techniques to one another?
3. Can you give some examples of error related to your life?
4. What do you mean by quantitative Analysis?
5. Discriminate which of the following collected volumes of a gas in gas preparation is accurate, precise or accurate and precise both or non of these?

32 cm^3 45 cm^3 17 cm^3 23 cm^3		32cm^3 33 cm^3 34 cm^3 35 cm^3	
32 cm^3 45 cm^3 45 cm^3 32 cm^3		32 cm^3 32 cm^3 33 cm^3 32 cm^3	

6. Why we use Potentiomatric Analysis in advance instrumental methods?
7. How scientists are using Infrared spectroscopy in quality control of different industries?
8. List down the applications of Conductometry?

SECTION- C: DETAILED QUESTIONS:

1. Distinguish between following:
    (a) Quantitative Analysis and Qualitative Analysis
    (b)Titrrametic Analysis and Gravimatric Analysis
2. Prove that instrumental analytical methods are more effective then classical analytical methods?
3. Describe Gas Chromatography in detail?
4. Justify that electrochemical methods depend upon Electrochemical Cells?

Chapter 8

Industrial Chemistry

Time Allocation

Teaching periods	= 15
Assessment period	= 03
Weightage	= 15%

MAJOR CONCEPTS:

8.1 Preparation of soap
8.2 Preparation of sugar from sugar cane
8.3 Preparation of soft drinks
8.4 Petroleum Industry
8.5. Pharmaceutical Industry

STUDENTS LEARNING OUT COMES (SLO'S)

- Know different products prepared in industry. (Remembering)
- Know about saponification process (soap). (Remembering)
- Explain different materials required for soap preparation. (Understanding)
- Construct the flow chart diagram of full process of soap formation. (Applying)
- Describe the preparation of sugar from cane sugar. (Applying)
- Describe the various steps of sugar formation. (Understanding)
- Explain about the importance of pharmaceutical industries. (Creating)
- Define petroleum (Remembering)
- Describe the formation of petroleum and natural gas. (Understanding)
- Describe the composition of petroleum. (Remembering)
- Describe briefly the fractional distillation of petroleum. (Remembering)

Introduction

Almost everything used in human life for the human survival is made up of chemical products. In the modern world Chemical industries play an important role. In every industrial process chemical products are involved which play an essential vital role. The Chemical industry is the one responsible industry for converting raw materials like Petroleum, water, air, minerals, crops, metals and etc into more valuable products. There are several chemical products which have assumed the status of integral part of our daily life some of them are soaps, sugar, soft drinks, Medicines and several petroleum like Liquified Petroleum Gas (LPG), natural gas (stove gas) or compressed natural gas (CNG), polymers, petrol, diesel, lubricating oils and bitumen (damar).There are more than 70,000 different products that are manufactured through chemical industries. Here at this level we shall discuss only those which are mentioned above.

8.1 Preparation of soap

What is saponification?

Saponification is the reaction of triglycerides with sodium or potassium hydroxide to create glycerol and "soap," a fatty acid salt. Animal fats or vegetable oils are the most common sources of triglycerides. A hard soap is created when sodium hydroxide is used. The use of potassium hydroxide produces a soft soap.

When soap is dissolved in water, grime may be washed away. It may be used to treat skin lesions cleansing your body in some situations. However, we now use soap mostly for its aroma and as a cleaning.

Household uses for soaps include washing, bathing, and other types of houskeeping, where soaps act as surfactants, emulsifying oils to enable them to be carried away by water. In industry, they are used as thickeners, components of some lubricants, and precursors to catalysts.

8.1.1 Material needed for soap preparation

The raw material needed for the preparation of soap are as follows:

- Animal Fat
- Plant Oil
- Caustic Soda
- Potassium hydroxide
- Additives (color, texture, scent)
- Abrasives (silica, talc, marble)

Animal Fat

Animal fat tallows from cows, such as lard, are often used for soap making.

Plant oil

Soybean oil, like canola, safflower, and sunflower, is often used as a portion of a soap making recipe in combination with other "core" oils like coconut, olive, and palm. It's pretty unremarkable, but if you have it on hand, use it 5-15% of your soap recipe. It is mild, moisturizing and gives a low creamy lather.

Caustic soda / Potassium hydroxide (Alkali)

Caustic soda (NaOH) causes saponification and is an essential ingredient in soap-making. When flakes or beads of sodium hydroxide get added to a liquid, it forms a lye solution. This solution, when mixed with oils or fats, will lead to the chemical reaction called saponification.

Sodium hydroxide is employed as alkali for the saponification of soap now a days. Soap may also be manufactured with potassium hydroxide (caustic potash) as the alkali. Potassium soaps are more soluble in water than sodium soaps; in concentrated form, they are called soft soap. Although soft soaps are declining in importance, potassium soap is still produced in various liquid concentrations for use in combination with sodium soaps in shaving products and in the textile industry.

Additives

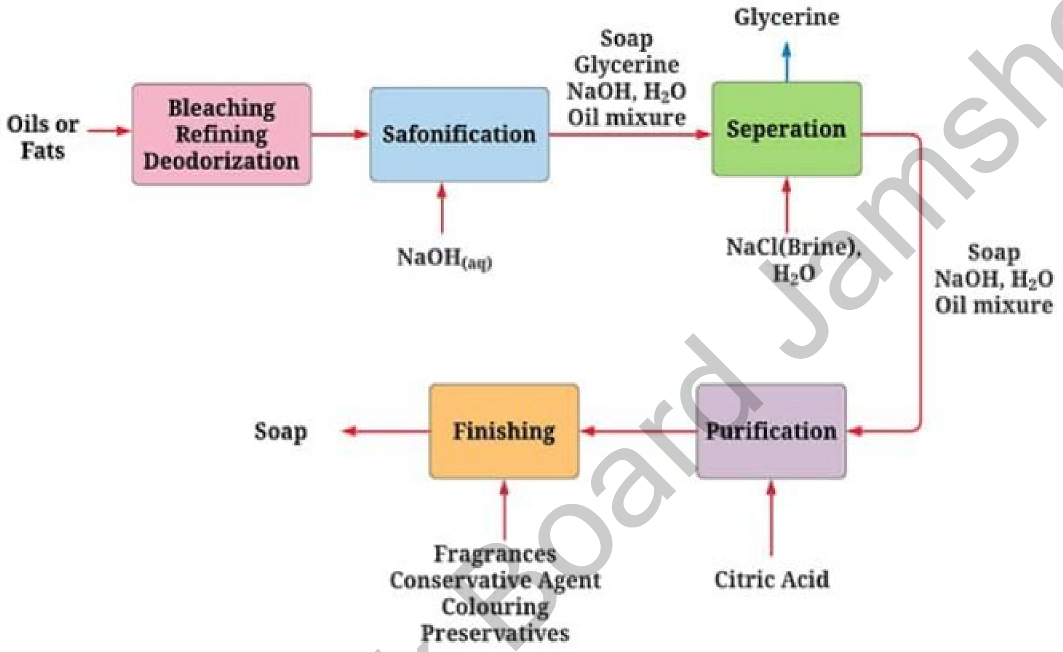
The major raw materials for soap manufacture are fat and alkali. Other substances, such as optical brighteners, colour, texture, scent, water softeners, are known as additives.

Abrasives

Water-insoluble minerals such as talc, diatomaceous earth, silica, marble, volcanic ash (pumice), chalk, feldspar, quartz, and sand are often powdered and added to soap or synthetic detergent formulations. Abrasives of an organic nature, such as sawdust, are also used. Abrasives help in removing grease and dirt from skin.

Figure 8.1 Abrasives

8.1.2 Flow sheet diagram of soap preparation



Flow Diagram for Soap Production

8.2 Preparation of sugar from sugar cane

The preparation of sugar from sugar cane composed of following steps.

- Harvesting and delivery
- Juice extraction
- Clarification
- Concentration
- Crystallization
- Crystal separation and drying

Harvesting and delivery of sugar cane

Sugarcane is generally harvested in the cooler months of the year, although it is harvested year-round in all over the Sindh. As much as two-thirds of the world's cane crop is harvested by hands but in some countries this process is also done by machines. Harvested cane is transported to the factory by many means and vehicles, such as oxcarts, trucks, railway cars, or barges.

Juice extraction of sugar cane

After weighing, sugarcane is loaded by hand or crane onto a moving table. The table carries the cane into one or two sets of revolving knives, which chop the cane into chips in order to expose the tissue and open the cell structure, thus readying the material for efficient extraction of the juice.

Clarification of extracted juice

Mixed juice from the extraction mills or diffuser is purified by addition of heat, lime, and flocculation aids. The lime is a suspension of calcium hydroxide, often in a sucrose solution, which forms a calcium saccharate compound. The heat and lime kill enzymes in the juice and increase pH from a natural acid level of 5.0–6.5 to a neutral pH. Control of pH is important throughout sugar manufacture.

This settling and separation process is known as defecation. Muds are pumped to rotary vacuum filters, where residual sucrose is washed out with a water spray on a rotating filter. Clarified juice, meanwhile, is pumped to a series of three to five multiple-effect evaporators.

Concentration of clarified juice

Steam is used to heat the first of a series of evaporators. The juice is boiled and drawn to the next evaporator, which is heated by vapour from the first evaporator. The process continues through the series until the clarified juice, which consists of 10–15 percent sucrose, is concentrated to evaporator syrup, consisting of 55–59 percent sucrose and 60–65 percent by weight total solids.

Crystallization of concentrated juice

Syrup from the evaporators is sent to vacuum pans, where it is further evaporated, under vacuum, to supersaturation. Fine seed crystals are added, and the sugar "mother liquor" yields a solid precipitate of about 50 percent by weight crystalline sugar. Crystallization is a serial process and named as A molasses, B molasses, C molasses and final molasses. which is 25% sucrose and 20% (Glucose and fructose).

Crystal separation and drying

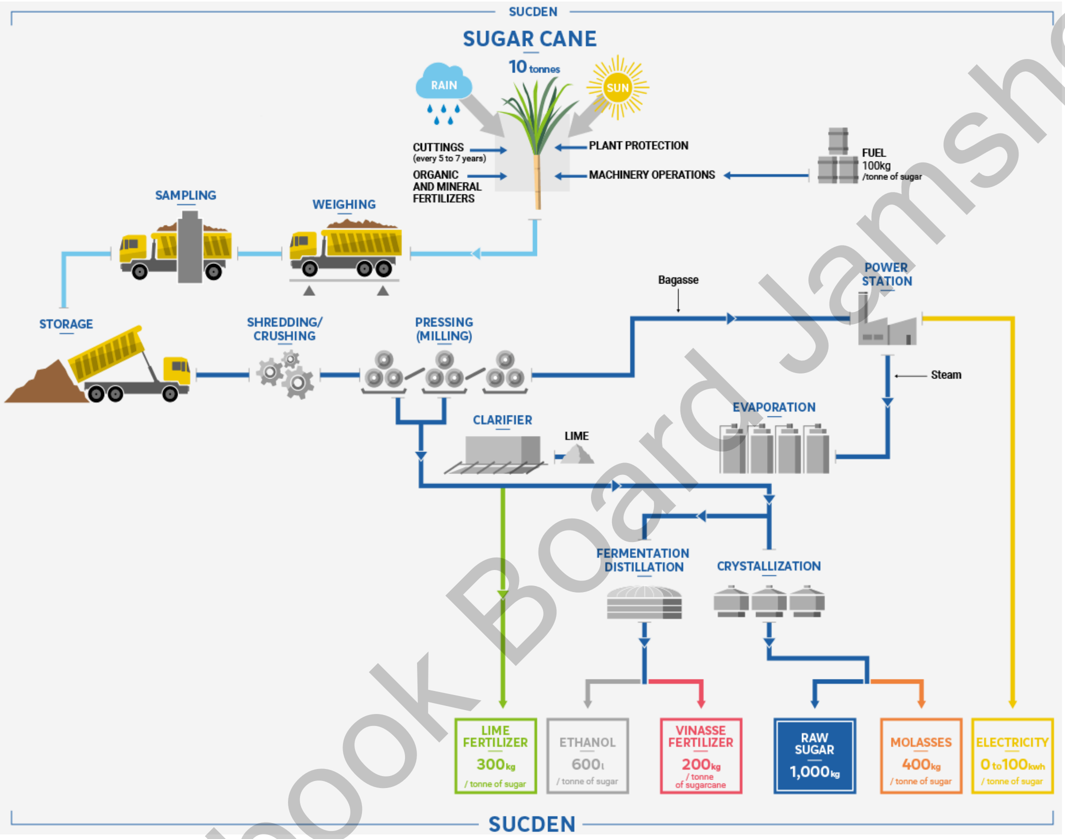
Crystals are separated in basket-type centrifuge machine. These machines continuously break the crystals through continuous centrifuge process and a fine jet of water is sprayed on the sugar pressed against the wall of the centrifugal basket, reducing the syrup coating on each crystal. In modern factories, the washing process is quite extensive in an effort to produce high-purity raw sugar.

8.2.1 Material needed for sugar preparation

The raw material needed for the preparation of sugar from sugar cane are as follows:

- Sugar cane beads
- Lime
- Water

8.2.2 Flow sheet diagram of sugar preparation



8.3 Preparation of soft drinks

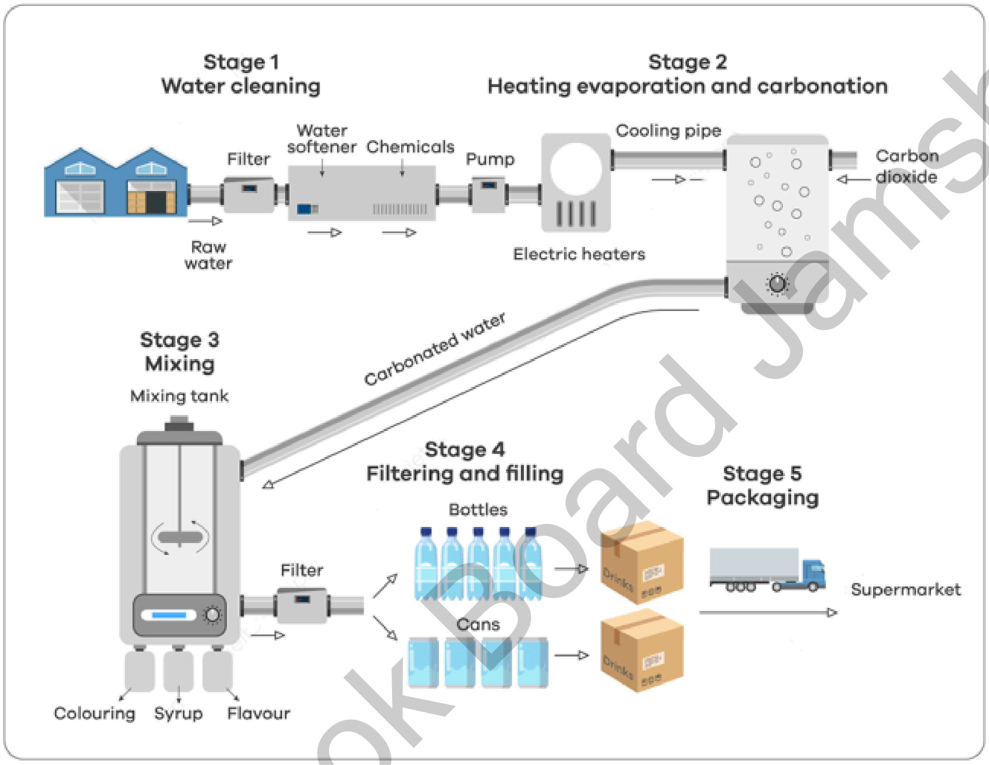
The basis of soft drinks, the syrup, is made up of water, sugar, acid, coloring and flavoring agents. This syrup is prepared by dissolving these ingredients into water to 65^0 Brix.

8.3.1 Material required for preparation of soft drink

The preparation of sugar from soft drinks compose of following steps.

- Water
- Calcium and other minerals
- Coloring and flavoring agent
- Sugar for microbial growth.
- Citric acid for sour taste.

8.3.2 Flow sheet diagram of soft drinks



8.4 Petroleum Industry

8.4.1 Petroleum

Petroleum is a natural substance trapped in rocks beneath the Earth's crust. The term "petroleum" refers to rock oil. Water, salts, and earth particles are all present in this complex combination of gaseous, liquid, and solid hydrocarbons. It is a liquid that is lighter than water yet insoluble in it.

Formation of petroleum and natural gas

Oil and gas are made up of organic material that is deposited on the seafloor as sediments, then broken down and altered over millions of years. The presence of an appropriate mix of source rock, reservoir rock, cap rock, and a trap in a given location may lead to the discovery of viable oil and gas resources.

The majority of the oil and gas resources on the Norwegian shelf are formed by a thick layer of black clay that lies thousands of meters beneath the seabed.

The black clay is a source rock, which indicates it came from a deposit with a lot of organic waste.

Composition of petroleum

Petroleum is mostly made up of hydrogen and carbon, but it also includes trace amounts of oxygen, nitrogen, sulfur, and metals including vanadium, cobalt, and nickel. Alkanes (paraffins), naphthenes, aromatics, and heterocompounds are some of the most prevalent organic substances.

The exact molecular composition of crude oil varies widely from formation to formation but the proportion of chemical elements varies over fairly narrow limits as follows:

Composition by weight	
Element	**Percent range**
Carbon	83 to 85%
Hydrogen	10 to 14%
Nitrogen	0.1 to 2%
Oxygen	0.05 to 1.5%
Sulfur	0.05 to 6.0%
Metals	< 0.1%

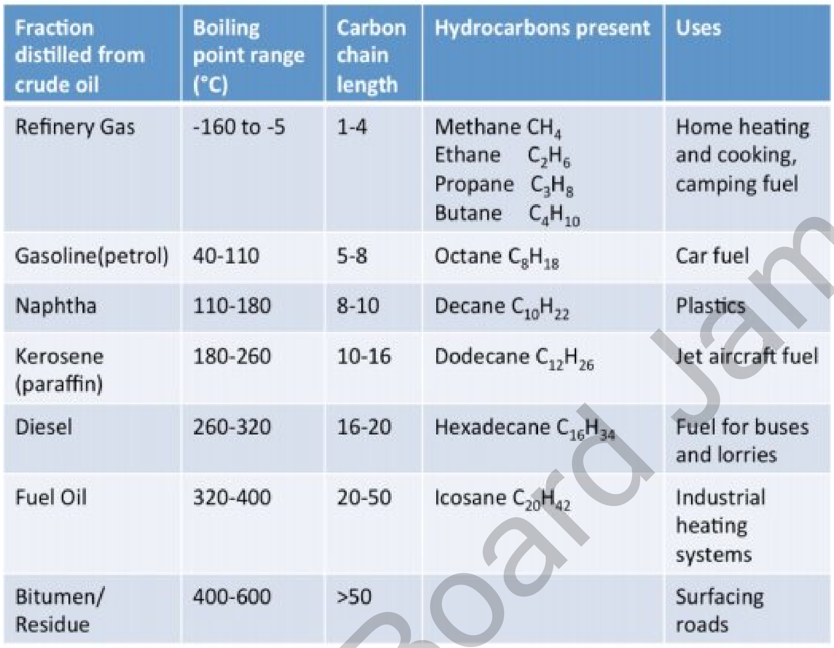
8.4.4 Fractional distillation of petrolium

This is done in oil refineries with the use of massive fractionating columns (also known as fractionating towers). These are frequently found near to the crude oil source.The industrial fractionating column is intended to be cold at the top and hot at the bottom, allowing it to cool and condense crude oil vapour at distinctively different temperature ranges defined by the column's temperature gradient.

Do You Know?

Fractional Distillation

The process of separating the constituents of a liquid mixture by heating it and separating the components according to their different boiling points.



Fraction distilled from crude oil	Boiling point range (°C)	Carbon chain length	Hydrocarbons present	Uses
Refinery Gas	-160 to -5	1-4	Methane CH_4 Ethane C_2H_6 Propane C_3H_8 Butane C_4H_{10}	Home heating and cooking, camping fuel
Gasoline(petrol)	40-110	5-8	Octane C_8H_{18}	Car fuel
Naphtha	110-180	8-10	Decane $C_{10}H_{22}$	Plastics
Kerosene (paraffin)	180-260	10-16	Dodecane $C_{12}H_{26}$	Jet aircraft fuel
Diesel	260-320	16-20	Hexadecane $C_{16}H_{34}$	Fuel for buses and lorries
Fuel Oil	320-400	20-50	Icosane $C_{20}H_{42}$	Industrial heating systems
Bitumen/ Residue	400-600	>50		Surfacing roads

8.5 Pharmaceutical Industry

8.5.1 Origin of pharma

Pharmacy as a separate science dates back to the first third of the nineteenth century. Pharmacy had been as a part of medicine since antiquity. Although the history of pharmacy and the history of medicine are closely related, it is vital to distinguish between the two subjects. Every country's healthcare system is dependent on the pharmaceutical sector. Companies authorised to study, manufacture, sell, and distribute drugs for the prevention, treatment, and cure of illnesses and other health issues make up the pharmaceutical sector. The pharmaceutical industry develops, manufactures, and markets pharmaceuticals that are administered (or self-administered) to patients with the goal of curing, vaccinating, or alleviating symptoms.

8.5.1 Importance of Pharmaceutical Industry

Pakistan's pharmaceutical business has risen significantly in recent decades. Pharmaceutical firms are always working on novel therapies that will help people live longer, healthier lives. Here are some of the industry's most important contributions, as well as why pharmaceutical firms are so vital to patients, society, and the life sciences industry:

1. Treatments increase life expectancy

The pharmaceutical business has made a significant contribution to the global increase in life expectancy for men and women. Pharmaceutical improvements are said to have responsible for 73% of the entire increase in life expectancy between 2000 and 2009 in 30 developing and high-income nations.

2. The industry strives to eradicate and eliminate diseases

When it comes to creating remedies, the ultimate objective is disease elimination, as this helps ecosystems on a worldwide scale. Smallpox is the first – and so far only – human illness to be declared eliminated globally, according to the World Health Organization (WHO).

3. Reduced pain and suffering

According to a research conducted by the World Health Organization, people who live with chronic pain are four times more likely to have melancholy, anxiety, and difficulties working than those who do not.

4. Vaccines save money

Vaccines not only serve to save millions of lives, but they also help to save money. Vaccines are commonly regarded as a cost-effective public health intervention that reduces healthcare costs and prevents lost productivity, hence limiting the economy's overall impact.

5. Hospital stays are shorter

Many illnesses that used to necessitate invasive procedures and surgery can now be addressed with medications. Patients' ability to be discharged more quickly has relieved pressure on the healthcare system and personnel.

6. The industry employees millions of people

Pharmaceutical firms employ millions of people across the world. Who labor in fields as diverse as scientific research, technological support, and manufacturing. Pharmaceutical enterprises demand highly trained and educated employees, with positions ranging from administrative to Ph.D. scientists.

7. Pharmaceutical companies boost the global economy

The pharmaceutical business is a vital asset to the global economy, as well as driving medical development by researching, developing, and providing innovative medications to people throughout the world that enhance their health and quality of life.

Pharmaceutical businesses, on the whole, play an important role in assisting patients and communities. They supply more than just possible cures and life-saving treatments;

Pharmaceutical businesses, on the whole, play an important role in assisting patients and communities. They supply more than just possible cures and life-saving treatments; they also give rewarding jobs and help to power the global economy. Looking ahead, the

Society, Technology and Science

Different types of fire require different methods to extinguish.

Extinguishing different sorts of fires necessitates different approaches.

The following items are required to start and maintain a fire:

Wood, oil, and electricity are examples of fuels that burn in the combustion process.

Heat is the energy component of a fire that supplies the energy required for ignition and the continuation of the combustion process when it comes into contact with fuel.

Air (oxygen) is a key component in the combustion process.

A self-sustaining chemical chain reaction is a complicated reaction that necessitates the precise combination of fuel, oxygen, and heat energy.

Any of the above-mentioned components can be removed to put out a fire. Various fuels necessitate different strategies for extinguishment.

Water can be thrown on a wood fire to put it out. Water absorbs a lot of heat during the evaporation process, therefore it absorbs a lot of heat and deprives the wood fire of heat, making it impossible to keep the fire going.Oil and water do not mix, hence water will not put out an oil fire. Because oil is lighter than water, it floats and spreads across it. Water aids in the propagation of the fire. To put out an oil fire, the oxygen supply must be shut off. Throwing sand, table salt, or baking soda on the flames will help contain this.

Because its source of heat is electrical energy, an electric fire is far more powerful than ordinary flames. To put it out, the oxygen supply must be shut off. Fire extinguishers can be used to regulate oxygen delivery.

Chemistry as a career in industry

A professional chemist can be obtained through studying chemistry. He researches the chemical composition and characteristics that are now accessible. Then he devises procedures for mass-producing novel compounds on a commercial scale to fulfill societal demands. He also creates and improves tools and processes to make production more cost-effective.

Chemists can work in practically any industry, depending on their areas of specialty.

Organic chemists work in a variety of sectors, including pharmaceuticals, petroleum, petrochemicals, cosmetics, polymers, and plastics.

Inorganic chemists operate in metallurgical industries, textile, cement, sugar, and chemical manufacturing facilities, and fertilizer, acids, and caustic soda making plants.

Work prospects for physical chemists exist in the energy transformation industry. They

Chemistry as a career in industry

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Summary

- The Chemical industry is the one responsible industry for converting raw valuable products.
- Soap is the term for a salts of a fatty acid or for a variety of cleansing and lubricating products produced from such a substance
- Petroleum is a complex mixture of hydrocarbons that can be refined into several chemical compounds.
- Petroleum is formed by decomposition of dead animals and plants buried under the earth crust.
- Petroleum (crude oil) can be separated into several useful products by fractional distillation.
- The pharmaceutical industry plays a significant role in developing medications and vaccines to reduce the incidence of diseases, to treat diseases and enhance the quality of life of people.
- The pharmaceutical industry is the part of the healthcare sector that deals with medications.
- The industry comprises different subfields pertaining to the development, production and marketing of medications.
- These more or less interdependent subfields consist of drug manufacturers, drug marketers and biotechnology companies.

Exercise

SECTION- A: MULTIPLE CHOICE QUESTIONS

1. Soap is the term for a salts of a:
   (a) Carboxylic acid (b) citric acid (c) Sulphuric acid (d) fatty acid

2. Surfactants reduce the __________ of water.
   (a) Viscosity (b) Surface tension (c) Boiling point (d) Melting Point

3. The carboxylate end of the soap molecule that is attracted to water is called __.
   (a) hydrophobic end (b) end point (c) hydrophilic end (d) n.o.t

4. The use of potassium hydroxide produced a:
   (a) Hard soap (b) Soft soap (c) Moderate soap (d) All of these

5. The citric acid is used in preparation of cold drinks for:
   (a) Sweet taste (b) Bitter taste (c) Sour taste (d) Salty taste

6. The centrifuge machine used for separation of:
   (a) Juice (b) pH (c)Mud (d)Crystal

7. The abrasives are:
   (a) Water soluble minerals
   (b) Water insoluble minerals
   (c) Water semi soluble minerals
   (d) Water absorving minerals

8. The harvesting is most important step of:
   (a) Preparation of soap
   (b) Preparation of coldrinks
   (c) Preparation of sugar
   (d) Preparation of medicines

9. Which of the following is used as jet fuel:
   (a) Kerosene oil (b) Diesel oil (c) fuel oil (d) petrol

10. Which one of the following is not a fraction of crude oil?
   (a) paraffin wax (b) ammonia (c) fuel oil (d) petroleum coke

SECTION- B: SHORT QUESTIONS:

1. Define saponification process.
2. Describe that NaOH or KOH are used in preparation of soap.
3. List down the raw material needed for sugar preparation.
4. Explain components of soft drinks.
5. Define petroleum
6. Justify the petroleum is "Black Gold".

SECTION- C: DETAILED QUESTIONS:

1. Describe fractions of petroleum in detail.
2. Explain the process of preparation of sugar from sugar cane.
3. Write down the importance of pharma industry.
4. Describe the soap preparation with the help of flow sheet diagram.
5. Draw stepwise preparation of soft drinks in flow sheet diagram.