

31

BIOMOLECULES

You are aware that our body, plants and other animals are made up of many chemical substances. There are certain complex organic molecules which form the basis of life. These build up living organisms and are also required for their growth and maintenance. Such molecules are called **biomolecules**. The main classes of biomolecules are carbohydrates, proteins, lipids, nucleic acids, enzymes, hormones etc. In this lesson, you will study about the structures and functions of some important biomolecules.



Objectives

After reading this lesson you will be able to :

- identify and define different types of biomolecules;
- describe the important structural features of biomolecules;
- classify carbohydrates, proteins and lipids on the basis of their structure & functions;
- give the composition of proteins and nucleic acids;
- explain the difference between DNA and RNA;
- differentiate between oils and fats;
- explain the action of enzymes and their characteristic features and
- list the functions of biomolecules in biological systems.

31.1 Carbohydrates

Carbohydrates form a very large group of naturally occurring organic compounds which play a vital role in daily life. They are produced in plants by the process of **photosynthesis**. The most common carbohydrates are glucose, fructose, sucrose, starch, cellulose etc. Chemically, the carbohydrates may be defined as **polyhydroxy aldehydes** or **ketones**

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or **substances which give such molecules on hydrolysis**. Many carbohydrates are sweet in taste and all sweet carbohydrates are called as **sugars**. The chemical name of the most commonly used sugar in our homes is sucrose.

31.1.1 Classification of Carbohydrates

Carbohydrates are classified into three groups depending upon their behaviour on hydrolysis.

- (i) **Monosaccharides**: A polyhydroxy aldehyde or ketone which cannot be hydrolysed further to a smaller molecule containing these functional groups, is known as a *monosaccharide*. About 20 monosaccharides occur in nature and glucose is the most common amongst them.

Monosaccharides are further classified on the basis of the number of carbon atoms and the functional group present in them. If a monosaccharide contains an aldehyde group, it is known as an **aldose** and if it contains a keto group, it is known as a **ketose**. The number of carbon atoms present is also included while classifying the compound as is evident from the examples given in Table 31.1. Name of some naturally occurring monosaccharides are given in brackets.

Table 31.1 Classification of monosaccharides

No. of carbon atoms present	Type of monosaccharide	
	Aldose	Ketose
3	Aldotriose (Glyceraldehyde)	Ketotriose
4	Aldotetrose ((Xylose)	Ketotetrose
5	Aldopentose (Erythrose)	Ketopentose
6	Aldohexose (Glucose)	Ketohexose
7	Aldoheptose	Ketoheptose

- (ii) **Disaccharides**: Carbohydrates which give two monosaccharide molecules on hydrolysis are called disaccharides e.g. sucrose, maltose, lactose etc.

- (iii) **Polysaccharides**: Carbohydrates which yield a large number of monosaccharide units on hydrolysis e.g. starch, glycogen, cellulose etc.

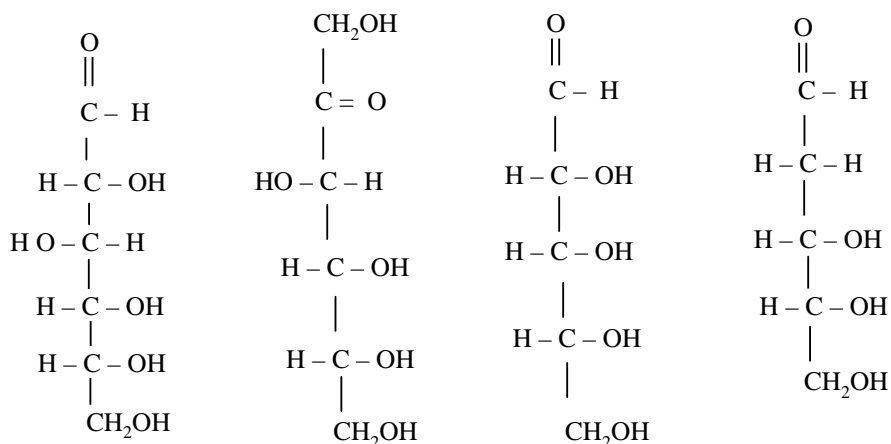
31.1.2 Structure of Monosaccharides

Although a large number of monosaccharides are found in nature, we will confine our discussion here to four of them only viz. D-glucose, D-fructose, D-ribose and 2-deoxy-D-ribose.

D-Glucose (an aldohexose) is the monomer for many other carbohydrates. Alone or in combination, glucose is probably the most abundant organic compound on the earth. D-Fructose (a ketohexose) is a sugar that is found with glucose in honey and fruit juices. D-Ribose (an aldopentose) is found in ribonucleic acids (RNA) while. 2-Deoxy-D-ribose is an important constituent of the deoxyribonucleic acids (DNA). Here, the prefix 2-Deoxy indicates that it lacks oxygen at carbon no. 2.



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D-Glucose

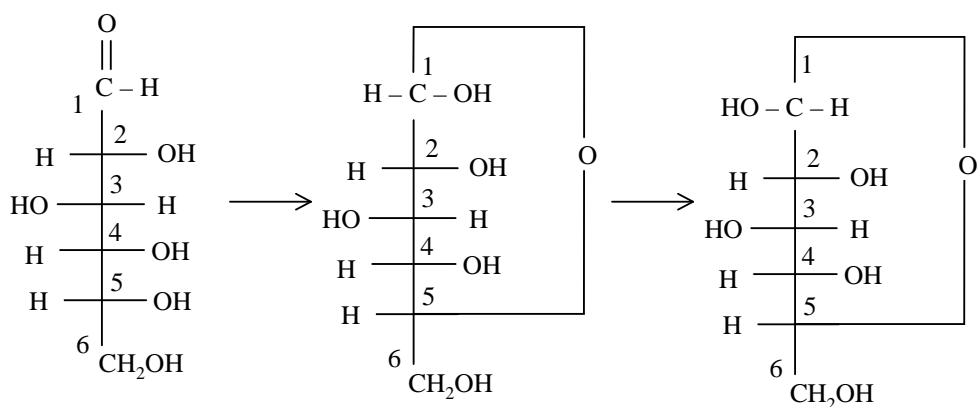
D-Fructose

D-Ribose

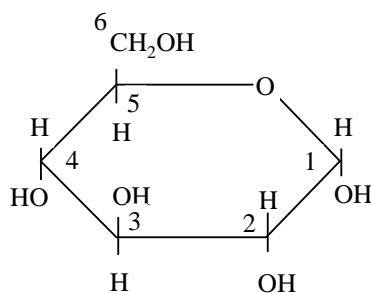
2-Deoxy-D-ribose

These monosaccharides generally exist as cyclic compounds in nature. A ring is formed by a reaction between the carbonyl group and one of the hydroxyl groups present in the molecule. Glucose preferentially forms the six membered ring which can be in two different isomeric forms called α - and β -forms (shown below as I & II). The two forms differ only in the arrangement of the hydroxyl group at carbon No.1. Such isomers are called **anomers**.

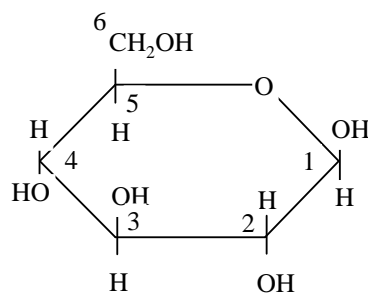
Formation of these cyclic structures (I and II) from the open chain structure can be shown as follows.

(I) α -D-glucose(II) β -D-glucose

The cyclic structures I and II are more appropriately represented as Ia and IIa.



(Ia)



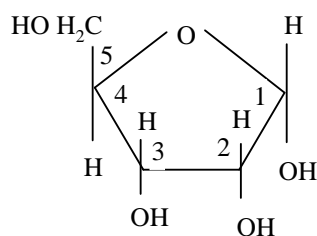
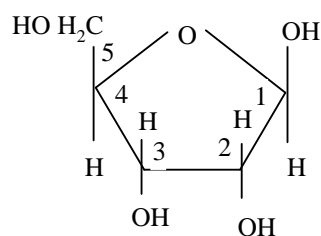
(IIa)

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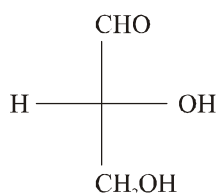
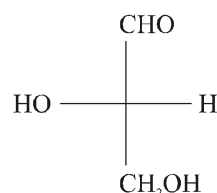


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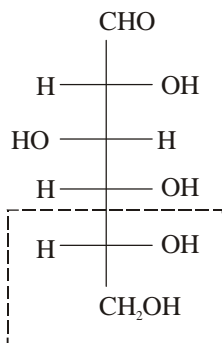
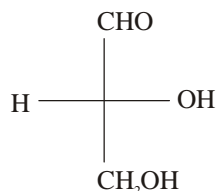
The α - and β -forms of other sugars also exist in the cyclic form. D-Ribose forms a five membered ring structure as shown below

 α - D - ribose β - D - ribose

D-before the name of above example indicates the configuration of particular stereoisomer. Stereoisomers are assigned relative configurations as D- or L-. This system of assigning the relative configuration refers to their relation with glyceraldehyde. Glyceraldehyde contains one asymmetric carbon atom so exists in two enantiomeric forms as shown below.

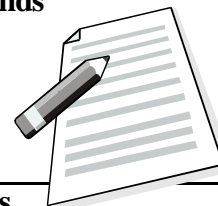
**(+) -glyceraldehyde****(-) -glyceraldehyde**

All those compounds which can be correlated to (+) -glyceraldehyde are said to have D-configuration and those can be correlated to (-) -glyceraldehyde are said to have L-configuration. In monosaccharides it is the lowest asymmetric carbon atom (shown in the box) by which the correlation is made. As in (+) glucose the lowest asymmetric carbon atom has -OH group on the right side which matches with (+) glyceraldehyde hence it is assigned D-configuration.

**(+) - glucose or D-glucose****(+) - glyceraldehyde or D-glyceraldehyde**

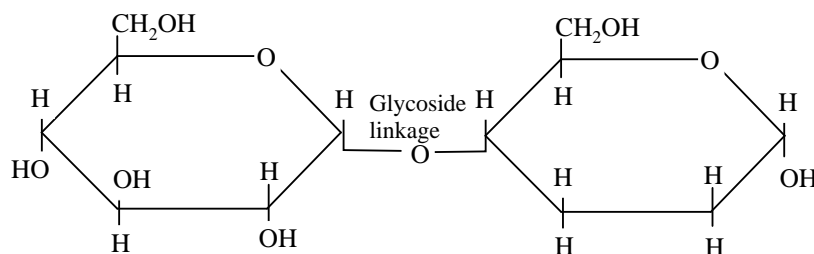
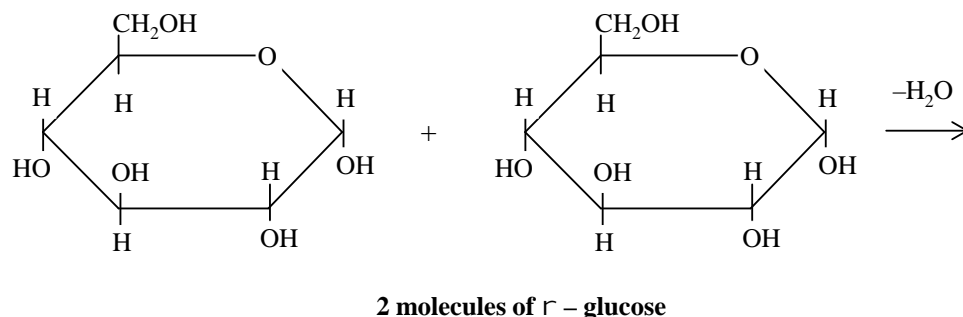
31.1.3 Structure of Di-Saccharides and Polysaccharides

Disaccharides are formed by the condensation of two monosaccharide molecules. These monosaccharides join together by the loss of a water molecule between one hydroxyl



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group on each monosaccharide. Such a linkage, which joins the monosaccharide units together is called **glycoside linkage**. If two α -glucose molecules are joined together, the disaccharide maltose is formed.



Maltose

Similarly, sucrose (the common sugar) consists of one molecule of glucose and one molecule of fructose joined together. Lactose (or milk sugar) is found in milk and contains one molecule of glucose and one molecule of galactose.

If a large number of monosaccharide units are joined together, we get polysaccharides. These are the most common carbohydrates found in nature. They have mainly one of the following two functions- either as food materials or as structural materials. Starch is the main food storage polysaccharide of plants. It is a polymer of α -glucose and consists of two types of chains- known as **amylose** and **amylopectin**.

Amylose is a water soluble fraction of starch and is a linear polymer of α -D-glucose. On the other hand amylopectin is a water insoluble fraction and consists of branched chain of α -D-glucose.

The carbohydrates are stored in animal body as glycogen which is also a polymer of α -glucose and its structure is similar to amylopectin.

Cellulose is another natural polysaccharide which is the main component of wood and other plant materials. It consists of long chain of β -D-glucose molecules.

31.1.4 Biological Importance of Carbohydrates

- (i) Carbohydrates act as storage molecules. For example they are stored as starch in plants and as glycogen in animals.
- (ii) D-Ribose and 2-deoxy-D-ribose are the constituents of RNA and DNA, respectively.

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- (iii) Cell walls of bacteria and plants are made up of cellulose. It may be of interest to note that human digestive system does not have the enzymes required for the digestion of cellulose but some animals do have such enzymes.
- (iv) Some carbohydrates are also linked to many proteins and lipids. These molecules are known as glycoproteins and glycolipids, respectively. These molecules perform very specific functions in organisms.



Intext Questions 31.1

1. Name three constituents of your diet which provide carbohydrates.
2. How are carbohydrates produced in nature?
3. What are the hydrolysis products of starch and sucrose?
4. Write the linear and ring forms of D-glucose.

31.2 Proteins

Proteins are the most abundant macromolecules in living cells. The name protein is derived from the Greek word '**proteios**' meaning 'of prime importance'. These are high molecular mass complex amino acids. You will study about amino acids in the next section. Proteins are most essential class of biomolecules because they play the most important role in all biological processes. A living system contains thousands of different proteins for its various functions. In our every day food pulses, eggs, meat and milk are rich sources of proteins and are must for a balanced diet.

31.2.1 Classification of Proteins

Proteins are classified on the basis of their chemical composition, shape and solubility into two major categories as discussed below.

- (i) **Simple proteins:** Simple proteins are those which, on hydrolysis, give only amino acids. According to their solubility, the simple proteins are further divided into two major groups **fibrous** and **globular proteins**.
 - (a) **Fibrous Proteins:** These are water insoluble animal proteins eg. collagen (major protein of connective tissues), elastins (protein of arteries and elastic tissues), keratins (proteins of hair, wool, and nails) are good examples of fibrous proteins. Molecules of fibrous proteins are generally long and thread like.
 - (b) **Globular Proteins:** These proteins are generally soluble in water, acids, bases or alcohol. Some examples of globular proteins are albumin of eggs, globulin (present in serum), and haemoglobin. Molecules of globular proteins are folded into compact units which are spherical in shape.
- (ii) **Conjugated proteins:** Conjugated proteins are complex proteins which on hydrolysis yield not only amino acids but also other organic or inorganic components. The non-amino acid portion of a conjugated protein is called **prosthetic group**.

Unlike simple proteins, conjugated proteins are classified on the basis of the chemical nature of their prosthetic groups. These are



- Nucleoproteins (protein + nucleic acid)
- Mucoproteins and glycoproteins (protein+ carbohydrates)
- Chromoproteins (proteins + a coloured pigment)
- Lipoproteins (proteins + lipid)
- Metalloproteins (metal binding proteins combined with iron, copper or zinc)
- Phosphoproteins (proteins attached with a phosphoric acid group).

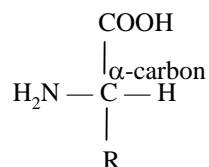
Proteins can also be classified on the basis of functions they perform, as summarized in table 31.2.

Table 31.2 : Classification of proteins according to their biological functions

Class	Functions	Examples
1. Transport Proteins	Transport of oxygen, glucose and other nutrients	Haemoglobin Lipoproteins
2. Nutrient and storage Proteins	Store proteins required for the growth of embryo	Gliadin(wheat) Ovalbumin(egg) Casein (milk)
3. Structural Proteins	Give biological structures, strength or protection	Keratin(Hair, nails,etc.) collagen(cartilage)
4. Defence Proteins	Defend organisms against invasion by other species	Antibodies Snake venoms
5. Enzymes	Act as catalysts in biochemical reactions	Trypsin,Pepsin
6. Regulatory Proteins	Regulate cellular or physiological activity	Insulin

31.2.2 Structure of Proteins

Protein molecules are polymers of different sizes and shapes with different physical and chemical properties. The monomer units for proteins are amino acids. All the amino acids that are found in proteins have an amino group($-\text{NH}_2$) on the carbon atom adjacent to carbonyl group, hence are called α -amino acids. The general formula of α -amino acids is shown below.



All proteins found in nature are the polymers of about twenty (20) different α -amino acids and all of these have L-configuration. Out of these ten (10) amino acids cannot be synthesized by our body and hence must form the part of our diet. These are called **essential amino acids**.

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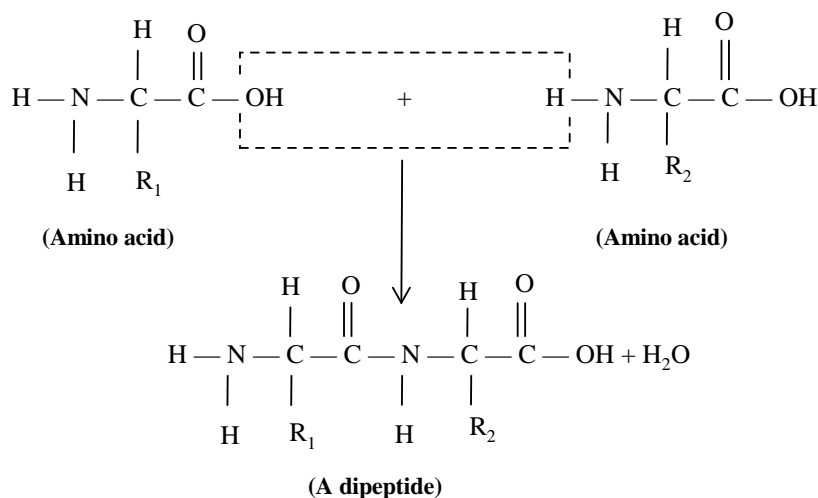


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All proteins have one common structural feature that their amino acids are connected to

one another by *peptide linkages*. By a peptide linkage we mean an amide $\left(\begin{array}{c} \text{O} \\ || \\ -\text{C}-\text{N}- \\ | \\ \text{H} \end{array} \right)$

bond formed when the carboxyl group of one amino acid molecule reacts with the α -amino group of another. In the process, a molecule of water is given off. The product of the reaction is called a *peptide* or more precisely a *dipeptide* because it is made by combining two amino acids, as shown below:

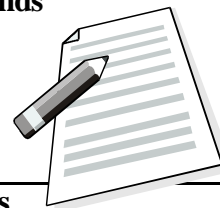


If a third amino acid is joined to a **dipeptide** in the same manner, the product is a **tripeptide**. Thus, a tripeptide contains three amino acids linked by two peptide linkages. Similar combinations of four, five, six amino acids give a **tetrapeptide**, a **pentapeptide**, a **hexapeptide**, respectively. Peptides formed by the combination of more than ten amino acid units are called **polypeptides**. **Proteins are polypeptides** formed by the combination of **large number of amino acid units**. There is no clear line of demarcation between polypeptides and proteins. For example insulin, although it contains only 51 amino acids, is generally considered a small protein.

The amino acid unit with the free amino group is known as the *N*-terminal residue and the one with the free carboxyl group is called the *C*-terminal residue. By convention, the structure of peptide or proteins written with the *N*-terminal residue on the left and the *C*-terminal on the right.

The actual structure of a protein can be discussed at four different levels.

- (i) **Primary structure:** Information regarding the sequence of amino acids in a protein chain is called its primary structure. The primary structure of a protein determines its functions and is critical to its biological activity.
- (ii) **Secondary structure:** The secondary structure arises due to the regular folding of



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the polypeptide chain due to hydrogen bonding between $\text{--}\overset{\text{O}}{\underset{\text{||}}{\text{C}}}\text{--}$ and >N--H group.

Two types of secondary structures have been reported. These are α helix (Fig. 31.1) when the chain coils up and β -pleated sheet (Fig. 31.2) when hydrogen bonds are formed between the chains.

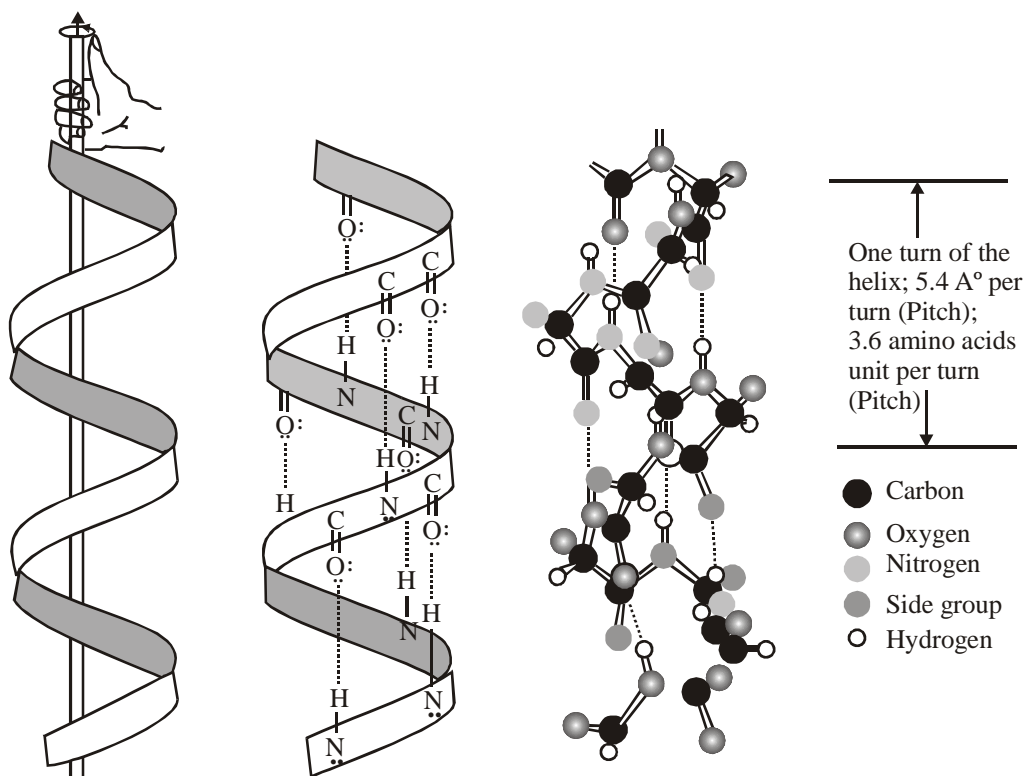


Fig. 31.1 : The α -helix structure of protein

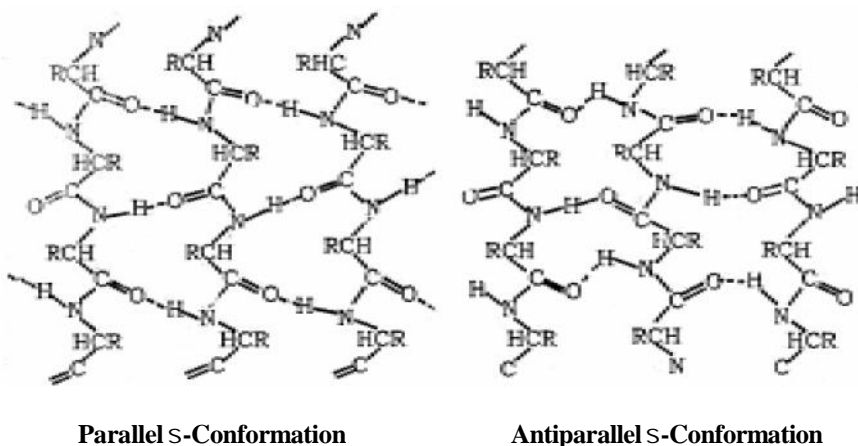


Fig. 31.2 : The β -pleated-sheet structure of protein

(iii) **Tertiary structure:** It is the three-dimensional structure of proteins. It arises due to folding and superimposition of various α -helical chains or β -pleated sheets. For example Fig. 31.3 represents the tertiary structure for the protein myoglobin.

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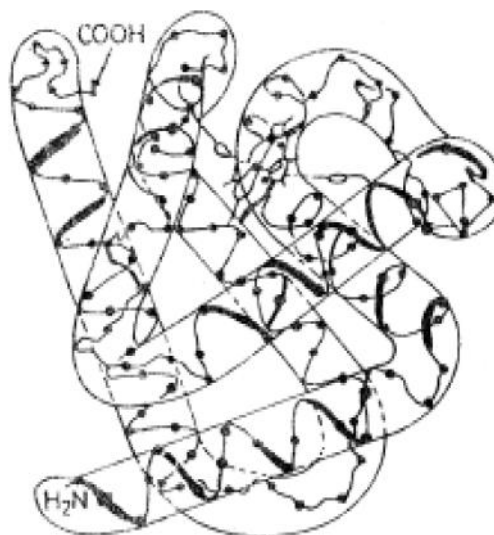


Fig. 31.3 : Structure of myoglobin

(iv) **Quaternary structure:** The quaternary structure refers to the way in which simple protein chains associate with each other resulting in the formation of a complex protein.

By different modes of bonding in secondary and tertiary structural levels a protein molecule appears to have a unique three-dimensional structure.

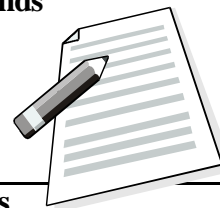
31.2.3 Denaturation

One of the great difficulties in the study of the structure of proteins is that if the normal environment of a living protein molecule is changed even slightly, such as by a change in *pH* or in temperature, the hydrogen bonds are disturbed and broken. When attractions between and within protein molecules are destroyed, the chains separate from each other, globules unfold and helices uncoil. We say that the protein has been denatured.

Denaturation is seen in our daily life in many forms. The curdling of milk is caused by bacteria in the milk which produce lactic acid. The change in *pH* caused by the lactic acid causes denaturation, coagulation and precipitation of the milk proteins. Similarly, the boiling of an egg causes precipitation of the albumin proteins in the egg white. Some proteins (such as those in skin, fingernails, and the stomach lining) are extremely resistant to denaturation.

31.2.4 Biological Importance of Proteins

- (i) Proteins are structural components of cells.
- (ii) The biochemical catalysts known as enzymes are proteins.
- (iii) The proteins known as immunoglobins serve in defence against infections.
- (iv) Many hormones, such as insulin and glucagon are proteins.
- (v) Proteins participate in growth and repair mechanism of body tissues.
- (vi) A protein called fibrinogen helps to stop bleeding.
- (vii) Oxygen is transported to different tissues from blood by haemoglobin which is a protein attached to haeme part.



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**Intext Questions 31.2**

1. What do you understand by primary structure of protein ?

.....

2. What do you mean by a peptide bond?

.....

3. Write the general structural formula of an α -amino acid?

.....

4. What are conjugated proteins ?

.....

31.3 Lipids

The lipids include a large number of biomolecules of different types. The term lipid originated from a Greek word '*Lipos*' meaning fat. In general, those constituents of the cell which are insoluble in water and soluble in organic solvents of low polarity (such as chloroform, ether, benzene etc.) are termed as *lipids*. Lipids perform a variety of biological functions.

31.3.1 Classification of Lipids

Lipids are classified into three broad categories on the basis of their molecular structure and the hydrolysis products.

- (i) **Simple Lipids:** Those lipids which are esters and yield fatty acids and alcohols upon hydrolysis are called simple lipids. They include oils, fats and waxes.
- (ii) **Compound Lipids:** Compound lipids are esters of fatty acids and alcohol with additional compounds like phosphoric acid, sugars, proteins etc.
- (iii) **Derived Lipids:** Compounds which are formed from oils, fats etc. during metabolism. They include steroids and some fat soluble vitamins.

31.3.2 Structure of lipids

The structure of all three types of lipids are briefly discussed below.

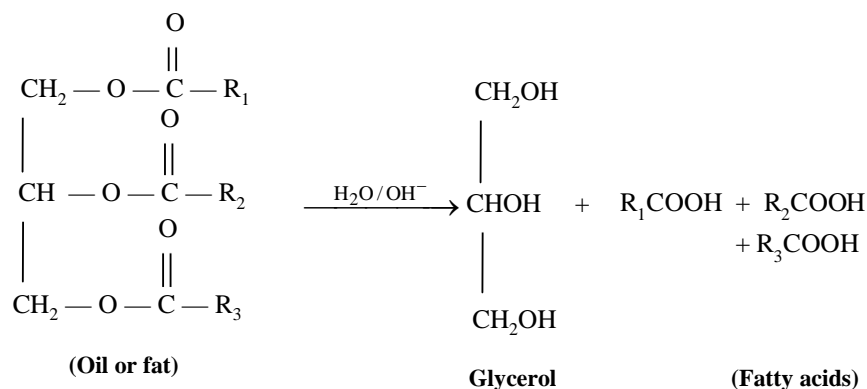
- (i) **Simple Lipids**

The simple lipids are esters. They are subdivided into two groups, depending on the nature of the alcohol component. Fats and oils are triglycerides, i.e. they are the esters of glycerol with three molecules of long chain fatty acids. Variations in the properties of fats and oils is due to the presence of different acids. These long chain acids may vary in the number of carbon atoms (between C_{12} to C_{26}) and may or may not contain double bonds. On hydrolysis of a triglyceride molecule, one molecule of glycerol and three molecules of higher fatty acids are obtained as shown below:

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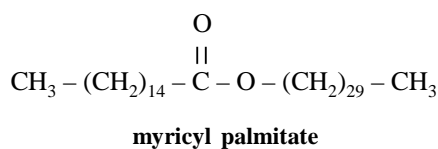
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By definition, a fat is that triglyceride which is solid or semisolid at room temperature and an oil is the one that is liquid at room temperature. Saturated fatty acids form higher melting triglycerides than unsaturated fatty acids. The saturated triglycerides tend to be solid fats, while the unsaturated triglycerides tend to be oils. The double bonds in an unsaturated triglyceride are easily hydrogenated to give a saturated product, and in this way an oil may be converted into a fat. Hydrogenation is used in the manufacture of *vanaspati ghee* from oils.

Fats and oils are found in both plants and animals. Our body can produce fats from carbohydrates. This is one method that the body has for storing the energy from unused carbohydrates. The vegetable oils are found primarily in the seeds of plants.

The second type of simple lipids are waxes. They are the esters of fatty acids with long chain monohydroxy alcohols 26 to 34 carbons atoms. Waxes are wide-spread in nature and occur usually as mixtures. They form a protective coating on the surfaces of animals and plants. Some insects also secrete waxes. The main constituent of bees wax obtained from the honey comb of bees is myricyl palmitate:



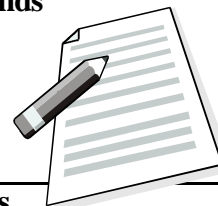
The waxes discussed above should not be confused with household paraffin wax which is a mixture of straight chain hydrocarbons.

(ii) Compound Lipids

Compound lipids on hydrolysis yield some other substances in addition to an alcohol and fatty acids. The first type of such lipids are called phospholipids, because they are the triglycerides in which two molecules of fatty acids and one molecule of phosphoric acid are present. Glycolipids contain a sugar molecule in addition to fatty acid attached to an alcohol.

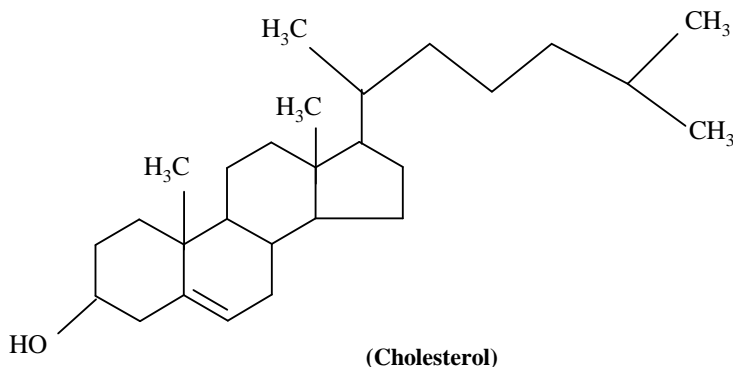
(iii) Derived Lipids

Steroids are another class of lipids which are formed in our body during metabolism. These are the compounds with a distinctive ring system that provides the structural



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backbone for many of our hormones. Steroids do not contain ester groups and hence cannot be hydrolysed. Cholesterol is one of the most widely distributed steroids in animal and human tissues.



Another important group of derived lipids is that of fat-soluble vitamins. This includes vitamins A, D, E and K, whose deficiency causes different diseases.

31.3.3 Biological Importance of Lipids

- (i) Fats are main food storage compounds and serve as reservoir of energy.
- (ii) Presence of oils or fats is essential for the efficient absorption of fat soluble vitamins A, D, E and K.
- (iii) Subcutaneous fats serve as biological insulator against excessive heat loss.
- (iv) Phospholipids are the essential component of cell membrane.
- (v) Steroids control many biological activities in living organisms.
- (vi) Some enzymes require lipid molecules for maximum action.



Intext Questions 31.3

1. What are lipids?
.....
2. What are the products of hydrolysis of an oil?
.....
3. Name two important types of compound lipids.
.....
4. What is the basic difference between fats and oils?
.....

31.4 Nucleic Acids

Why is a dog a dog and not a cat? Why do some people have blue or brown eyes and not black? From a chemical standpoint, how does the body know what particular type of

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protein is to be synthesized? How is this information transmitted from one generation to the next? The study of the chemistry of heredity is one of the most fascinating fields of research today. It was recognized in the 19th century that the nucleus of a living cell contains particles responsible for heredity, which were called chromosomes. In more recent years, it has been discovered that chromosomes are composed of nucleic acids. These are named so because they come from the nucleus of the cell and are acidic in nature. Two types of nucleic acids exist which are called DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). They differ in their chemical composition as well as in functions.

31.4.1. Structure of Nucleic Acids

Like all natural molecules, nucleic acids are linear polymeric molecules. They are chain like polymers of thousands of nucleotide units, hence they are also called polynucleotides. A nucleotide consists of three subunits: a nitrogen containing heterocyclic aromatic compound (called base), a pentose sugar and a molecule of phosphoric acid. So a nucleic acid chain is represented as shown below.

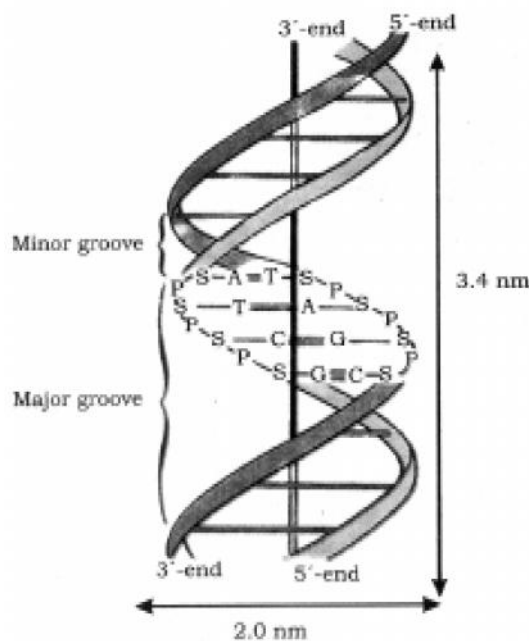
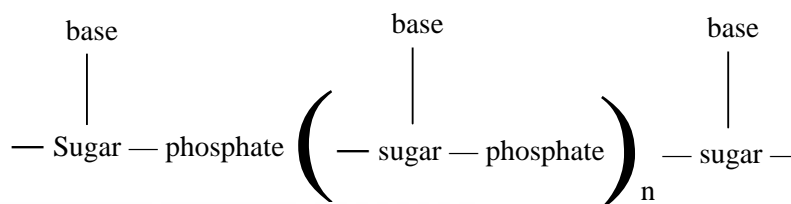
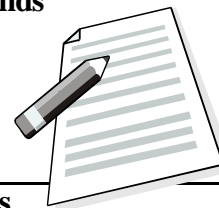


Fig. 31.4 : Watson and Crick's double helix structure of DNA

In DNA molecules, the sugar moiety is 2-deoxyribose, whereas in RNA molecules it is ribose. In DNA, four bases have been found. They are adenine (A), guanine (G), cytosine (C) and thymine (T). The first three of these bases are found in RNA also but the fourth is uracil (U).

The sequence of different nucleotides in DNA is termed as its primary structure. Like proteins, they also have secondary structure. DNA is a double stranded helix. Two nucleic acid chains are wound about each other and held together by hydrogen bonds between pairs of bases. The hydrogen bonds are specific between pairs of bases that is guanine and cytosine form hydrogen

bonds with each other, whereas adenine forms hydrogen bonds with thymine. The two stands are complementary to each other. The overall secondary structure resembles a flexible ladder (Fig. 31.4). This structure for DNA was proposed by James Watson and Francis Crick in 1953. They were honoured with a Nobel Prize in 1962 for this work.



Unlike DNA, RNA is a single stranded molecule, which may fold back on itself to form double helix structure by base pairing in a region where base sequences are complimentary. There are three types of RNA molecules which perform different functions. These are named as messenger RNA(*m*-RNA), ribosomal-RNA(*r*-RNA) and transfer RNA(*t*-RNA)

31.4.2 Biological Functions of Nucleic Acids

A DNA molecule is capable of self duplication during cell divisions. The process starts with the unwinding of the two chains in the parent DNA. As the two strands separate, each can serve as a master copy for the construction of a new partner. This is done by bringing the appropriate nucleotides in place and linking them together. Because the bases must be paired in a specific manner (adenine to thymine and guanine to cytosine), each newly built strand is not identical but complimentary to the old one. Thus when replication is completed, we have two DNA molecules, each identical to the original. Each of the new molecule is a double helix that has one old strand and one new strand to be transmitted to daughter cells (Fig. 3.15).

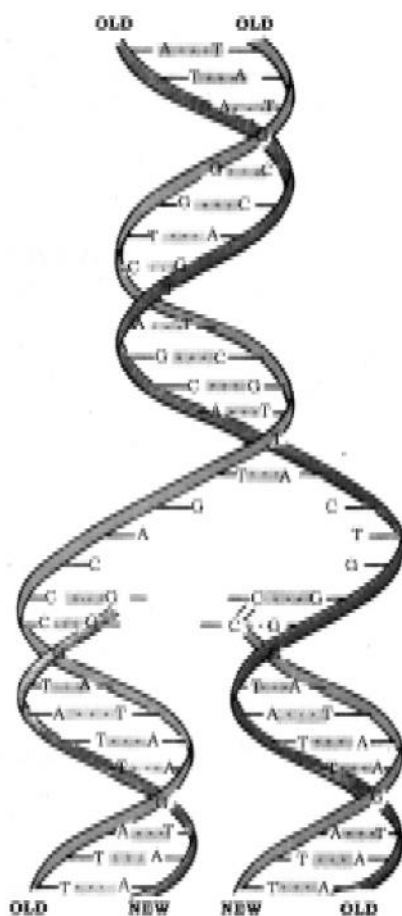


Fig. 31.5 : Replication of DNA



Another important function of nucleic acids is the protein synthesis. The specific sequence of bases in DNA represents coded information for the manufacture of specific proteins. In the process, the information from DNA is transmitted to another nucleic acid called messenger RNA, which leaves the nucleus and goes to the cytoplasm of the cell. Messenger RNA acts as template for the incorporation of amino acids in the proper sequence in protein. The amino acids are brought to the messenger RNA in the cell, by transfer RNA. Where they form peptide bonds. In short it can be said that DNA contains the coded message for protein synthesis whereas RNA actually carries out the synthesis of protein.



Intext Questions 31.4

1. What is a nucleotide?

.....

2. Why structure DNA is called a “doublehelix”?

.....

3. Write two main structural differences between DNA and RNA.

.....

31.5 Enzymes

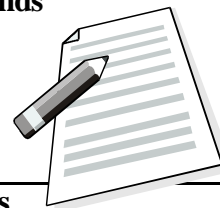
In a living system, many complex reactions occur at the temperature of about 310K. An example of this is the digestion of food, during which stepwise oxidation to CO_2 and water and energy production. These reactions are carried out under such mild conditions due to presence of certain chemicals which are called enzymes. They act as catalysts for biochemical reactions in living cells. Almost all the enzymes are globular proteins.

Enzymes are very selective and specific for a particular reaction. They are named after the compound or class of compounds upon which they work or after the reaction that they catalyze. The ending of an enzyme name is- **ase**. For example, maltase is an enzyme that specifically catalyzes the hydrolysis of maltose into glucose. Similarly, an esterase is an enzyme which induces hydrolysis of ester linkage.

31.5.1 Mechanism of Enzyme Action

Just like chemical catalysts, enzymes are needed only in small quantities. Similar to the action of chemical catalysts, enzymes lower the energy barrier that reactants must pass over to form the products. For example, hydrolysis of the ester that needs boiling with aqueous NaOH in the laboratory, whereas it occurs at nearly neutral pH and at moderate temperature when catalyzed by an enzyme.

There is a particular enzyme for each substrate and they are said to have lock and key arrangement. It is said that first the substrate molecule binds to the active site of the enzyme which results in the formation of an enzyme-substrate complex. In this complex, the substrate is placed in the right orientation to facilitate a given reaction (Fig.31.6). This



Notes

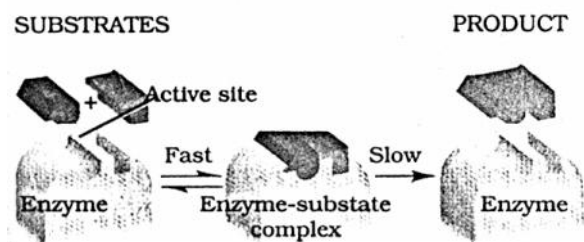


Fig. 31.6 : Lock and Key arrangement of enzyme action

complex then breaks to give the molecule of the product and regenerates the enzyme for the next molecule of the substrate.

31.5.2 Characteristics of Enzymes

- Enzymes speed up biochemical reactions up to ten million times compared to the uncatalysed reaction.
- Enzyme catalysed reactions rapidly attain equilibrium.
- Enzymes function in dilute aqueous solutions, at moderate temperatures and at a specific pH .
- They are very specific and selective in their action on substrates.
- Enzymes are highly efficient and are needed in small amounts only.
- In addition to the protein structure, most active enzymes are associated with some non-protein component required for their activity, called *coenzymes*. For example nicotinamide adenine dinucleotide (NAD) is a coenzyme which is associated with a number of dehydrogenation enzymes.



Intext Questions 31.5

- How do enzymes increase the rate of a reaction?
.....
- What do you understand by lock and key arrangement?
.....



What You Have Learnt.

- Carbohydrates are polyhydroxy aldehydes or ketones or substances which provide such molecules on hydrolysis.
- They are classified as mono-, di- and polysaccharides.
- Proteins are the polymers of α -amino acids which are linked by peptide bonds.
- All proteins are the polymers of twenty different α -amino acids. Out of these 10 amino acids cannot be synthesized by our body and hence must form the part of our diet. These are called essential amino acids.



Chemistry

- Proteins are very important to us and perform many functions in a cell that are absolutely necessary for our survival.
- Chief sources of proteins are pulses, milk, meat, eggs, etc.
- Biomolecules which are insoluble in water and soluble in organic solvents are called lipids. They are classified as simple, compound and derived lipids.
- Nucleic acids are the compound which are responsible for the transfer of characters from parents to offsprings.
- There are two types of nucleic acids- DNA and RNA. They are polymers composed of repeating units called nucleotides.
- DNA contains a five carbon sugar molecule called 2-deoxyribose whereas RNA contains ribose.
- The four bases present in DNA are adenine, cytosine, guanine and thymine whereas RNA contains uracil in place of thymine.
- DNA is a double strand molecule whereas RNA is a single strand molecule.
- DNA is present in the nucleus and have the coded message for proteins to be synthesized in the cell.
- Proteins are actually synthesized by RNA which are of three types – messenger-RNA (*m*-RNA), ribosomal-RNA (*r*-RNA) and transfer- RNA (*t*-RNA).
- Enzymes are biocatalysts which speed up the reactions in biosystems.
- Chemically all enzymes are proteins. They are very specific and selective in their action on substrates.



Terminal Exercise

1. How is excess glucose stored in our body?
2. What is a disaccharide? Give an example.
3. What are the products formed by the hydrolysis of lactose?
4. What are essential amino acids?
5. Differentiate between globular and fibrous proteins with suitable examples.
6. What are triglycerides? Mention one of its important uses.
7. What is a nucleotide?
8. Differentiate between the nucleotides of RNA and DNA.
9. What are different types of RNA found in the cell? Mention their functions.
10. What are enzymes?



Answers to Intext Questions

31.1

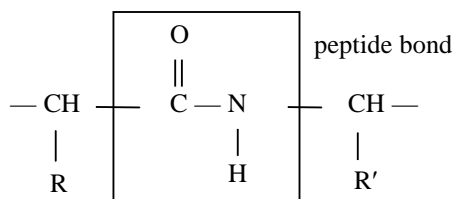
1. Cereals, fruits and sugar.
2. Plants produce carbohydrates during photosynthesis.
3. Starch on hydrolysis gives glucose whereas sucrose on hydrolysis gives glucose and fructose.



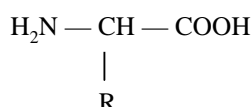
4. Refer to section 31.1.2.

31.2

- Information regarding the sequence of amino acids in a protein chain is called its primary structure.
- Proteins are made up of many α -amino acids which join together by the formation of an amide bond between $-\text{NH}_2$ group of one amino acid and $-\text{COOH}$ group of another. When two amino acids combine in this way, the resulting product is called a dipeptide and the amide bond between them is called a peptide bond.



3. An α -amino acid may be represented as



4. Refer to section 31.2.1.

31.3

- Biomolecules which are insoluble in water and soluble in organic solvents like benzene, ether or chloroform are called lipids.
- Oils on hydrolysis give glycerol and long chain fatty acids.
- Two types of compound lipids are phospholipids and glycolipids.
- A triglyceride which is solid at room temperature is called a fat and if it is liquid then it is called an oil.

31.4

- A nucleotide consists of three subunits which are (i) a nitrogen containing heterocyclic aromatic compound, also called a base; (ii) a pentose sugar (ribose or 2-deoxy ribose) and (iii) a molecule of phosphoric acid.
- In DNA, two chains are wound around each other in the form of helix, hence the structure is called a double helix.
- Two main structural differences between DNA and RNA are :
 - DNA molecules are double stranded whereas RNA are single strand molecules.
 - In DNA molecules, the sugar moiety is 2-deoxyribose whereas in RNA molecules, it is ribose.

31.5

- Refer to section 31.5.1
- Refer to section 31.5.1

SENIOR SECONDARY COURSE

CHEMISTRY

Student's Assignment – 6

Maximum Marks: 50

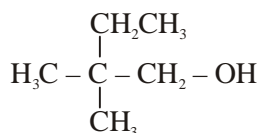
Time : $1\frac{1}{2}$ Hours

INSTRUCTIONS

- Answer all the questions on a separate sheet of paper.
- Give the following information on your answer sheet:
 - Name
 - Enrolment Number
 - Subject
 - Assignment Number
 - Address
- Get your assignment checked by the subject teacher at your study centre so that you get positive feedback about your performance.

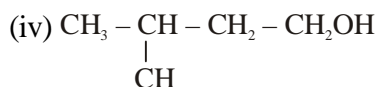
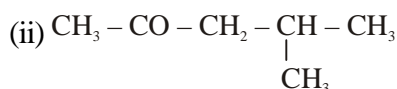
Do not send your assignment to NIOS
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1. (a) Write the molecular formula of a carbocation.
(b) Give the structural formula of the product of bromination of benzene.
(c) What is the IUPAC name of

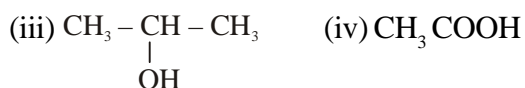


- (d) Name the isomer exhibited by the following pair of compounds:
(i) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ (ii) $\text{CH}_3\text{CH}_2\text{COOCH}_3$
(e) Explain the meaning of chiral carbon.
(f) Give the name of the product of dehydrohalogenation of 2-butyl bromide.
(g) Which of the following is a stronger acid?
 HCOOH and CH_3COOH
(h) Give an example of a zwitterion.
(i) What is sulphonation? $1 \times 10 = 10$
2. (a) What do you understand by the term 'electrophilic aromatic substitution'? Illustrate it with the help of an example giving equation.
(b) Give reason for the fact that unsaturated aliphatic compounds undergo addition reactions.

- (c) Describe the preparation of alkanes using Grignard reagents.
- (d) In alkanes, how do the boiling points vary with increase in branching. Give reason.
- (e) What is Markownikoff's rule? Illustrate this using the addition of HBr to 1-butene.
- (f) Write the chemical equations of the preparation of ethanol from 2-butene by ozonolysis.
- (g) Write the structural formulae of the following :



- (h) What is haloform reaction? Which of the following compounds will show haloform reaction?



- (i) How are primary and secondary alcohols distinguished?

- (j) What is Cannizzaro's reaction?

(2 × 10 = 20)

3. (a) What is meant by geometrical isomerism? Explain giving any two examples.
- (b) What is meant by dehydration reactions? Write the mechanism of one dehydration reaction.
- (c) How are the following prepared?

- (i) Chlorobenzene using Sandmeyer reaction.

- (ii) Chloroform from acetone.

- (d) (i) Write the preparation of aniline using Hofmann reaction.

- (ii) Write the reactions of aniline with (i) ethanoyl chloride and (ii) bromine.

- (iii) How are aliphatic amines distinguished from aromatic amines.

(3 × 4 = 12)

4. (a) (i) A compound (A) contains C, H and Cl only. Its molecular mass is 119.5. On heating (A) with aniline and Potassium hydroxide solution, a nauseating odour compound (B) is formed. Identify the compounds A and (B) and give the equation of the reaction taking place.

- (ii) Give the IUPAC name of (A).

- (b) (i) Discuss any two general methods of preparation of aldehydes.

- (ii) Aldehydes and ketones undergo addition reactions. Discuss in the light of structural features which enable this reaction to proceed.

(4 × 2 = 8)



Notes

TERMS YOU SHOULD KNOW

Boiling point : The temperature at which vapour pressure of the liquid becomes equal to the atmospheric pressure is called the boiling point.

Catalyst : The chemical substances which alter (increase or decrease) the rate of a reaction without undergoing any permanent change in themselves.

Cis Isomer: An alkene, in which the similar groups are on the same side of a double bond, is called cis-isomer.

Destructive Distillation : The process of heating a substance either in the absence or the presence of limited supply of air or oxygen is called destructive distillation.

Diazotisation : A process in which an aromatic amine with nitrous acid yields, diazonium salt.

Diffused Sun Light: Light obtained after passing sun light through a coloured glass.

Electronegative : The relative ability of an atom in a molecule to retain or gain electrons.

Electrophile : An ion or a neutral molecule with a constitutional affinity for electrons.

Elimination : The reaction involving the removal of a small molecule (H_2O , NH_3 , etc) from another molecule.

Enzymes : Enzymes are catalyst which enable living organism to bring about necessary chemical reactions at body temperature.

Fermentation : Breaking of large molecules into smaller molecules with the help of enzymes is called fermentation.

Free Radical : species with at least one unpaired electron.

Fuming Sulphuric Acid : Concentrated Sulphuric acid in which Sulphur trioxide is absorbed.

Functional group : The reactive site in a molecule.

Grignard's Reagent : Alkyl Magnesium halides are called Grignard's reagents ($R-Mg-X$).

Halogenation : A reaction for introducing a halogen atom in a molecule.

Homolytic : To produce free radical and **heterolytic** to produce charged species called carbocations and carbanions.

Hybridization : The process of intermixing of two or more orbitals of equivalent energies and different shapes to form new hybrid orbitals of same shape and energy is called hybridization.

Hydrogen Bond : The hydrogen bond is an electrostatic force between covalently bonded hydrogen atom of one molecule and an electronegative atom (such as $F > O > N$) of another molecule.

Inductive Effect : The inductive effect (I-effect) refers to the polarity produced in a molecule as a result of higher electronegativity of one atom compared to another.

Isomers : Different compounds with the same molecular formula are called isomers.

Lewis acids : A Lewis acid may be defined as a substance that can accept a lone pair of electrons.

Lewis base : Any substance that can donate a lone pair of electrons.



Notes

Lubricants : The chemical substances used to reduce friction between the two machine parts.

Nitration : A reaction for introducing—NO₂ group in a molecule.

Nucleophilic substitution : A substitution reaction that is initiated by a nucleophile.

Nucleophile : A reagent which can donate an electron pair in a reaction is called a nucleophile. It may or may not have a negative charge.

Nucleophilic addition reaction : When an addition reaction involved the initial attack by a nucleophile, the reaction is referred to as Nucleophilic addition reaction.

Nucleophilic addition elimination reaction : A Nucleophilic addition reaction followed by elimination of water molecule is called nucleophilic addition elimination reaction.

Optical Active : Compounds capable of rotating the plane of polarized light are called optically active.

Organometallic compound : A carbon compound in which a metal atom is directly attached to a carbon atom.

Oxidation : The process in which oxygen or some electronegative radical is added or the process in which there is loss of electrons or the process in which there is increase in oxidation number.

Pesticides : Chemicals used to control the pests i.e. any form of plant or animal life or virus that is harmful to man, plants or animals.

Petroleum : It is a mixture of solid and gaseous hydrocarbons dissolved in liquid hydrocarbons.

Plane polarized light : Light composed of waves that vibrates in only one plane is called plane polarized light.

Resonance : The phenomenon in which two or more structures can be written for a compound which involve identical positions of atoms, is called resonance.

Stereoisomers : Isomers whose atoms are bonded together in the same order but which differ in how the atoms are oriented in space are called **stereoisomers**.

Substitution : A reaction which are identical in all the respects. In these compounds the three-dimensional position of all the atoms coincides when the object is placed on its mirror image.

Trans-Isomer : An Alkene, in which similar groups are on the opposite sides of a double bond, is called trans isomer.

Van der Waals forces : Very weak forces of attraction, which exist between the molecules of a compound are known as van der Waals forces.

Zinc dust : Powdered zinc metal.

DESIGN OF THE SAMPLE QUESTION PAPER

Subject : Chemistry
Paper : Theory

Class : XII
Marks : 80

Duration : 3 hours

1. Weightage by Objectives

Objective	Knowledge	Understanding	Appliction
Percentage of marks	25%	45%	30%

2. Weightage to Questions

Total no. of question	25 (core-20 + optional-5)		
Form of questions	LA	SA	VSA
Marks	6	4	2

3. Distribution of marks

80 marks paper (20 marks Practical)	CORE MODULE	OPTIONAL MODULE
	$1 \times 3 = 3$	$1 \times 1 = 1$
	$2 \times 6 = 12$	$2 \times 2 = 4$
	$4 \times 8 = 32$	$4 \times 1 = 4$
	$6 \times 3 = 18$	$6 \times 1 = 6$
	<hr/>	<hr/>
	20 65	5 15

Total time 180 minutes

LA (6 marks) 70

SA (4 marks) 70

VSA (2 marks) 20

Reading & revision 20

4. Weightage by Content

	Module	Marks
1.	Atoms Molecules and Chemical Arithmetic	7
2.	Atomic Structure and Chemical Bonding	12
3.	States of matter	8
4.	Chemical Energetics	8
5.	Chemical Dynamics	8
6.	Chemistry of Elements	10
7.	Chemistry of organic Compounds	2
8.	Optional Module	
	(a) Environmental Chemistry	15
	(b) Chemistry and Industry	

BLUE PRINT

Subject : Chemistry
Maximum Marks : 80

Class : Senior Secondary
Time : 3 hours

Sl. No.	Form of Questions	Knowledge				Understanding				Application				Marks
	Content Unit	E	SA (I)	SA (II)	VSA	E	SA (I)	SA (II)	VSA	E	SA (I)	SA (II)	VSA	
1.	Atoms, Molecules And Chemical Arithmetics			2(1)	1(1)						4(1)			7
2.	Atomic Structure And Chemical Bonding		4(1)			6(1)						2(1)		12
3.	States of Matter		4(1)		1(1)				1(1)			2(1)		8
4.	Chemical Energetics			2(1)		6(1)								8
5.	Chemical Dynamics					4(1)					4(1)			8
6.	Chemistry of Elements						4(1)	2(1)			4(1)			10
7.	Chemical of organic Compounds		4(1)			6(1)						2(1)		12
8.	Optionals (a) Environmental Chemistry (b) Chemistry and Industry		4(1)			6(1)			1(1)			2(2)		15
	Total													80

Note: Figures within brackets indicate the number of question and figures outside the brackets indicate marks.

Summary

Essay (E) No.4 Marks : 24

Short-Answer (I) (SA(I)) No.9 Marks : 36

Short Answer (II) SA(II)) No.8 Marks : 16

Very Short Answer (VSA) No.4 Marks : 4

Total 80

SAMPLE QUESTION PAPER

CHEMISTRY (313)

Time : 3 hrs.

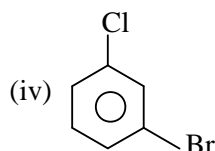
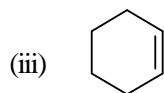
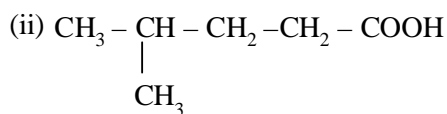
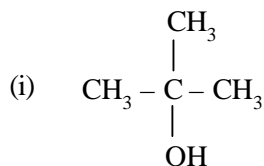
Maximum Marks : 80

- Note:** (i) All question in Section A are compulsory.
(ii) Attempt only one out of two options in section B, i.e., attempt either Part I or Part II or Part III in Section B.
(iii) Marks for each question is indicated against it.
(iv) Use log tables if necessary.

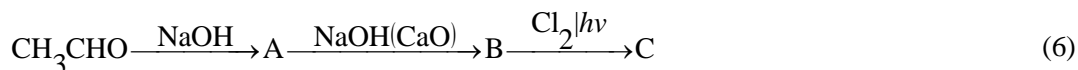
Section A

- What is the molar mass of NH_3 ? (1)
- A Sample of nitrogen gas consists of 4.63×10^{22} nitrogen atoms. How many moles of N atoms are there? (1)
- What is the lowest possible temperature in Kelvin units? (1)
- Derive SI units for
(i) Force (ii) Pressure (2)
- Explain the geometry of the following:
(i) NH_3 (ii) BF_3 (2)
- A sample of nitrogen gas weighing 9.3 g at a pressure of 0.99 atm occupies a volume of 12.4 litres at 55K temperature. What do you expect its volume to be when the temperature is 220 K? Assume that pressure stays constant. (2)
- What is the relationship between the standard free energy change and the equilibrium constant of the reaction? (2)
- Calculate enthalpy for the following reaction:
 $2\text{H}_2 + \text{O}_2 (\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$
Given Bond energy of H-H bond = 436 KJ mol⁻¹
Bond energy of O – H bond = 423 KJ mol⁻¹
Bond energy of O = O bond 496.4 KJ mol⁻¹ (2)
- Arrange the following oxides in the increasing order of acidic property. Justify your answer.
 Al_2O_3 , CO_2 , SO_2 , B_2O_3 (2)
- Draw the structure of the following:
(i) H_3PO_3 (ii) P_4O_{10}
(iii) $\text{H}_2\text{S}_2\text{O}_3$ (iv) ClO_2 (4)
- Explain the following giving suitable reasons
(i) BF_3 is weaker Lewis acid as compared to BCl_3
(ii) CCl_4 does not hydrolyse but SnCl_4 does.
(iii) N_2 is inert at room temperature.
(iv) SF_4 is known but SnCl_6 is not. (4)
- (i) What is Le Chatelier's principle?
(ii) For the following reaction:
 $\text{C}_2\text{H}_4 (\text{g}) + \text{I}_2 (\text{g}) \rightarrow \text{C}_2\text{H}_4\text{I}_2(\text{g})$
the rate of reaction is $\text{rate} = K [\text{C}_2\text{H}_4 (\text{g}) / \text{I}_2 (\text{g})]^{3/2}$
(a) What is the order of the reaction with respect to each reactant?

- (b) What is the overall order of the reaction?
- (c) What is the unit of K, if the concentrations are measured in $\text{mol dm}^{-3} \text{ sec}^{-1}$? (4)
13. A cell is set up between Cr and Cu electrodes
- (a) $\text{Cr(s)} | \text{Cr}^{3+}(\text{aq}) || \text{Cu}^{2+}(\text{aq}) | \text{Cu(s)}$
 If the two half cells work under standard conditions, calculate the e.m.f. of the cell.
 $E^\circ \text{Cr}^{3+} | \text{Cr} = -0.74 \text{ V}$; $E^\circ \text{Cu}^{2+} | \text{Cu} = +0.34 \text{ V}$
- (b) Calculate K_p for the reaction $\text{COCl}_2 \rightleftharpoons \text{CO} + \text{Cl}_2$ in atm and Nm^{-2} , The equilibrium partial pressure of COCl_2 , CO and Cl_2 are 0.20, 0.16 and 0.26 atm . respectively. (1 $\text{atm} = 101300 \text{ Nm}^{-2}$) (4)
14. (a) Write down ideal gas equation.
- (b) Give three different values of R in the ideal gas equation. (4)
15. (a) Write the IUPAC names of the following organic compounds :



- (b) Define the following (any two only)
- (i) Electrophiles (ii) Nucleophiles
- (iii) Catenation (iv) Isomerism (4)
16. (a) What is electrovalent bond? Explain the term lattice energy as applied to ionic crystal. How is enthalpy of formation of NaCl calculated, using Born Haber cycle?
- (b) Why is sigma bond stronger than π - bond? (4)
17. (a) 0.0663g of an organic compound on combustion gave 0.621 g of CO_2 and 0.0381g of H_2O . It also
- (b) What is the ratio of the mass of oxygen that combines with 1.0g Carbon in carbon monoxide and carbon dioxide? (4)
18. (a) Write de Broglie expression.
- (b) Write down Balmer formula and explain the terms involved, what is the wavelength of the light emitted when the electron in a hydrogen atom jumps from $N_2 = 4$ to $N_1 = 1$ levels?
 (Rydberg Constant $R = 109677 \text{ cm}^{-1}$) (6)
19. Define 'Entropy'. What are its SI units?
- Predict giving reasons, the sign of entropy change, ΔS for the following reaction:
 $2\text{SO}_3(\text{g}) \rightarrow 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$
 What is the significance of the term $T \Delta S$ in $\Delta G = \Delta H - T \Delta S$?
- (b) The heat evolved in the combustion of glucose is shown in the following equation:
 $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \quad \Delta H = -2840 \text{ KJ}$
 How much energy will be required for production of 1.08 g of glucose?
 (Molar mass of glucose = 180 g mol^{-1}) (6)
20. (a) Explain with the help of the relevant structural changes, the stronger acidic character of Phenol than alcohols
- (b) Identify the products A, B, and C in the following reaction :



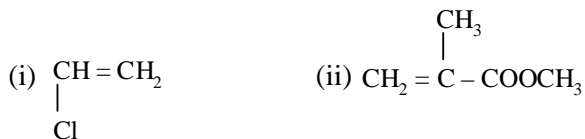
Section - B

PART-I (ENVIRONMENTAL CHEMISTRY)

1. (a) Define any Two of the following terms
(i) Pollutant (ii) Biosphere
(iii) Eutrophication (iv) Biological oxygen Demand (BOD) (2)
(b) List four effects of acid rain (2)
2. Describe with the help of diagram the three stages of treatment of waste water (6)
3. How does carbon get into the environment from dead organic mater. (1)
4. Show diagrammatically how heavy metals enter into the echo system. (2)
5. The increase in concertration of accumulated toxic chemicals as one goes higher in the food chain is termed as Bio magnification. Draw an appropriate food chain consisting of Mosquito, Marshy plant, Bird and fish and also label these components as producer, Primary consumer, Secondary consumer and tertiary consumer, showing in increase in concentration of toxic chemicals. (2)

PART-II (CHEMISTRY AND INDUSTRY)

1. Define any Four of the following :
Dyes, Drugs medicines, paints, mother glass
Petrochemicals, Polymerisation, (4)
2. (a) Distinguish between thermoplastic and thermosetting polymers (4)
(b) Differentiate between analgesics and antipyretics
(c) Differentiate between antiseptics and disinfectants (2)
3. What do you understand by Reinforced concrete Construction (RCC). (1)
4. Each of the following monomer polymerises to give different product. Show the formation of the polymer products by using the 3 monomer units each. (2)



5. Justify the superiority of Allopathic system of medicine over the alternative systems of medicine by giving atleast two advantages. (2)

MARKING SCHEME

CHEMISTRY

Question No. Expected value points Distribution of Marks

1. The molar mass of NH_3 is 17
 $14 + 3 = 17$ 1 mark

2. $\frac{4.63 \times 10^{27} \text{ atom}}{6.02 \times 10^{23} \text{ atoms/mol}}$ 1/2 mark
 0.0769 mol 1/2 mark
 If units are not given deduct $\frac{1}{2}$ mark

3. Zero Kelvin 1 mark

4. (i) Force $\text{Mass} \times \text{Acceleration}$ 1/2 mark
 (ii) Pressure $\text{Force} / \text{Area}$ 1/2 mark
 (iii) $\text{Kg m}^{-1} \text{ s}^{-2}$ 1/2 mark

5. (i) correct Geometry $\frac{1}{2}$ 1/2 mark

 Pyramid Shape $\frac{1}{2}$ 1/2 mark

6. $V_1 = 12.42, V = ? \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$ 1 mark
 $T_1 = 55 \text{ k } T_2 = 220 \text{ k}$
 $\frac{12.42}{55\text{k}} = \frac{V_2}{220\text{k}}$
 $V_2 = 4.92$ 1 mark

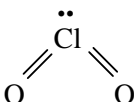
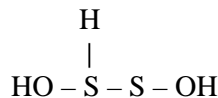
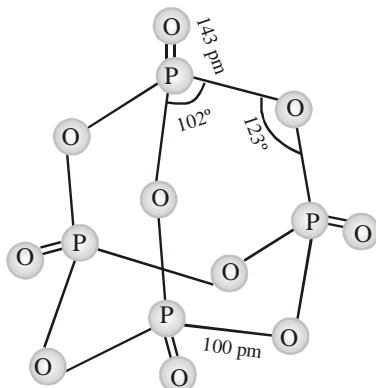
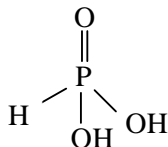
7. Correct relation 2 mark

8. $\begin{array}{ccc} 2\text{H} - \text{H} & \text{O} - \text{O} & 2\text{H} - \text{O} \\ 2 \times 436 & 496.4 & | \\ & & \text{H} \\ & & 4 \times 463 \end{array}$ 1 mark

 $\Delta H = 1852 - 1368.4 = 483.6 \text{ K J}$ 1 mark

9. $\text{B}_2\text{O}_3 > \text{Al}_2\text{O}_3 > \text{CO}_2 > \text{SO}_2$ 1 mark
 Justification 1 mark
 Large the Size of cation less acidic will be the oxide.

10. Correct Structure



1 × 4 marks

11. (i) Due to back bonding
 (ii) Due to absence of d – orbital in C
 (iii) Dissociation energy is very high
 (iv) Due to larger size of Cl Six Cl can not be accommodated around S 1 × 4 = 4 marks
12. (a) It states that when a system at equilibrium is disturbed by a change in concentration, Pressure or temperature, a net change occurs in it in a direction that tends to decrease the disturbing factor. 1 mark
 (b) (i) First order with respect to C₂H₄ and 1.5 w. r. t. I₂ 1 mark
 (ii) The overall order of reaction is 2 – 5 1/2 mark
 (iii) $x = \frac{\text{sec}^{-1}}{(\text{mol dm}^{-3})^{3/2}}$ 1/2 mark
 $= \text{mol}^{-3/2} \text{ dm}^{9/2} \text{ sec}^{-1}$ 1 mark
 deduct half mark if units are not given
13. (a) Anode reaction = $\text{Cr (S)} \rightarrow \text{Cr}^{3+} + 3\text{e}^-$
 Cathode = $\text{Cu}^{2+} (\text{aq}) + 2 \text{e}^- \rightarrow \text{Cu}$ 1 mark
 E Cell = $E^\circ \text{ Cell} = 0.34 - (-0.74) = 1.08 \text{ V}$ 1 mark
 K_p in atmosphere
 $\text{COCl}_2 (\text{g}) \rightleftharpoons \text{CO} (\text{g}) + \text{Cl}_2 (\text{g})$
 $K_p = \frac{P_{\text{CO}} \times P_{\text{Cl}_2}}{P_{\text{COCl}_2}} = \frac{(0.16 \text{ atm})(0.26 \text{ atm})}{(0.20 \text{ atm})}$ 1 mark
 $= \frac{0.16 \times 0.26}{0.20} = 0.21 \text{ atm}$

(b) K_p in N m^{-2}

$$K_p = 0.21 \text{ atm and } 1 \text{ atm} = 101300 \text{ N m}^{-2}$$

$$\therefore K_p = (0.21 \text{ atm}) (101300 \text{ N m}^{-2} \text{ atm}^{-1}) = 21273 \text{ N m}^{-2}$$

1 mark

14. (a) $V \propto \frac{1}{P}$ at Constant temp. (Boyle's Law)

$V \propto T$ at Constant Pressure (Charles Law)

$V \propto n$ at constant temp and pressure (Avogadro's Law)

$V \propto n T/P$ or $PV \propto nT$

or $PV = \text{Constant} \times nT$

$$PV = n R T$$

1/2 mark

(b) $R = 0.082057 \text{ atm mol}^{-1} \text{ K}^{-1}$

$$R = 8.314 \times 10^7 \text{ erg mol}^{-1} \text{ K}^{-1}$$

$$R = 1.987 \times 10^7 \text{ Cal mol}^{-1} \text{ K}^{-1}$$

$\frac{1}{2} \times 3 = 1\frac{1}{2}$ marks

15. (a) (i) 2-methyl propane-2 ol

(ii) 4-methyl pentanoic acid

(ii) Cyclohexene

(iv) 3-bromo-chloro benzene

$4 \times \frac{1}{2} = 2$ marks

(ii) An electrophile is positively charged species It is electron seeking, It attacks at position of high density.

Examples H^+ , NO_2^+ , Ag^+

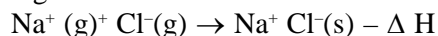
(iii) Nucleophile is a negatively charged species. It is nucleus seeking. It attacks a position of low electron density examples OH^- , NO_2^- etc.

(iii) The property of linking of atoms of the same element with one another to form chains or rings is known as catenation.

(iv) The substances which have the same molecular formula but differ in their physical and chemical properties are called isomers. This general phenomenon is known as isomerism. $1 \times 2 = 2$ marks

16. (a) An electrovalent bond is formed when one or more electron from one atom gets completely transferred to another atom or atoms and each atom acquires a nearest noble gas Configuration.

Lattice energy is the amount of energy released when one mole of the substance is formed from its ions e.g.



$$\Delta H = -788.5 \text{ KJ mol}^{-1}$$

1/2 mark

Born Haber Cycle

$$\Delta H_f = \Delta H_s + I E + \Delta H_{\text{diss}} - E A + \Delta H \text{ Lattice energy}$$

ΔH_f = Heat of formation

1 1/2 marks

$I E \rightarrow$ Ionization enthalpy

$\Delta H_{\text{dis}} \rightarrow$ Heat of dissociation

$E A \rightarrow$ Electron gain enthalpy

$\Delta H_{\text{lattice}} \rightarrow$ Lattice energy

(b) σ -bond is formed due to end overlap

π -bond is formed due to side ways overlapping

1 mark

$$17. (a) \% C = \frac{0.621 \times 12}{44 \times 0.0663} \times 100 = 25.54 \quad \frac{25.54}{12} = 2.128 \quad C = 1$$

$$\% H = \frac{0.6381 \times 2}{18 \times 0.0663} = 6.38 \quad \frac{6.38}{1} = 6.38 \quad H = 3$$

$$\frac{68.1}{32} = 2.128$$

$S = 1$

3 marks

- (b) $\text{CO} = 4 : 3$
 $\text{CO}_2 = 8 : 3$ 1 mark

18. (a) $E = h\nu$ $\nu = \frac{c}{\lambda}$

$\lambda = \frac{h}{mc}$ or $\lambda = \frac{h}{p}$ 1 mark

(b) $\nu = \frac{1}{\lambda} = \left(n_1^2 - \frac{1}{n_2^2} \right)$ 1 mark

$= 109677 \left(\frac{1}{(1)^2} - \frac{1}{(2)^2} \right)$

$= 109677 \times \frac{15}{16} = 102\,822 \text{ cm}^{-1}$ 1 mark

$\lambda = \frac{1}{\nu} = \frac{1}{102822} = 9.7 \times 10^{-6} \text{ cm} = 97 \text{ nm}$ 1 mark

19. (a) The entropy is measure of disorder or randomness in a system. the greater the disorder in a system, the greater is the entropy of the system 1 mark

SI unit = $\text{J mol}^{-1} \text{ K}^{-1}$ 1/2 mark

entropy decrease

It ΔS total is positive then section will be spontaneous

$\Delta G_{\text{Syst}} = -T \Delta S_{\text{univ}}$ 1/2 mark

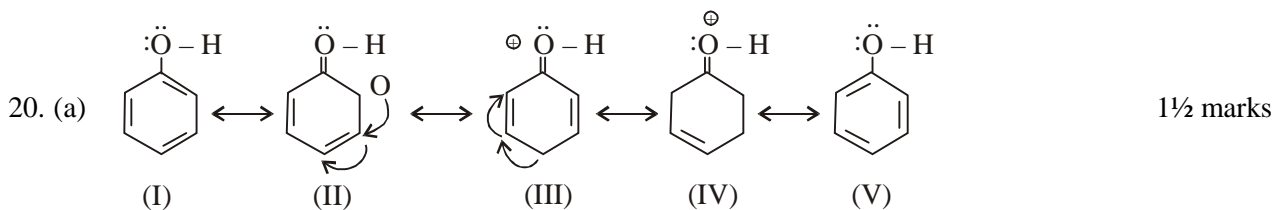
- (b) $1 \text{ mol} = -2840 \text{ K J}$
 $180 = -2840 \text{ K J}$

$1.08 = \frac{-2840}{180} \times 1.08 = \text{K J} = \Delta H$ 1 mark

$\Delta E = \Delta H - \Delta V_{2q} RT$

$\Delta H - O. R T = \Delta H$

$= 17.04 \text{ K J}$ 1 mark



- (b) A = $\text{CH}_3 \text{ COO Na}$
 B = CH_4
 C = $\text{CH}_3 \text{ Cl}$

$4 \times \frac{1}{2} \text{ markw}$

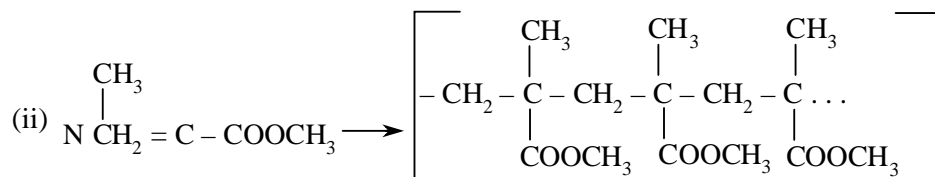
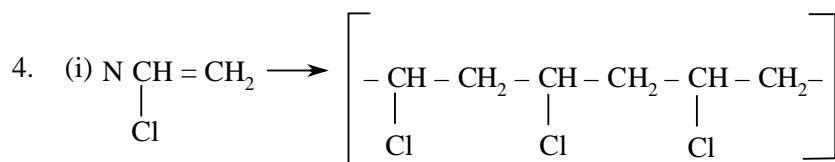
SECTION B

PART-I ENVIRONMENTAL CHEMISTRY

1. (a) 1 Mark for each of the two correct definitions 2 marks
 (b) $\frac{1}{2}$ Mark for each of four correct effects 2 marks
2. Correct explanation and diagram of stages for primary treatment 2 marks
 Correct explanation and diagram of stages for Secondary treatment 2 marks
 Correct explanation and diagram of stages for Tertiary treatment 2 marks
3. Through Decay and decomposition due to micro-organisms 1 mark
4. For indicating correct sources 1 mark
 For showing correct pathways 1 mark
5. Marshy Plant \longrightarrow Mosquito \longrightarrow Fish \longrightarrow Bird
Producer Pri-consumer Sec-consumer Ter-consumer
 Correct food chain 1 mark
 Correct labelling 1 mark

PART-II CHEMISTRY AND INDUSTRY

1. 1 Mark for each of the Four correct definition 4 marks
2. (a) 1 Mark for each definition 4 marks
3. correct description 4 marks



1 mark

5. Correct Advantages 2 marks
 1 mark for each