2 OUR LIFE AND CHEMISTRY

In this chapter you will learn:

- The building elements for life.
- Importance of carbon.
- An introduction to organic chemistry.
- Water and its properties.
- The role of different gases in air.
- Essential elements for life.

2.1 The Basic Building Elements for Life

In the body of living organisms, many elements are found in different quantities. In them carbon, hydrogen and oxygen have great importance. The human body also constitute these three elements. These elements combine to form organic compounds such as proteins, carbohydrates and lipids. All these compounds work as building material for the bodies of living organisms e.g. meat, pulses, fats, cooking oil, sugar, wheat etc.

Carbon

Carbon is one of the essential part of all living things on this planet. Small quantities of carbon are found in the earth's crust as the free element. Carbon is an important element of natural compounds such as natural gas, petroleum and wood etc. Carbon is also present in the food you eat. The food containing carbon, hydrogen and oxygen are either carbohydrates (starch, sugar, cellulose) or fats (butter, oils) while the food containing carbon, hydrogen oxygen, and sulphur or nitrogen are proteins (meat, fish). All the plant life is also made up of compounds containing carbon, hydrogen and oxygen. Other carbon containing compounds are silk, soap, alcohol, plastic etc.

Hydrogen

Hydrogen is an essential part of water (H_2O) and therefore important for all living things. Other than this it is found in natural gas. It is most common element in the universe, for example the sun is a huge white-hot ball consisting almost entirely of hydrogen.

Oxygen

Oxygen is a colourless, odourless gas which is slightly soluble in water. Fish and all form of aquatic life rely on this property. It is the major constituent of air. The various organic compounds containing oxygen are glucose, sugar, cellulose, fats, proteins etc.

Importance of Carbon, Hydrogen and Oxygen

You have already studied that carbon, hydrogen and oxygen play important role in the living organisms. Respiration is a process which provides energy to the body while photosynthesis is a direct or indirect source of food for living beings. These three elements have basic role in these two processes.

Respiration

Oxygen is essential for life. It plays an important role in respiration. Respiration is the process by which living things use oxygen from the air to oxidize food substances (mainly glucose) in their body cell.

$$\text{Glucose} + \text{Oxygen} \longrightarrow \text{Carbon dioxide} + \text{Water} + \text{Energy}$$

When we breathe in, we take air into our lungs. The oxygen from the air then dissolves in the blood in our lungs. This dissolved oxygen is taken by hemoglobin to all parts of our body to react with glucose to produce energy. At the same time, carbon dioxide produced as a waste product is taken back to the lungs and breathed out.

Photosynthesis

Photosynthesis is a process by which green plants manufacture carbohydrates (glucose) from atmospheric carbon dioxide and water from the soil, in the presence of energy of sunlight.

$$\text{Water} + \text{Carbon dioxide} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Glucose} + \text{Oxygen}$$

This process only occurs in chlorophyllous cells of the leaves and stems. Oxygen is produced in this process as a by-product and released into the atmosphere. Photosynthesis is effectively the reverse of respiration.

This is also called anabolic (building up) process while the respiration process is called catabolic(breaking down) process.

2.2 Carbon and its importance

Very small quantities of carbon are found in the earth crust as the free element. It is present in approximately one million known compounds. One of the unique property of carbon is that its atoms combine with each other to form long ring compounds.

Allotropic Forms of Carbon:

Carbon exists in three different forms having different physical properties. When an element is found in more than one physical forms in the same state, it is called **allotropy** and such physical forms are called **allotropic forms**. Diamond, graphite and bucky balls are the allotropic forms of carbon. These allotropic forms have different physical properties such as appearance and density but they are the same element and have the same chemical properties.

(i) Diamond:

It is a colourless, transparent and crystalline form of carbon (Fig.2.1a) which is found in the earth under great heat and pressure. It is one of the hardest substance known, hence is used for tipping rock drills, in glass cutting, in polishing other precious stones.

(a) Diamond

(b) Graphite

Fig: 2.1 The Allotropic forms of Carbon

(ii) Graphite:

It is a second crystalline form of carbon (Fig. 2.1b) found in nature or made from coal by heating it in an electric furnace. It is a soft black solid which has shiny and a greasy feeling. It is used for the core of "lead pencils", as a lubricant and in paints.

(iii) Bucky Balls:

Bucky balls is the third form of pure carbon known to exist naturally. It is used as a semi-conductor, conductors and lubricants.

> **Interesting Information**
>
> If a key is stiff in a lock, rub the end of the key with a soft pencil. This contains lots of graphite which will lubricate the movement of the key and hopefully, make the lock easier to open.

The Non-Allotropic forms of carbon.

Charcoal and soot are also forms of carbon but they do not occur naturally. They are made by heating animal bones, wood, nut shell, sugar, blood or coal in a limited amount of air. Coke is another form of carbon which is made by heating coal at about 1300 °C in the absence of air. Charcoal is used for absorbing dangerous gases. It is also used by the artists. Coke is used as a fuel and as a reducing agent in various chemical industries.

Fig: 2.2 Coke (The Non-Allotropic forms of carbon)

2.3 Organic Chemistry

Organic chemistry is the chemistry of compounds which contain the element carbon. Most of these compounds also contain hydrogen and many also contain oxygen or other element. There are a few compounds which contain carbon but are not classified as organic compounds. Carbon monoxide, carbon dioxide and the metal carbonates are examples.

Types of Carbon Compounds

Carbon occurs in large number of naturally occurring compounds. e.g. natural gas (methane) and many of our fuels are compounds of carbon and hydrogen. Coal is a mixture of compound containing carbon, hydrogen and oxygen. There are many inorganic carbon compounds such as carbonates of sodium, calcium, and magnesium.

Carbon is also present in our food and every part of our body. All plant life is made up of compounds containing carbon, hydrogen and oxygen. In the atmosphere it is present in the form of carbon dioxide.

(a) Plastic

(b) Paints

(c) Medicines

(d) Carbohydrates containing food

Fig: 2.3 Types of Carbon compounds

Hydrocarbons are the simplest organic compounds. The molecules of hydrocarbons are made up of only two elements hydrogen and carbon. They occur naturally in fossil fuels, petroleum, coal and peat. The important class of naturally occurring organic compound is carbohydrates. The simplest form of carbohydrates is glucose. Other than

carbohydrates proteins, fats and oils are also very important organic compounds. The flesh of human beings, animals , birds and fishes are made of proteins.

Many of the organic compounds are made by man. They are artificial fibres, plastics, medicines , paints and many other things.

2.4 Water

Water is the common compound on earth. For instance, about four fifth of the earth's surface is covered with sea. It is the only chemical compound found naturally as a liquid, as a solid (ice) and as a gas (water vapours). Water plays a vital role in industry, in home and in laboratory and is also essential for life. About two thirds of the human body is water and many foods consist predominantly of water (Table2.1)

Interesting Information

Ethene gas can be used to help to ripen fruits specially bananas before they are sold. Crates of green bananas are left to ripen in special ripening rooms high in concentration of ethene gas.

Table 2.1: Water contents of some foods and living organs.

Food	% age of water by mass	Living organs	% age of water by mass
Tomatoes	95	Bones	22
Milk	87	Kidneys	82
Oranges	86	Blood	90
Apples	84	Egg	75
Potatoes	76		

Properties of Water

Water is a clear colorless and odorless liquid. It has abnormal low freezing point ($0^{o}C$) and high boiling point ($100^{o}C$) at one atmospheric pressure.

Ice floats over water indicating that ice is lighter than water. In other words the density of ice is less than the density of water. As the temperature of ice rises the ice melts and its density increases. The density

Interesting Information

The body of a young boys contains approximately 35 litres of water. This is over two thirds of the body weight. However, girls have very slightly less water per body weight. It is for this reason that certain medicines or drugs are faster acting on girls than on boys.

of water at 0°C is somewhere between 0.9990 g/cm^3 and 1.000 g/cm^3, while the density of ice at 0°C is of the order 0.918 g/cm^3. Therefore, there is considerable increase in volume when liquid changes to solid at 0°C. This is because that water molecules are less tightly packed (are at greater densities) in ice than in liquid water. The density of water is maximum at 4°C. The fact that water contracts on cooling from 0°C to 4°C is quite contrary of the behaviour of many of the other liquids. This property helps nature to preserve fish and other aquatic animals in winter in countries where freezing of water takes place during winter. When cooling of water starts, as winter approaches the density of water increases until it reaches its maximum (density 1.00 g/cm^3) at 4°C. Thus water is heavier at 4°C and sinks to its bottom. Further cooling cools down the surface layer below 4°C and since the density of water now is lower than the water at 4°C stays at the top and frozen to solid ice, while the liquid below remains at 4°C.

The soluble air present in the water below the ice, helps animals to breath and thus they spend a nice winter under a thick blanket of ice.

Water as Universal Solvent

One of the most interesting things about water is that it dissolves a variety of substances. It is therefore extensively used as a solvent in industrial chemical processes and also many chemical reactions are carried out in it. The solubilities of solids increase with increasing temperature. Different solutes have different solubilities at a particular temperature. For example at 50°C 100g of water will dissolve 84g of potassium nitrate but only 33g of copper sulphate.

Besides these, all gases can dissolve in water to some extent. Examples of such gases are oxygen, hydrogen, nitrogen and carbon dioxide. In general, the solubilities of gases decrease with an increase in the temperature. Water is also a universal solvent for biochemical reactions.

2.5 Air

The atmosphere surrounding our earth is a mixture of various gases. The percentage composition of air by volume is shown in table 2.2.

Table 2.2: Percentage composition of various gases in air

Component	Percentage composition by volume
Nitrogen	78
Oxygen	21
Argon	0.9
Carbon dioxide	0.03
Neon	0.002
Helium, Krypton and Xenon	0.00055

The composition of air remains approximately constant. For example, the composition of oxygen and carbon dioxide is kept constant by the process of photosynthesis and respiration respectively.

Interesting Information
Each day a normal man breathe in 15,000 to 20,000 litres of air

Role of Oxygen in Air

Oxygen is the second most abundant gas found in air after nitrogen. It is essential for supporting life and phenomena of burning and rusting. For burning or combustion, we require three things, fuel, heat and oxygen. These make up the three principles of fire-fighting, because in the absence of any one of these, the fire goes out.

Burning or combustion is a chemical process, which is accompanied by the production of light and heat. During this process, the combustible material usually combines with atmospheric oxygen to form oxides. This oxide form acid, when it is dissolved in water.

Degradation of all kinds of food like vegetable, meat etc., is because of the oxidation of organic materials present in it. Ozone is produced from oxygen which is present in the earth atmosphere, is useful to protect the living organisms, by absorbing ultraviolet light of the sun.

Role of Nitrogen in Air

Nitrogen occur in the atmosphere as diatomic molecules. It is the major constituent of air. It is relatively inert, as compared to oxygen , but it acts as an important diluent of the air to slow down combustion and corrosion.

Nitrogen also occurs in plants and animals in the form of proteins. Animals obtain protein by consuming plants. Plants produces protein from the nitrate in the soil. Nitrates are produced from atmospheric nitrogen and ammonia present in soil. Plants get their nitrogen from nitrates present in soil. This nitrogen directly or indirectly reaches the animal. As dead plants and animals decay, some soluble nitrogen containing compounds, usually nitrates, are produced and can be absorbed by these plants. Some of these nitrates are converted into nitrogen by bacteria in the soil. This is then released back into the atmosphere. In nature the process in which nitrogen is transferred from living organisms to soil and from soil to living organisms regularly is called nitrogen cycle and this nitrogen cycle keeps the amount of nitrogen constant in air.

Role of Carbon Dioxide in Air

The atmospheric air contains only approximately 0.03% by volume of carbon dioxide. This proportion is kept constant by a balance in nature between the process of photosynthesis, which remove carbon dioxide from the atmosphere, and those of respiration, decay and combustion which return it to the atmosphere. These processes are called carbon cycle.

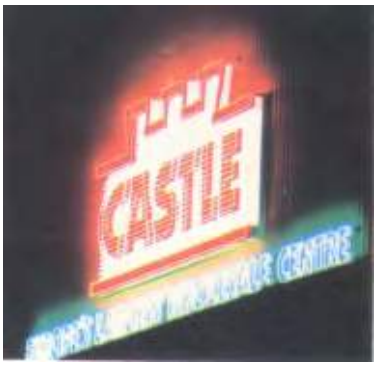
Carbon dioxide also plays an important part in the air by absorbing infrared rays from the sun. Thus CO_2 protects the living organisms from the harmful rays.

However, the problem will rise in the near future through the burning of too much carbon containing fuel. This could upset the balance of the carbon cycle by liberating too much carbon dioxide into the air. It is thought that if the amount of carbon dioxide increases in the air then the temperature of the earth will rise. This is called green house effect. The higher temperature would cause the ice on the mountains to melt and flooding to occur. Weather pattern on our planet would also be affected.

Rare Gases and their uses

The atmosphere contains approximately 1% by volume of rare noble gases. These are characterized by their chemical inertness. Helium is very light gas, so it is used as an alternative to hydrogen in weather balloons.

(a) Argon containing bulb



(b) Neon in advertising sign

(c) Divers use mixture of helium and oxygen

Fig. 2.4 Some uses of rare gases

A mixture of helium (80%) and oxygen (20%) is used as an artificial atmosphere by divers. It is used instead of nitrogen as it is less soluble than nitrogen in blood to prevent the bends in high pressure work.

Neon glow red when electricity is passed through it and so it finds a use in advertising sign. Argon is used to fill electric light bulbs and various types of fluorescent and phototubes. Krypton is used to fill fluorescent lights and photographic flash lamps. Radon is used in the treatment of cancer.

Since the noble gases are extremely unreactive, they provide a useful inert atmosphere for some chemical reactions. These are also used in the electric welding of metals.

2.6 Important Elements for Life

Some elements are found to be essential (some in large, some in small quantities) for maintainence of our health, agriculture and daily life uses. We shall not attempt to cover all the elements known to be involved in above mentioned functions. Instead, we discuss only those that are presently recognized to be most important or about which most is known. Based on one or both of these criteria, the functions of some elements are discussed.

(i) Iron

Iron is the second most abundant metal found in the earth's crust after aluminium. It has been known and used by mankind for a long time. Today, it is one of the best known metals in the world because of its very great economic and industrial importance. It is used for general engineering purposes such as corrugated sheets, car bodies, nails, screws, steel pipes, tools etc.

Iron is essential to all living organisms. It is present at the active centre of molecules (Hemoglobin and Myoglobin) responsible for oxygen carrier and of other types of molecules (cytochromes and Ferredoxins) for electron transport. Normally it is slightly toxic, but excessive intake can cause siderosis and damage to some organs.

The iron content in plant tissue is normally between 50-250 ppm. It is absorbed, by plant roots from the soil as Fe^{2+} and Fe^{3+} These irons are involved in photosynthesis.

(ii) Sodium

It is used in sodium vapour lamps (which gives a bright orange-yellow light), for street lighting. It is used for the preparation of important compounds such as sodium peroxide (Na_2O_2), sodium cyanide (NaCN) which is used in the extraction of gold. It is also used for the preparation of tetraethyl lead which is added in petrol as an anti-knocking agent.

Sodium is a major component of vertebrate blood plasma. It is important in different functions of living organisms. It is associated with some forms of hypertension in some individuals.

Sodium is absorbed by plants as Na^{+1} and its concentration varies widely from 0.01 to 10% in leaf tissue. It is essential for halophytic plant species that accumulate salts in vacuoles to maintain turgor and growth. Crops that require sodium for optimum growth include spinach, sugar beet, turnip etc.

(iii) Potassium

Potassium in the form of carbonates is used in the preperation of glass and soap. One of its another compound potassium phosphate is used in preperation of detergents. Potassium nitrate is used in preperation of glass and explosive material.

It is an essential element for almost all living organisms. It plays an important role in nerve action and cardiac function. It is moderately toxic to mammals when injected intravenously otherwise harmless.

Potassium is absorbed by plant roots as K^+. The concentration of potassium in vegetative tissue usually ranges from 1 to 4% on a dry matter basis. Many plant enzymes require potassium for their activation.

(iv) Magnesium

Because of its low density, Mg is used in preparing light but rough alloys such as magnalium (a mixture of aluminum and magnesium). These alloys are used for the construction of cars, aircrafts and moving parts of machines.

It is essential to all organisms. It is present in chlorophyll. It has electrochemical and enzyme activating functions.

Magnesium is absorbed as Mg^{2+} and its concentration in crops varies between 0.1 and 0.4%. The importance of Mg^{2+} is obvious since it is a primary constituent of chlorophyll molecule and without chlorophyll the autotropic green plant would fail to carry on photosynthesis.

(v) Calcium

This element is used as deoxidant in steel casting. It is used in extraction of uranium and in preparation of calcium fluorides and calcium hydrides.

It is an essential element for all organisms, it is used in cell walls, bones, and some shells as important compound. It is involved in blood clotting.

In plants calcium concentration ranges from 0.2 to 1%. It has an important role in the structure and permeability of cell membranes. Lack of Ca^{2+} produces a general breakdown of membrane structures.

(vi) Phosphorous

Phosphorous occurs in most plants in concentration between 0.1 and 0.4%. Plants absorb either $H_2PO_4^-$ or HPO_4^- orthophosphate ions. The most essential function of phosphorous in plants is in energy storage and transfer. Adenosine di and tri-phosphates (ADP and ATP) act as "energy currency" within the plants. In human beings during carbohydrate metabolism and in plants during photosynthesis the energy produced is stored in the form of phosphate compounds i.e. ADP and ATP. When the phosphate compounds from either ATP or ADP is split off, a relatively large amount of energy (12,000) cal/mol) is liberated. This energy is used in growth and reproductive processes.

It is an important constituent of DNA (deoxyribonucleic acid) and RNA (ribonucleic acid), bones, teeth, some shells, membrane, phospholipids, Adenosine diphosphate (ADP) and Adenosine triphosphate (ATP).

This element is used in the form of superphosphate and tri-phosphate in fertilizers. Phosphoric acid and its salts are used in food industry, detergents and baking powders. Phosphorous is also used in matches.

(vii) Fluorine

Trace amounts of fluorine (2.5 ppm) in diet is essential for optimal growth and strengthens teeth in mammals.

Fluorine generally occurs in plant material in the range of 2-20 ppm in the dry matter, although some plant species are capable of accumulating much higher amounts. The high concentration of fluorine (i.e. 200 ppm) in plants is toxic to animal. It is neither required for plant's growth nor it play any essential role in plant metabolism

Some fluorides and other compounds of fluorine are used as a refrigerant, anaesthetic, non-stick agent insulator. Hydroflouric acid is used in etching glass and in cleaning steel. Sodium fluoride in trace amount is used for the fluoridation of drinking water, while tin fluoride is used in many tooth pastes to protect the decay of tooth.

(viii) Chlorine

Although, the chlorine gas is very poisonous but it has many beneficial uses in daily life. It is used to kill germs and bacteria and is commonly used in domestic bleaches. It is also used in water purification and in swimming pools. Polyvinyl chloride is a common plastic compound of chlorine and is known as PVC. It has many uses, especially as an insulator or as a water proofing material.

It is an essential element for higher plants and mammals. Sodium salt of chloride (NaCl) act as electrolyte and hydrochloric acid as digestive juices in body. Deficiency of chloride cause the impaired growth in infants.

Chlorine is essential for higher plants. It is present in chloroplasts which is essential for photosynthesis. Plants which take up large amount of Cl^{-1} usually have a high water content.

(ix) Iodine:

Iodine is used in making dyes for colour photography and pharmaceutical chemicals. A dilute solution of iodine in ethanol, which is known as tincture of iodine, is commonly used as an antiseptic.

It is essential element in many organisms. Low iodide availability in certain areas increases the incidence of goiter. Iodine – 131 is used to treat the thyroid.

Iodine has not been shown to be essential to plants but are reputed to produce stimulating effects on plant growth at low concentrations. In healthy plants the iodine level is 0.5 ppm. at higher concentrations.

IMPORTANT POINTS

- Carbon, hydrogen and oxygen are the building elements for life.
- Oxygen and carbon dioxide are important for respiration and photosynthesis.
- Carbon exists in three allotropic forms diamond, graphite and bucky balls.
- Organic chemistry is the chemistry of compounds which contain carbon as essential element.
- Water is very common and important compound on earth. It is a universal solvent. It shows maximum density at $4^{o}C$.
- Ice floats on the surface of water due to lower density.
- Air is a mixture of various gases i.e. nitrogen, oxygen and carbon dioxide.
- Oxygen is necessary for burning, combustion and fire.
- Nitrogen is an essential element for proteins.
- Rare or noble gases are inert and are found in trace amount in air. They are used for different purposes.
- Different elements play very important role in biological systems, daily life and agriculture.

GLOSSARY

Carbohydrates: These are the major class of naturally occurring organic compounds, which contain carbon, hydrogen and oxygen.

Proteins: These are the naturally occurring macromolecules which contain polymers of amino acids.

Respiration: It is the process by which living things use oxygen from the air to oxidize food substances.

Photosynthesis: It is a process by which green plants manufacture carbohydrates from atmospheric carbon dioxide and water from soil, in the presence of sun light.

Allotropy: When an element is found in more than one physical forms in the same state, it is called allotropy. Carbon is the most common example which exist in three allotropic forms diamond, graphite and bucky balls.

Organic Chemistry: It is the chemistry of compounds of carbon as an essential element.

Nitrogen Cycle: It is the process in which atmospheric nitrogen is converted into its compounds which then decomposes into nitrogen and goes back in the atmosphere.

Rare gases Those gases which are found in trace amount in atmosphere and are characterized by their inertness are called noble gases.

QUESTIONS

Q.1 Fill in the blanks:

(i) _____ is the process by which plants produce glucose.

(ii) The %age composition of the methane is about _____ in natural gas.

(iii) _____ is the only chemical compound found naturally as a liquid as a solid, and as a gas.

(iv) Nitrogen occurs in plants and animals in the form of _____.

(v) Dilute solution of Iodine in ethanol is called _____.

(vi) Phosphorous is an important constituent of _____.

(vii) Carbon is an important _____ for all organisms

Q.2 Choose the correct Answer

(i) The form of carbon which is not crystalline is .

(a) Charcoal (b) Graphite (c) Bucky Ball (d) Diamond

(ii) The process of converting atmospheric nitrogen to useable form is called.

(a) Nitrogen Cycle (b) Carbon Cycle (c) Nitrogen fixation (d) Water cycle.

(iii) Oxygen and nitrogen react to form

(a) Nitric acid (b) Nitrogen oxide (c) Nitrogen peroxide (d) Nitrate.

(iv) The amount of carbon dioxide in the air is increased by

(a) Photosynthesis (b) Respiration (c) Burning (d) Evaporation

(v) The deficiency of Iodine in human body cause.

(a) Goiter (b) Cancer (c) Tuberculosis (d) Cholera.

(vi) The contents of sodium in leaf tissues vary from.

(a) 0.01 – 10% (b) 10–15% (c) 16 –12% (d) 16 – 20%

Q.3 Short Questions:

(i) What is allotropy?

(ii) Name those three elements which are abundantly found in human body.

Q.4 Why do the water expands on freezing

Q.5 Write the notes on (1) Water as universal solvent (2) Properties of water

Q.6 Write the importance of any two elements found in air.