# Contents of This Booklet

## GENERAL SCIENCE

# Sample Chapters of This Booklet

## Gist of Chemistry from NCERT Books

### Acid, Base and Salts

#### 1. Acid

- The word 'acid' is derived from a Latin word, which means "sour". The sour taste of most of the fruits and vegetables is due to various types of acids present in them. The digestive fluids of most of the animals and humans also contain acids.
- An acid is a compound, which on dissolving in water yields hydronium ions ($H_3O^+$) as the only positive ions. The characteristic property of an acid is due to the presence of these hydronium ions.
- Acids are compounds that contain Hydrogen (Hydrochloric, HCl; Sulphuric, $H_2SO_4$; Nitric, $HNO_3$). However, not all compounds that contain Hydrogen are acids (Water, $H_2O$; Methane, $CH_4$). Acids are usually compounds of non metals with Hydrogen and sometimes Oxygen.
- Acids can be classified in various ways, depending on the factors mentioned below:
  1. Classification Based on the Strength of the acid.
  2. Classification Based on the Basicity of the Acid.
  3. Classification Based on the Concentration of the acid.
  4. Classification Based on the presence of Oxygen.
- The strength of an acid depends on the concentration of the hydronium ions present in a solution. Greater the number of hydronium ions present, greater is the strength of acid. However, some acids do not dissociate to any appreciable extent in water such as carbonic acid. Therefore, these acids will have a low concentration of hydronium ions.
- **Strong Acid:** An acid, which dissociates completely or almost completely in water, is classified as a strong acid. It must be noted that in these acids all the hydrogen ions ($H^+$) combine with water molecule and exist as hydronium ions ($H_3O^+$). Examples of strong acids are: hydrochloric acid, sulphuric acid, nitric acid etc.
- **Weak Acid:** An acid that dissociates only partially when dissolved in water, is classified as a weak acid. Most of the molecules remain in solution in molecular form itself in such acid. Examples are: acetic acid, formic acid, carbonic acid etc.
- Acids are generally sour in taste. Special type of substances are used to test whether a substance is acidic or basic. These substances are known as indicators. The indicators change their colour when added to a solution containing an acidic or a basic substance. Turmeric, litmus, china rose petals (Gudhal), etc., are some of the naturally occurring indicators.
- The most commonly used natural indicator is litmus. It is extracted from lichens . It has a mauve (purple) colour in distilled water. When added to an acidic solution, it turns red and when added to a basic solution, it turns blue. It is available in the form of a solution, or in the form of strips of paper, known as litmus paper. Generally, it is available as red and blue litmus paper.
- The solutions which do not change the colour of either red or blue litmus are known as neutral solutions. These substances are neither acidic nor basic.
- Acids are corrosive and can burn flesh and dissolve metal.

#### 2. Bases and Alkalis

- A Base is a substance that gives OH- ions when dissolved in water. Bases are usually metal hydroxides (MOH). Examples include Sodium Hydroxide, NaOH, Calcium Hydroxide, Ca(OH)2. The solution of a base in water is called an alkali.
- Bases and acids neutralize each other, therefore another way to define a base is 'a compound which reacts with an acid to give salt and water only'. Like acids, alkalis can be strong or weak. The more hydroxide ions they produce, the stronger the alkali.
- The acidic property of an acid is due to the presence of hydrogen ions (H+) while that of a base or alkali, is due to the presence of hydroxyl (OH–) ions in them. When an acid and base (alkali) combine, the positively charged hydrogen ion of the acid combines with the negatively charged hydroxyl ion of the base to form a molecule of water. Hence, the water molecule formed does not have any charge because the positive and negative charges of the hydrogen ions and hydroxyl ions get neutralized.
- The strength of a base depends on the concentration of the hydroxyl ions when it is dissolved in water.
  **1. Strong Base:** A base that dissociates completely or almost completely in water is classified as a strong base. The greater the number of hydroxyl ions the base produces, the stronger is the base. Examples: Sodium hydroxide: NaOH, Potassium hydroxide: KOH, Calcium hydroxide: Ca(OH)2.
  **2. Weak Base:** A base that dissociates in water only partially is known as a weak base. Examples: Magnesium hydroxide: Mg(OH)2, Ammonium hydroxide: NH4OH.
- Bases are bitter to taste. They are soapy and slippery to touch. Strong alkalis like sodium hydroxide and potassium hydroxide are highly corrosive or caustic in nature. Sodium hydroxide and potassium hydroxide are commonly called caustic soda and caustic potash respectively. Organic tissues like skin, etc. get completely corroded by these two alkalis. However, the other alkalis are only mildly corrosive.

## 3. pH

- A scale for measuring hydrogen ion concentration in a solution, called pH scale has been developed. The p in pH stands for 'potenz' in German, meaning power. On the pH scale we can measure pH from 0 (very acidic) to 14 (very alkaline). pH should be thought of simply as a number which indicates the acidic or basic nature of a solution. Higher the hydronium ion concentration, lower is the pH value. The pH of a neutral solution is 7. Values less than 7 on the pH scale represent an acidic solution. As the pH value increases from 7 to 14, it represents an increase in OH– ion concentration in the solution, that is, increase in the strength of alkali. Generally paper impregnated with the universal indicator is used for measuring pH. One such paper is shown in .
- There are chemicals that change colour at different pH values. These are called indicators. One of the most famous is Litmus. This substance turns red when the pH is less than 7 (acidic) and turns blue when the pH is greater than 7 (basic).

## 4. Salts

- A Salt results when an acid reacts with a base. Both are neutralised. The H+ and OH- ions combine to form water. The non metalic ions of the acid and the metal ions of the base form the salt.
- Important salts used in everyday life and industrial applications are Sodium chloride (NaCl), Sodium carbonate, (Na 2 CO3), Sodium Bicarbonate, (NaHCO3), Sodium Hydroxide (NaOH)
- The salt ions normally stay in solution. The salt crystalizes out when the water is removed. Some salts are insoluble. They will precipitate out when the acid and base are added together.

- Salts of a strong acid and a strong base are neutral with pH value of 7. On the other hand, salts of a strong acid and weak base are acidic with pH value less than 7 and those of a strong base and weak acid are basic in nature, with pH value more than 7.

## Atomic Structure

- An atom is the smallest particle of the element that can exist independently and retain all its chemical properties. Atoms are made up of fundamental particles: electrons, protons and neutrons.
- **Dalton's Atomic Theory:** John Dalton provided a simple theory of matter to provide theoretical justification to the laws of chemical combinations in 1805. The basic postulates of the theory are:
- All substances are made up of tiny, indivisible particles called atoms.
- Atoms of the same element are identical in shape, size, mass and other properties.
- Each element is composed of its own kind of atoms. Atoms of different elements are different in all respects.
- Atom is the smallest unit that takes part in chemical combinations.
- Atoms combine with each other in simple whole number ratios to form compound atoms called molecules.
- Atoms cannot be created, divided or destroyed during any chemical or physical change.
- **Representation of an Atom by a Symbol:** Dalton was the first scientist to use the symbols for elements in a very specific sense. When he used a symbol for an element he also meant a definite quantity of that element, that is, one atom of that element. A symbol signifies a shorthand representation of an atom of an element. The symbol of any element is based on the English name or Latin name (written in English alphabets) and many of the symbols are the first one or two letters of the element's name in English. The first letter of a symbol is always written as a capital letter (uppercase) and the second letter as a small letter (lowercase). Examples are: (i) hydrogen- H (ii) aluminium- Al and not AL (iii) cobalt- Co and not CO. Symbols of some elements are formed from the first letter of the name and a letter, appearing later in the name. Examples are: (i) chlorine, Cl, (ii) zinc, Zn etc.
- Other symbols have been taken from the names of elements in Latin, German or Greek. For example, the symbol of iron is Fe from its Latin name ferrum, sodium is Na from natrium, potassium is K from kalium. Therefore, each element has a name and a unique chemical symbol.
- **Size of the Atom/ Elements:** Atoms are very small, they are smaller than anything that we can imagine or compare with. One hydrogen atom, the smallest atom known, is approximately 5 x 10-8 mm in diameter. Atomic radius is measured in nanometres. 1 m = 109 nm.
- **Atomic Mass:** The mass of a particular atom is taken as a standard unit and the masses of other atoms are related to this standard. Hydrogen being the lightest element and being the smallest atom was chosen and assumed to have a mass of 1. An atom of hydrogen was assigned an atomic mass equal to one atomic mass unit (a.m.u). The number does not signify the mass of an atom in grams. It is just a pure number. The masses of atoms of other elements were compared to that of hydrogen, in order to find their atomic mass relative to it. If one atom of sulphur weighs as much as 32 atoms of hydrogen, then the relative atomic mass of sulphur is 32 a.m.u. This way of defining the mass of one atom of hydrogen has its difficulties. While the mass of one atom of hydrogen is considered as 1 atomic mass unit, hydrogen gas in its natural state has 3 isotopes of atomic mass 1, 2 and 3 respectively. Thus average mass works out to be 1.008 a.m.u rather than 1 a.m.u. This in turn complicates the atomic masses of all other elements. Later on, an atom of oxygen was preferred as standard by taking its mass as 16 units. However, in 1961 for a universally accepted atomic mass unit, carbon-12 isotope was chosen as the standard reference for measuring atomic masses. One atomic mass unit is a mass unit equal to exactly onetwelfth

(1/12th) the mass of one atom of carbon-12. The relative atomic masses of all elements have been found with respect to an atom of carbon-12. It is equal to 1.66 × 10-24 g.

- **Molecule:** A molecule is in general a group of two or more atoms that are chemically bonded together, that is, tightly held together by attractive forces. A molecule can be defined as the smallest particle of an element or a compound that is capable of an independent existence and shows all the properties of that substance. Atoms of the same element or of different elements can join together to form molecules.
- The molecules of an element are constituted by the same type of atoms. Molecules of many elements, such as argon (Ar), helium (He) etc. are made up of only one atom of that element. But this is not the case with most of the nonmetals. For example, a molecule of oxygen consists of two atoms of oxygen and hence it is known as a diatomic molecule, O2. If 3 atoms of oxygen unite into a molecule, instead of the usual 2, we get ozone. The number of atoms constituting a molecule is known as its atomicity.
- Atoms of different elements join together in definite proportions to form molecules of compounds. Compounds composed of metals and nonmetals contain charged species. The charged species are known as ions. An ion is a charged particle and can be negatively or positively charged. A negatively charged ion is called an 'anion' and the positively charged ion, a 'cation'. Take, for example, sodium chloride (NaCl). Its constituent particles are positively charged sodium ions (Na+) and negatively charged chloride ions (Cl–). Ions may consist of a single charged atom or a group of atoms that have a net charge on them. A group of atoms carrying a charge is known as a polyatomic ion.
- **Chemical Formulae:** The chemical formula of a compound is a symbolic representation of its composition. The chemical formulae of different compounds can be written easily.
- The combining power (or capacity) of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemical compound. The valency of the atom of an element can be thought of as hands or arms of that atom.
- The simplest compounds, which are made up of two different elements are called binary compounds. While writing the chemical formulae for compounds, we write the constituent elements and their valencies. Then we must crossover the valencies of the combining atoms.
- The formulae of ionic compounds are simply the whole number ratio of the positive to negative ions in the structure.
- **Molecular Mass:** The molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance. It is therefore the relative mass of a molecule expressed in atomic mass units (u).
- The formula unit mass of a substance is a sum of the atomic masses of all atoms in a formula unit of a compound. Formula unit mass is calculated in the same manner as we calculate the molecular mass. The only difference is that we use the word formula unit for those substances whose constituent particles are ions. Scientists use the relative atomic mass scale to compare the masses of different atoms of elements. Atoms of carbon-12 isotopes are assigned a relative atomic mass of 12 and the relative masses of all other atoms are obtained by comparison with the mass of a carbon-12 atom.
- **Mole Concept:** Since it is not possible to calculate the weight of particles individually, a collection of such particles called mole is taken for all practical purposes. It was discovered that the number of atoms present in 12g of carbon of 12C isotope is 6.023 × 1023atoms. This is referred to as Avogadro number after the discoverer Avogadro. A mole of a gas is the amount of a substance containing 6.023 × 1023 particles. It is a basic unit of the amount or quantity of a substance. The substance may be atoms, molecules, ions or group of ions.
- Mass of 1 mole of a substance is called its molar mass. One mole of any gas at STP will have a volume of 22.4 L. This is called molar volume.
- Credit for the discovery of electron and proton goes to J.J. Thomson and E.Goldstein, respectively. J.J. Thomson proposed that electrons are embedded in a positive sphere.

- Rutherford's alpha-particle scattering experiment led to the discovery of the atomic nucleus. Rutherford's model of the atom proposed that a very tiny nucleus is present inside the atom and electrons revolve around this nucleus. The stability of the atom could not be explained by this model.
- Neils Bohr's model of the atom was more successful. He proposed that electrons are distributed in different shells with discrete energy around the nucleus. If the atomic shells are complete, then the atom will be stable and less reactive.
- J. Chadwick discovered presence of neutrons in the nucleus of an atom. So, the three sub-atomic particles of an atom are: (i) electrons, (ii) protons and (iii) neutrons. Electrons are negatively charged, protons are positively charged and neutrons have no charges.
- The discovery of the electron, proton and neutron was the starting point of new avenues of research in science, which gave physicists an insight into the structure and nature of the atoms of matter. An atom is made up of three elementary particles, namely electrons, protons and neutrons. Electrons have a negative charge, protons have a positive charge and neutrons have no charge. Neutrons are neutral. Due to the presence of equal number of negative electrons and positive protons the atom as a whole is electrically neutral. Based on the above findings, one can say that the atom has two major divisions.
- The first is the centre of an atom, called its nucleus. The protons and neutrons are located in the small nucleus at the centre of the atom. Due to the presence of protons the nucleus is positively charged.
- The second are electrons, which revolve around the nucleus in different shells (or orbits). Shells of an atom are designated as K,L,M,N,….The space around the nucleus in which the electrons revolve, determines the size of the atom.
- The maximum number of electrons present in a shell is given by the formula 2n2, where 'n' is the orbit number or energy level index, 1,2,3,… Hence the maximum number of electrons in different shells are as follows: first orbit or K-shell will be = 2 .12 = 2, second orbit or L-shell will be = 2 .22 = 8, third orbit or M-shell will be = 2 .32 = 18, fourth orbit or N-shell will be = 2 .42= 32, and so on. The maximum number of electrons that can be accommodated in the outermost orbit is 8. Electrons are not accommodated in a given shell, unless the inner shells are filled. That is, the shells are filled in a step-wise manner.
- **Valency:** The electrons present in the outermost shell of an atom are known as the valence electrons. It is the decisive shell during a chemical reaction. The electrons of only this outermost shell are involved during chemical combinations; electrons are either given out from the outermost shell, or accepted into the outermost shell, or shared with the electrons in the outermost shell of another element. Elements having same number of valence electrons in their atoms possess similar chemical properties. The number of the valence shell in an atom determines its position in the Periodic Table i.e. the period to which the element belongs. Elements having 1, 2 or 3 electrons in the valence shell are metals. Exception is H and He. Elements having 4 to 7 electrons in their valence shell are non-metals. Valency is the combining capacity of an element. It is the number of electrons in an atom that actually take part in bond formation. For example, carbon atom with an atomic number 6 has 4 valence electrons.
- **Calculation of Valency:** The number of valence electrons is the valency of the element. The valency of an element can also be calculated by finding the number of electrons required to complete octet (8). If the outermost shell of an atom is completely filled, its valency = 0. The outermost shells of the noble gases helium, neon, argon, krypton etc. are completely filled. Hence their valency is zero. Such elements are very un-reactive and inert by nature.
- **Atomic Number:** The nuclei of atoms is made up of protons and neutrons. These two components of the nucleus are referred to as nucleons. The electrons occupy the space outside the nucleus. Since an atom is electrically neutral, the number of protons in the nucleus is exactly equal to the number of electrons. This number is the atomic number given by the symbol Z.

- **Mass Number:** The total number of protons and neutrons present in one atom of an element is known as its mass number. Mass number = number of protons + number of neutrons.
- **Isotopes:** Isotopes are atoms of the same element, which have different mass numbers. It is interesting to note that atoms of a given atomic number can have different number of neutrons. For example, take the case of hydrogen atom, it has three atomic species, namely protium (11 H), deuterium ((21 H or D) and tritium ((31 H or T). The atomic number of each one is 1, but the mass number is 1, 2 and 3, respectively. All isotopes of an element have the same number of valence electrons thus have identical chemical properties. The physical properties of the isotopes are different due to the difference in the number of neutrons in their nuclei. The densities, melting points and boiling points etc., are slightly different.
- **Isobars:** Atoms of different elements with different atomic numbers, which have the same mass number, are known as isobars. These have different number of protons but equal sum of number of protons and neutrons.
- **Isotones:** The atoms of different elements, which have the same number of neutrons but different atomic numbers, are called isotones.
- **Radioactivity:** Radioactivity is a nuclear phenomenon. It is the spontaneous emission of radiation from the nucleus. In 1899, the study of radioactivity was taken up by Ernest Rutherford. He placed a little radium at the bottom of a small lead box and subjected the rays that emerged from it to the action of a very strong magnetic field at right angles to their direction. He found that the rays separated into three distinct constituents. Rutherford called the three types of radiation alpha (á), beta (â) and gamma (g) rays. The á-rays were deflected in a direction opposite to that of â-rays and á-rays carried a positive charge, â-rays carried a negative charge and those which passed undeviated were neutral or uncharged were g-rays.

## Chemical Bonding

- Atoms are made up of three smaller particles called protons, neutrons and electrons. The protons and neutrons are found in the nucleus of the atom. Protons have a single positive charge. This is called the Atomic Number of an atom. The Atomic Number tells us the number of electrons that the atom contains. It is these electrons that determine the chemical properties of the atom and the way it combines with other atoms to form specific compounds. Electrons have a single negative charge. Normally, atoms are electrically neutral so that the number of electrons is equal to the number of protons.
- Electrons orbit around the nucleus. Electrons cannot orbit the nucleus of an atom in any orbit. The electrons are restricted to specific paths called orbitals or shells. Each shell can only hold a certain number of electrons. When a shell is full, no more electrons can go into that shell. The key to the properties of atoms is the electrons in the outer shell. A complete outer shell of electrons is a very stable condition for an atom.
- **Valency:** Hydrogen is the simplest element. It has one electron. Its outer shell only holds two electrons. Valency can be simply defined as the number of Hydrogen atoms that an element can combine with. The atoms with full electron shells (Helium, Neon, Argon) are chemically inert forming few compounds. The atoms don't even interact with each other very much. These elements are gases with very low boiling points. The atoms with a single outer electron or a single missing electron are all highly reactive. Sodium is more reactive than Magnesium. Chlorine is more reactive than Oxygen. Generally speaking, the closer an atom is to having a full electron shell, the more reactive it is. Atoms with one outer electron are more reactive than those with two outer electrons, etc. Atoms that are one electron short of a full shell are more reactive than those that are two short.
- Chemical bonds are what hold atoms together to form the more complicated aggregates that we know as molecules and extended solids. The forces that hold bonded atoms

together are basically just the same kinds of electrostatic attractions that bind the electrons of an atom to its positively-charged nucleus. chemical bonding occurs when one or more electrons are simultaneously attracted to two nuclei. .

- Mainly 3 Types of bonds can be present in Chemical Compounds.

  **1. Electrovalent or Ionic Bond:** It is formed by Transferring of Electrons between 2 Atoms. These types of bonds are mainly formed between Metals and Non - Metals. These compounds exist in solid form. These compounds have high boiling Point, Melting Point and thermal stability.

  **2. Covalent Bond:** It is formed by equal sharing of Electrons between 2 Atoms. This type of bond is mainly formed between non - metals. These compounds may be solid, liquid or gas. These compounds have low boiling Point, Melting Point and thermal stability in comparison to Ionic Bond.

  **3. Co - Ordinate or Dative Bond:** It is formed by unequal sharing of Electrons between 2 Atoms. This bond is also called as Semi - Polar bond since; it involves Electrovalency and Covalency both. These compounds may be solid, liquid or gas. These compounds are insoluble in $H_2O$. These compounds do not conduct Electricity. These compounds have high B.P. than Covalent Compounds but less than Electrovalent Compounds.

## Chemical Reactions and Equations

- **Atoms and Molecules, Elements and Compounds:** There are about a hundred different types of atoms in the Universe. Substances made up of a single type of atom are called Elements. Some elements are made up of single atoms: Carbon©, Helium(He), Sodium(Na), Iron(Fe) etc. He, Fe, and Na are the Chemical Symbols of the elements.
- Some elements are made up of groups of atoms: Oxygen($O_2$), Ozone($O_3$), Chlorine($Cl_3$) etc. These groups of atoms are called molecules.
- Molecules can also be made up of combinations of different types of atoms. These substances are called compounds: Common Salt(NaCl), Methane($CH_4$), Ammonia($NH_3$) etc. $O_2$, $CH_4$, $NH_3$ are the Chemical Formulas of Oxygen, Methane and Ammonia respectively. $CH_4$ means that a single molecule of methane contains one atom of Carbon and four atoms of Hydrogen. This chemical formula could have been written but the $C_1 H_4$ is never written. Similarly, a molecule of Ammonia ($NH_3$) contains one atom of Nitrogen and three atoms of Hydrogen.
- A change in which one or more new substances are formed is called a chemical change. A chemical change is also called a chemical reaction. The change may conveniently be represented by a chemical equation.
- Chemical reactions occur when different atoms and molecules combine together and spit apart. For example, if Carbon (C) is burnt in Oxygen ($O_2$) to form Carbon Dioxide, a Chemical Reaction occurs. This reaction can be written: $C + O_2 \longrightarrow CO_2$. This is called a Chemical Equation. The substances on the left hand side of the equation are called the Reactants. The substances on the right hand side are called the Products.
- There is one very important rule with chemical equations: The number of individual atoms on each side of the equation must be the same. On the left had side, there is an atom of Carbon and a molecule of Oxygen (containing two atoms). On the right hand side there is a molecule of carbon dioxide (containing one atom of carbon and two atoms of Oxygen). The number of atoms on the left hand side is equal to the number of atoms on the right hand side. All that has changed is the arrangement of the atoms. In a chemical reaction atoms are re-arranged; no atoms are destroyed or created.
- Hydrogen gas is mixed with Oxygen gas. If the mixture is sparked, it explodes to form water. This chemical reaction can be expressed as: $H_2 + O_2 \longrightarrow H_2O$. On the left had side,

there is a molecule of Hydrogen (containing two atoms) and a molecule of Oxygen (also containing two atoms). On the right hand side there is a molecule of water (containing two atoms of Hydrogen and one atom of Oxygen). The left hand side has one extra atom of Oxygen. This is not allowed by the Law of Conservation of Matter. Both sides must contain the same number of atoms. To make the equation conform, we must balance the equation. It is not possible to change the chemical formulas of the reactants or products. Water will always be H2O. Balancing the equation is achieved by changing the number of molecules involved. The balanced form of the above equation is: 2H2 + O2—> 2H2O. Now, on the left had side, there are two molecules of Hydrogen (each containing two atoms making four atoms) and a molecule of Oxygen (containing two atoms). On the right hand side there are two molecule of water (each containing two atoms of Hydrogen and one atom of Oxygen making a total of four atoms of Hydrogen and two of Oxygen). The equation is now balanced. In summary, when Hydrogen reacts with Oxygen, two molecules of Hydrogen react with one molecule of Oxygen to give two molecules of water.

- The reaction goes in both directions. While the Nitrogen and Hydrogen are combining to form Ammonia, Ammonia splits to form Hydrogen and Nitrogen. A mixture of all three substances results. This type of reaction is called an Equilibrium and is represented by arrows going in both directions. N2 + 3H2—> 2NH3.
- It is possible to push the reaction in one direction by adding a Catalyst. A catalyst is a substance that helps a reaction without being used up. If Ammonia is removed from the equilibrium mixture, the reaction will move to produce more Ammonia so that equilibrium is attained.
- The total mass of the elements present in the products of a chemical reaction has to be equal to the total mass of the elements present in the reactants. In other words, the number of atoms of each element remains the same, before and after a chemical reaction.
- During a chemical reaction atoms of one element do not change into those of another element. Nor do atoms disappear from the mixture or appear from elsewhere. Actually, chemical reactions involve the breaking and making of bonds between atoms to produce new substances.
- In a combination reaction two or more substances combine to form a new single substance.
- Decomposition reactions are opposite to combination reactions. In a decomposition reaction, a single substance decomposes to give two or more substances.
- Reactions in which heat is given out along with the products are called exothermic reactions.
- Reactions in which energy is absorbed are known as endothermic reactions.
- When an element displaces another element from its compound, a displacement reaction occurs.
- Two different atoms or groups of atoms (ions) are exchanged in double displacement reactions.
- Precipitation reactions produce insoluble salts.
- Reactions also involve the gain or loss of oxygen or hydrogen by substances. Oxidation is the gain of oxygen or loss of hydrogen. Reduction is the loss of oxygen or gain of hydrogen. The substance that brings about oxidation and is itself reduced is termed as oxidizing agent and the substance that brings about reduction and is itself oxidized is referred to as reducing agent.There are a number of oxidation-reduction reactions that are of industrial use. The production of metals from their ores invariably involves these two processes.

## Matter and Its Nature

### A. MATTER AND ITS NATURE

- Anything that possesses mass, occupies space, offers resistance and can be perceived through one or more of our sense is called matter.

- Matter is made up of particles. Particles of matter have space between them and are continuously moving and attract each other.
- Matter can exist in three states-
  I. Solid
  II. Liquid
  III. Gas.
- Solid has a definite shape, distinct boundaries and fixed volumes, Solids have a tendency to maintain their shape when subjected to outside force. Solids may break under force but it is difficult to change their shape, so they are rigid.
- Liquids have no fixed shape but have a fixed volume. They take up the shape of the container in which they are kept. Liquids flow and change shape, so they are not rigid but can be called fluid.
- A gas has no definite volume or shape. gases are highly compressible as compared to solids and liquids. The liquefied petroleum gas (LPG) cylinder that we get in our home for cooking or the oxygen supplied to hospitals in cylinders is compressed gas. Compressed natural gas (CNG) is used as fuel these days in vehicles.
- The forces of attraction between the particles(inter-molecular force) are maximum in solids, intermediate in liquids and minimum in gases. The spaces in between the constituent particles and kinetic energy of the particles are minimum in the case of solids, intermediate in liquids and maximum in gases.
- The arrangement of particles is most ordered in the case of solids, in the case of liquids layers of particles can slip and slide over each other while for gases, there is no order, particles just move about randomly.
- In spite of above differences all kinds of matter have a common property, the property of having a mass.
- The states of matter are inter-convertible. The state of matter can be changed by changing temperature or pressure.
- On increasing the temperature of solids, the kinetic energy of the particles increases. Due to the increase in kinetic energy, the particles start vibrating with greater speed. The energy supplied by heat overcomes the forces of attraction between the particles. The particles leave their fixed positions and start moving more freely. A stage is reached when the solid melts and is converted to a liquid. The temperature at which a solid melts to become a liquid at the atmospheric pressure is called its melting point.
- The process of melting, that is, change of solid state into liquid state is also known as fusion.
- During the melting, the temperature of the system does not change after the melting point is reached, till all the ice melts. This happens even though we continue to heat the beaker, that is, we continue to supply heat. This heat gets used up in changing the state by overcoming the forces of attraction between the particles. As this heat energy is absorbed by ice without showing any rise in temperature, it is considered that it gets hidden into the contents of the beaker and is known as the latent heat.
- The amount of heat energy that is required to change 1 kg of a solid into liquid at atmospheric pressure at its melting point is known as the latent heat of fusion.
- The temperature at which a liquid starts boiling at the atmospheric pressure is known as its boiling point.
- Latent heat of vaporisation is the heat energy required to change 1 kg of a liquid to gas at atmospheric pressure at its boiling point.
- Sublimation is the change of gaseous state directly to solid state without going through liquid state, and vice versa.
- Evaporation is a surface phenomenon. Particles from the surface gain enough energy to overcome the forces of attraction present in the liquid and change into the vapour state. The rate of evaporation depends upon the surface area exposed to the atmosphere, the temperature, the humidity and the wind speed. Evaporation causes cooling.

- During summer, we perspire more because of the mechanism of our body which keeps us cool. We know that during evaporation, the particles at the surface of the liquid gain energy from the surroundings or body surface and change into vapour. The heat energy equal to the latent heat of vaporisation is absorbed from the body leaving the body cool.
- Let us take some ice-cold water in a tumbler. Soon we will see water droplets on the outer surface of the tumbler. The water vapour present in air, on coming in contact with the cold glass of water, loses energy and gets converted to liquid state, which we see as water droplets.
- Properties such as shape, size, colour and state of a substance are called its physical properties. A change , which does not involve any alteration in composition of the substance is called a physical change. A physical change is generally reversible. In such a change no new substance is formed.
- Some substances can be obtained in pure state from their solutions by crystallisation.
  8 A change that alters the composition of a substance or substances taking part in the change is termed a chemical change. A chemical change is also called a chemical reaction.All new substances are formed as a result of chemical changes.
  8 Burning of coal, wood or leaves is a chemical change. Explosion of a firework is a chemical change. If you leave a piece of iron in the open for some time, it acquires a film of brownish substance. This substance is called rust and the process is called rusting. The process of rusting can be represented by the following equation: Iron (Fe) + Oxygen ($O_2$, from the air)water ($H_2O$) '! rust (iron oxide- $Fe_2O_3$) For rusting, the presence of both oxygen and water (or water vapour) is essential. It is a chemical change.
  8 Prevent iron articles from coming in contact with oxygen, or water, or both. One simple way is to apply a coat of paint or grease. Another way is to deposit a layer of a metal like chromium or zinc on iron. This process of depositing a layer of zinc on iron is called galvanisation.
  8 Stainless steel is made by mixing iron with carbon and metals like chromium, nickel and manganese. It does not rust.
  8 Changes attended with absorption of heat are called endothermic changes, while those which occur with evolution of heat are called exothermic changes. The reactions in which heat is absorbed are known as endothermic reactions, while chemical reactions which evolve heat are called exothermic. The compounds formed from their elements with absorption of heat are called endothermic compounds, whilst those formed from their elements with evolution of heat are called exothermic compounds.

## B. Classifications

- A pure substance is one that contains one kind of materials throughout its body. A substance cannot be separated into other kinds of matter by any physical process. Mixtures are constituted by more than one kind of pure form of matter, known as a substance. Mixtures can be separated into pure substances using appropriate separation techniques like filteration, sublimation, decantation, chromato-graphy, crystallization, etc.
- A substance is said to be homogeneous if it has one and the same composition and properties in all its parts. On the other hand, if the composition and properties are not identical throughout the body the substance is heterogeneous. A pure substance must be homogeneous.
- Pure substance are classified into elements and compounds.
  Elements: An element is a form of matter that cannot be broken down by chemical reactions into simpler substances.Robert Boyle was the first scientist to use the term element in 1661. Elements can be normally divided into metals, non-metals and metalloids.
- **Compound:** A compound is a substance composed of two or more different types of elements, chemically combined in a fixed proportion. Properties of a compound are different from its constituent elements.

- **Symbols:** The symbol is an abbrevaiation for the full name of an element. In many cases the initial capital letter of the common name of element is used as abbrevaiation for it. H stands for Hydrogen, N for Nitrogen, etc. Two letters are used in cases of two or more elements having the same initial letter. A second prominent letter ( small) from its name is added to the initial letter. Al stands for Aluminium, Cl stands for chlorine, etc. In some cases the symbols are derived by taking letter or letters from the Latin name of the element. Cu stands for Copper ( Latin name Cuprum), Au stands for Gold ( Latin name Aurum), etc.
- Symbol represents one atom and naturally stands for a perfectly definite amount of the element concerned. Every substance is an aggregate of its molecules, and the symbolic representation of a molecule of the substance is called its formula. The number of atoms per molecule of the element is known as the atomicity of the molecule. If the molecule of an element contains one atom, then the molecule is represented by the symbol only, i.e., in such a case symbol represents also the formula.
- **Valency:** The number of chemical substances, except the element themselves, are composed of two or more of these elementary materials combined together. The valency of an element is the combining capacity of an atom of the element and is measured by the number of hydrogen atoms with which it can be combined. Hydrogen is chosen as the standard of referrence because the combining capacity of hydrogen is least. Though the combining capacity of an atom of the element is by and large fixed, valancy may vary; some elements exhibit different valancies. The highest valancy known being 8, the valancies range between 0 and eight. Helium, argon, etc., the so-called inert gases have no combining capacity and hence they are regarded as zero valent element. Valancy is always a whole number.
- Compounds too like elements are represented by molecular formula. To build up the formula of a compound the symbols of the constituent elements are written side by side and the number of atoms of each is indicated by putting numerals to the lower right of the symbols. But the subscript one is not written in formula.

## C. Solution

- A solution is a homogeneous mixture of two or more substances. The major component of a solution is called the solvent, and the minor, the solute. Lemonade, soda water etc. are all examples of solutions. We can also have solid solutions (alloys) and gaseous solutions (air).
- The particles of a solution are smaller than 1 nm (10-9 metre) in diameter. So, they cannot be seen by naked eyes. The solute particles cannot be separated from the mixture by the process of filtration. The solute particles do not settle down when left undisturbed, that is, a solution is stable.
- The concentration of a solution is the amount of solute present per unit volume or per unit mass of the solution/solvent.
- Materials that are insoluble in a solvent and have particles that are visible to naked eyes, form a suspension. A suspension is a heterogeneous mixture.

## D. Alloys

- Alloys are homogeneous mixtures of metals and cannot be separated into their components by physical methods. But still, an alloy is considered as a mixture because it shows the properties of its constituents and can have variable composition. For example, brass is a mixture of approximately 30% zinc and 70% copper.
- Non-homogeneous systems, in which solids are dispersed in liquids, are called suspensions. A suspension is a heterogeneous mixture in which the solute particles do not dissolve but remain suspended throughout the bulk of the medium. Particles of a suspension are visible to the naked eye.

- Colloids are heterogeneous mixtures in which the particle size is too small to be seen with the naked eye, but is big enough to scatter light. Colloids are useful in industry and daily life. The particles are called the dispersed phase and the medium in which they are distributed is called the dispersion medium.

## E. METALS AND NON-METALS

Elements can be normally divided into metals, non-metals and metalloids. Metals usually show some or all of the following properties:

- They have a lustre (shine).Exception: Mercury, though a metal is liquid.
- They have silvery-grey or golden-yellow colour.
- They conduct heat and electricity. Silver is the best while copper stands second.
- They are ductile (can be drawn into wires).Gold is the most ductile metal.
- They are malleable (can be hammered into thin sheets). Exception: Metals like antimony and bismuth are brittle.
- They are sonorous (make a ringing sound when hit).
  • Metals have high melting points. Exception:Gallium and Caesium have very low melting points.
  • Metals can form positive ions by losing electrons to non-metals. In electrolysis metals get deposited at the negative electrode(cathode).
  • Metals combine with oxygen to form basic oxides. Aluminium oxide and zinc oxide show the properties of both basic as well as acidic oxides. These oxides are known as amphoteric oxides.Different metals show different reactivities towards oxygen. Metals such as potassium and sodium react so vigorously that they catch fire if kept in the open. Hence, to protect them and to prevent accidental fires, they are kept immersed in kerosene oil.
  • Different metals have different reactivities with water and dilute acids.Metals above hydrogen in the Activity series can displace hydrogen from dilute acids and form salts.
  • Metals occur in nature as free elements or in the form of their compounds.The extraction of metals from their ores and then refining them for use is known as metallurgy.
  • The surface of some metals, such as iron, is corroded when they are exposed to moist air for a long period of time. This phenomenon is known as corrosion.

## Organic Chemistry

Organic chemistry is that branch of chemistry which deals with the study of compounds of carbon with hydrogen (hydrocarbons), and their derivatives. Presently about five million organic compounds are known. Organic compounds were found to contain mainly hydrogen and carbon. Therefore, organic chemistry is defined as the study of hydrocarbons and their derivatives. Most atoms are only capable of forming small molecules. However one or two can form larger molecules. By far and away the best atom for making large molecules with is Carbon. Carbon can make molecules that have tens, hundreds, thousands even millions of atoms! The huge number of possible combinations means that there are more Carbon compounds that those of all the other elements put together! A single Carbon atom is capable of combining with up to four other atoms. We say it has a valency of 4. Sometimes a Carbon atom will combine with fewer atoms. The Carbon atom is one of the few that will combine with itself. In other words Carbon combines with other Carbon atoms. This means that Carbon atoms can form chains and rings onto which other atoms can be attached. This leads to a huge number of different compounds. Organic Chemistry is essentially the chemistry of Carbon. Carbon compounds are classified according to how the Carbon atoms are arranged and what other groups of atoms are attached.

- **Hydrocarbons:** The simplest Organic compounds are made up of only Carbon and Hydrogen atoms only. Even these run into thousands! Compounds of Carbon and Hydrogen only are called Hydrocarbons.

1. **Alkanes:** In the alkanes, all four of the Carbon valency bonds are taken up with links to different atoms. These types of bonds are called single bonds and are generally stable and resistant to attack by other chemicals. Alkanes contain the maximum number of Hydrogen atoms possible. They are said to be saturated. The simplest Hydrocarbon is:

   • Methane: $CH_4$ This is the simplest member of a series of hydrocarbons. Each successive member of the series has one more Carbon atom than the preceeding member.
   • Ethane: $C_2H_6$.
   • Propane –( heating fuel): $C_3H_8$.
   • Butane – (lighter / camping fuel): $C_4H_{10}$.
   • Pentane: $C_5H_{12}$.
   • Hexane: $C_6H_{14}$.

   Polythene is a very large alkane with millions of atoms in a single molecule. Apart from being flammable, alkanes are stable compounds found underground.

2. **Alkenes:** Another series of compounds is called the alkenes. These have a general formula: $C_nH_{2n}$. These compounds are named in a similar manner to the alkanes except that the suffix is -ene. Alkenes have fewer hydrogen atoms than the alkanes. The extra valencies left over occur as double bonds between a pair of Carbon atoms. The double bonds are more reactive than single bonds making the alkenes chemically more reactive. The simplest alkenes are listed in the table below:

   • Ethene ( used as an industrial starter chemical): $C_2H_4$.
   • Propene: $C_3H_6$.
   • Butene: $C_4H_8$.
   • Pentene: $C_5H_{10}$.
   • Hexene: $C_6H_{12}$.

3. **Alkynes:** A third series are the alkynes. These have the following formula: $C_nH_{2n-2}$. These highly reactive substances have many industrial uses. Again the naming of these compounds is similar to the alkanes except that the suffix is -yne. Alkynes have two carbon atoms joined by a tripple bond. This is highly reactive making these compounds unstable. Examples of alkynes are:

   • Ethyne - better known as acetylene which is used for welding underwater: $C_2H_2$
   • Propyne: $C_3H_4$
   • Butyne: $C_4H_6$
   • Pentyne: $C_5H_8$
   • Hexyne: $C_6H_{10}$

4. **Carbon Rings:** Alkanes, alkenes and alkynes all contain Carbon atoms in linear chains. When rings are combined with chains, the number of hydrocarbons is virtually infinite. There are also hydrocarbons arranged in rings. Some examples follow:

   • Cyclohexane - a saturated hydrocarbon with the atoms arranged in a hexagonal ring: $C_6H_{12}$

   • Benzene - an industrial solvent. The Benzene Ring is one of the most important structures in organic chemistry. In reality, its alternate double and single bonds are "spread around" the ring so that the molecule is symmetrical: $C_6H_6$

• Toluene - an important solvent and starter chemical: $C_7H_8$

• Naphthalene - used in moth balls. This can be depicted as two fused Benzene Rings: $C_{10}H_8$

**Carbon, Hydrogen and Oxygen:** When Oxygen atoms are added, the variety of compounds grows enormously. Here are some examples where each molecule has a single functional group.

1. **Alcohols:** Alcohols have the OH (hydroxyl) group in the molecule. A group of atoms that gives an organic series its distinctive character is called a functional group. These have a general formula: $C_nH_{2n+1}OH$. Examples: Methanol (wood alcohol) $CH_3OH$, Ethanol(drinking alcohol) $C_2H_5OH$, Phenol(carbolic acid - used as disinfectant) $C_6H_5OH$.
2. Ethers (Ethers have an O atom attached to two hydrocarbon chains) $(C_nH_{2n+1})_2O$. Examples: Dimethyl Ether(a gas) $(CH_3)_2O$, Diethyl Ether (a liquid used as an anaesthetic) $(C_2H_5)_2O$
3. Ketones (Ketones have a CO group attached to two hydrocarbon chains) . These have a general formula: $(C_nH_{2n+1})_2CO$.Example: Dimethyl Ketone (Also known as acetone: nail-varnish remover), $CH_3COC H_3$
4. Aldehydes (Aldehydes have a CHO group attached to a hydrocarbon chain). These have a general formula: $C_nH_{2n+1}CHO$. Example: Formal-dehyde (preservative in labs) HCHO, Acetaldehyde- $CH_3CHO$.
5. Fatty Acids (Fatty Acids contain the $CO_2H$ (or COOH) group attached to a hydrocarbon chain or ring). These have a general formula: $C_nH_{2n} + 1CO_2H$. Example: Formic Acid(in ant bites and stinging nettles)- $HCO_2H$, Acetic Acid( vinegar)- $CH_3CO_2H$, Butyric Acid( the rancid butter smell)- $C_2H_5CO_2H$.
6. Esters (Esters are similar to Fatty Acids except that the H in the COOH group is another hydrocarbon chain. They are usually very sweet smelling liquids used in perfumes). These have a general formula: $RCO_2R'$( R and R' are Hydrocarbon chain or rings). Examples: Methyl Methoate (essence of pear drops) - $CH_3CO_2CH_3$.

- It is possible to have two or more functional groups on a molecule. These can be the same group (as in Oxalic Acid - a poison found in rhubarb leaves - which has two fatty acid groups) or different (as in Hydroxymethanoic Acid - which has a hydroxyl group and a fatty acid group): Oxalic Acid- $(COOH)_2$, Hydroxymethanoic Acid- $CH_2OHCOOH$.
- The most famous compounds containing Carbon, Hydrogen and Oxygen are the Carbohydrates. An example is the common sugar, Sucrose ($C_{12}H_{22}O_{11}$).
- **Isomerism:** An interesting phenomenon with organic molecules is called isomerism. Let us look at two compounds introduced earlier. Dimethyl Ether: $(CH_3)_2O$ and Ethanol: $C_2H_5OH$. The first is a gas which will knock you out if inhaled. The second is common alcohol drunk in spirits. Both compounds contain 2 Carbon atoms, 6 Hydrogen atoms and 1 Oxygen atom. Even though the atoms are the same, they are arranged differently. This yields two different compounds with the same number of atoms. These compounds are isomers and the phenomenon is called Isomerism. Isomerism increases the number of Organic compounds. The more Carbon atoms in a compound, the more ways of arranging the atoms and the larger number of isomers.
- **Adding Nitrogen:** Many very important organic compounds contain Nitrogen. This produces more series of compounds.

1. Amines (Amines have one or more of the Hydrogen atoms in Ammonia (NH3) replaced by a Hydrocarbon chain or ring). These have a general formula: CnH2n+1NH2. Examples: Methylamine (a pungent, water soluble gas)- CH3NH2.
2. Cyanides (Cyanides have the CN group). These have a general formula: CnH2n+1CN. Examples: Methyl Cyanide- CH3CN.
3. Amino Acids (Amino Acids have two functional groups: the amine (HN2) group and the fatty acid (COOH) group. These have a general formula: CnH2nNH2COOH. Examples: Glycine (the simplest amino acid)- CH2NH2COOH.
4. A famous compound containing Nitrogen is Trinitro Toluene (C 6H2CH3 (NO)3) - usually abbreviated to TNT). This is an artificially made explosive.
   o The vast majority of organic compounds contain Carbon, Hydrogen, Oxygen and Nitrogen. Other types of atoms can be included to form even more compounds. These can contain atoms like Phosphorus, Sulphur (e.g. Thiamine,), Chlorine (e.g. Chlorophyll-CHCl3, Dichloro Diphenyl Trichloro Methane – DDT-C 14H9Cl15) and Iron (e.g. Haemoglobin).

## Periodic Classification of Elements

- The grouping of elements with similar properties together and the separation of elements with dissimilar properties is known as classification of elements. The table, which classifies elements on the basis of their properties, is called the periodic table. Döbereiner grouped the elements into triads and Newlands gave the Law of Octaves. Mendeléev arranged the elements in increasing order of their atomic masses and according to their chemical properties.
- Dobereiner's Triads arranged elements in an increasing order of atomic mass, in groups of three. The atomic mass of the middle element was the arithmetic mean of the other two elements of the triad.
- Newland's law of octaves states that on arranging elements in increasing order of their atomic mass, the eighth element resembles the first in physical and chemical properties, just like the eighth node on a musical scale resembles the first note.
- According to Mendeleev's periodic law, the physical and chemical properties of elements are periodic functions of their atomic mass. Mendeleev corrected the atomic masses of a few elements on the basis of their positions in the periodic table. Mendeléev even predicted the existence of some yet to be discovered elements on the basis of gaps in his Periodic Table.
- Mendeléev's Periodic Table contains vertical columns called 'groups'and horizontal rows called 'periods'. While developing the Periodic Table, there were a few instances where Mendeléev had to place an element with a slightly greater atomic mass before an element with a slightly lower atomic mass. The sequence was inverted so that elements with similar properties could be grouped together. Mendeleev's table could not assign a proper position to hydrogen or to the lanthanides and actinides and isotopes. Isotopes of all elements posed a challenge to Mendeleev's Periodic Law. Another problem was that the atomic masses do not increase in a regular manner in going from one element to the next. So it was not possible to predict how many elements could be discovered between two elements — especially when we consider the heavier elements.
- In 1913, Henry Moseley showed that the atomic number of an element is a more fundamental property than its atomic mass. Accordingly, Mendeléev's Periodic Law was modified and atomic number was adopted as the basis of Modern Periodic Table and the Modern Periodic Law.
- The vertical columns are called groups, while the horizontal rows are called periods. There are 7 periods and 8 groups subdivided into 18 sub groups. The noble gases are on the extreme right of the table and on the table's extreme left, are the alkali metals. Transition elements are placed in the B subgroups in the middle of the table. The inner transition elements - lanthanides and actinides, are placed in two separate series at the bottom of the

periodic table. Group number is number of electrons in the valence shell. Elements having the same valence number, are grouped together. The number of shells present in the atom gives period number.

- **Atomic size:** The term atomic size refers to the radius of an atom. The atomic size may be visualised as the distance between the centre of the nucleus and the outermost shell of an isolated atom.

# The Digestive System

## INTRODUCTION

Animals, for the most part, ingest their food as large, complex molecules that must be broken down into smaller molecules (monomers) that can then be distributed throughout the body of every cell. This vital function is accpomplished by a series of specialized organs that comprise the digestive system.

## DIGESTIVE SYSTEM IN VARIOUS ORGANISM:

Single-celled organisms can directly take in nutrients from their outside environment. Multicellular animals, with most of their cells removed from direct contact with the outside environment, have developed specialized structures for obtaining and breaking down their food.

## ANIMALS DEPEND ON TWO PROCESSES: FEEDING AND DIGESTION

- Animals are heterotrophs, they must absorb nutrients or ingest food sources.
- Ingestive eaters, majority of animals, use a mouth to ingest food.
- Absorptive feeders, such as tapeworms, live in a digestive system of another animal and absorb nutrients from that animal directly through their body wall.
- Filter feeders, such as oysters and mussels, collect small organisms and particles from the surrounding water
- Substrate feeders, such as earthworms and termites, eat the material (dirt or wood) they burrow through.
- Fluid feeders, such as aphids, pierce the body of a plant or animal and withdraw fluids.

## LOCATIONS OF DIGESTIVE SYSTEM IN VARIOUS ANIMALS:

- The digestive system uses mechanical and chemical methods to break food down into nutrient molecules that can be absorbed into the blood. Once in the blood, the food molecules are routed to every cell in the animal's body. There are two types of animal body plans as well as two locations for digestion to occur.
- Sac-like plans are found in many invertebrates, who have a single opening for food intake and the discharge of wastes.
- Vertebrates, the animal group humans belong to, use the more efficient tube-within-a-tube plan with food entering through one opening (the mouth) and wastes leaving through another (the anus).
  Where the digestion of the food happens is also variable.
- Some animals use intracellular digestion, where food is taken into cells by phagocytosis with digestive enzymes being secreted into the phagocytic vesicles. This type of digestion occurs in sponges, coelenterates (corals, hydras and their relatives) and most protozoans.
- Extracellular digestion occurs in the lumen (or opening) of a digestive system, with the nutrient molecules being transferred to the blood or some other body fluid. This more advanced type of digestion occurs in chordates, annelids, and crustaceans.

## STAGES IN THE DIGESTIVE PROCESS

Food for the most part consists of various organic macromolecules such as starch, proteins, and fats. These molecules are polymers made of individual monomer units Breaking these large molecules into smaller components involves:

1. Movement: propels food through the digestive system
2. Secretion: release of digestive juices in response to a specific stimulus
3. Digestion: breakdown of food into molecular components small enough to cross the plasma membrane
4. Absorption: passage of the molecules into the body's interior and their passage throughout the body
5. Elimination: removal of undigested food and wastes Three processes occur during what we loosely refer to as "digestion".

Digestion proper, which is the mechanical and chemical breakdown of food into particles/molecules small enough to pass into the blood.

Absorption is the passage of food monomers into the blood stream. Assimilation is the passage of the food molecules into body cells.

## (A) THE MOUTH AND PHARYNX

Mechanical breakdown begins in the mouth by chewing (teeth) and actions of the tongue. Chemical breakdown of starch by production of salivary amylase from the salivary glands. This mixture of food and saliva is then pushed into the pharynx and esophagus. The esophagus is a muscular tube whose muscular contractions (peristalsis) propel food to the stomach.

In the mouth, teeth, jaws and the tongue begin the mechanical breakdown of food into smaller particles. Most vertebrates, except birds (who have lost their teeth to a hardened bill), have teeth for tearing, grinding and chewing food. The tongue manipulates food during chewing and swallowing; mammals have tastebuds clustered on their tongues.

Salivary glands secrete salivary amylase, an enzyme that begins the breakdown of starch into glucose. Mucus moistens food and lubricates the esophagus. Bicarbonate ions in saliva neutralize the acids in foods.

## THE HUMAN DIGESTIVE SYSTEM

The human digestive system, is a coiled, muscular tube (6-9 meters long when fully extended) stretching from the mouth to the anus. Several specialized compartments occur along this length: mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus.Accessory digestive organs are connected to the main system by a series of ducts: salivary glands, parts of the pancreas, and the liver and gall bladder (bilary system).

Swallowing moves food from the mouth through the pharynx into the esophagus and then to the stomach.

## (B) THE STOMACH

During a meal, the stomach gradually fills to a capacity of 1 liter, from an empty capacity of 50-100 milliliters. At a price of discomfort, the stomach can distend to hold 2 liters or more.

Epithelial cells line inner surface of the stomach, and secrete about 2 liters of gastric juices per day. Gastric juice contains hydrochloric acid, pepsinogen, and mucus; ingredients important in digestion. Secretions are controlled by nervous (smells, thoughts, and caffeine) and endocrine signals. The stomach secretes hydrochloric acid and pepsin. Hydrochloric acid (HCl) lowers pH of the stomach so pepsin is activated. Pepsin is an enzyme that controls the hydrolysis of proteins into peptides. The stomach also mechanically churns the food. Chyme, the mix of acid and food in the stomach, leaves the stomach and enters the small intestine. Hydrochloric acid does not directly function in digestion: it kills microorganisms, lowers the stomach pH to between 1.5 and 2.5; and activates pepsinogen. Pepsinogen is an enzyme that starts protein digestion.

Pepsinogen is produced in cells that line the gastric pits. Itis activated by cleaving off a portion of the molecule, producing the enzyme pepsin that splits off fragments of peptides from a protein molecule during digestion in the stomach.

Carbohydrate digestion, begun by salivary amylase in the mouth, continues in the bolus as it passes to the stomach. The bolus is broken down into acid chyme in the lower third of the stomach, allowing the stomach's acidity to inhibit further carbohydrate breakdown. Protein digestion by pepsin begins.

**Note:**

(Alcohol and aspirin are absorbed through the stomach lining into the blood.) Epithelial cells secrete mucus that forms a protective barrier between the cells and the stomach acids. Pepsin is inactivated when it comes into contact with the mucus. Bicarbonate ions reduce acidity near the cells lining the stomach. Tight junctions link the epithelial stomach-lining cells together, further reducing or preventing stomach acids from passing.

### Ulcers

Peptic ulcers result when these protective mechanisms fail. Bleeding ulcers result when tissue damage is so severe that bleeding occurs into the stomach. Perforated ulcers are life-threatening situations where a hole has formed in the stomach wall. At least 90% of all peptic ulcers are caused by Helicobacter pylori. Other factors, including stress and aspirin, can also produce ulcers.

### (C) The Small Intestine

The small intestine, is where final digestion and absorption occur.

The small intestine is a coiled tube over 3 meters long. Coils and folding plus villi give this 3mtube the surface area of a 500-600m long tube. Final digestion of proteins and carbohydrates must occur, and fats have not yet been digested. Villi have cells that produce intestinal enzymes which complete the digestion of peptides and sugars. The absorption process also occurs in the small intestine. Food has been broken down into particles small enough to pass into the small intestine. Sugars and amino acids go into the bloodstream via capillaries in each villus. Glycerol and fatty acids go into the lymphatic system. Absorption is an active transport, requiring cellular energy.

Food is mixed in the lower part of the stomach byperistaltic waves that also propel the acid-chyme mixture against the pyloric sphincter. Increased contractions of the stomach push the food through the sphincter and into the small intestine as the stomach eempties over a 1 to 2 hour period. High fat diets significantly increase this time period. The small intestine is the major site for digestion and absorption of nutrients. The small intestine is up to 6 meters long and is 2-3 centimeters wide.

The upper part, the duodenum, is the most active in digestion. Secretions from the liver and pancreas are used for digestion in the duodenum. Epithelial cells of the duodenum secrete a watery mucus. The pancreas secretes digestive enzymes and stomach acid-neutralizing bicarbonate.

The liver produces bile, which is stored in the gall bladder before entering the bile duct into the duodenum. Digestion of carbohydrates, proteins, and fats continues in the small intestine. Starch and glycogen are broken down into maltose by small intestine enzymes. Proteases are enzymes secreted by the pancreas that continue the breakdown of protein into small peptide fragments and amino acids.

Bile emulsifies fats, facilitating their breakdown into progressively smaller fat globules until they can be acted upon by lipases. Bile contains cholesterol, phospholipids, bilirubin, and a mix of salts.

Fats are completely digested in the small intestine, unlike carbohydrates and proteins. Most absorption occurs in the duodenumand jejeunum (second third of the small intestine). The inner surface of the intestine has circular folds that more than triple the surface area for absorption. Villi covered with epithelial cells increase the surface area by another factor of 10. The epithelial cells are lined with microvilli that further increase the surface area; a 6 meter long tube has a surface area of 300 square meters. Each villus has a surface that is adjacent to the inside of the small intestinal opening covered in microvilli that form on top of an epithelial cell known as a brush border. Each villus has a capillary network supplied by a small arteriole.Absorbed substances pass through the brush border into the capillary, usually by passive transport.

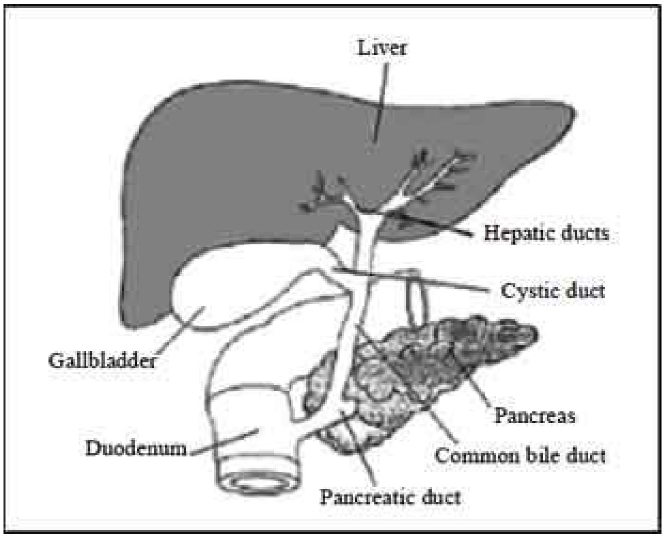
Maltose, sucrose, and lactose are the main carbohydrates present in the small intestine; they are absorbed by the microvilli. Starch is broken down into two-glucose units (maltose) elsewhere. Enzymes in the cells convert these disaccharides into monosaccharides that then leave the

cell and enter the capillary. Lactose intolerance results from the genetic lack of the enzyme lactase produced by the intestinal cells.

Peptide fragments and amino acids cross the epithelial cell membranes by active transport. Inside the cell they are broken into amino acids that then enter the capillary. Gluten enteropathy is the inability to absorb gluten, a protein found in wheat.

Digested fats are not very soluble. Bile salts surround fats to form micelles, that can pass into the epithelial cells. The bile salts return to the lumen to repeat the process. Fat digestion is usually completed by the time the food reaches the ileum(lower third) of the small intestine. Bile salts are in turn absorbed in the ileum and are recycled by the liver and gall bladder. Fats pass from the epithelial cells to the small lymph vessel that also runs through the villus.

## The Liver:




The liver produces and sends bile to the small intestine via the hepatic duct. Bile contains bile salts, which emulsify fats, making them susceptible to enzymatic breakdown. In addition to digestive functions, the liver plays several other roles:

(1) detoxification of blood;
(2) synthesis of blood proteins;
(3) destruction of old erythrocytes and conversion of hemoglobin into a component of bile;
(4) production of bile;
(5) storage of glucose as glycogen, and its release when blood sugar levels drop; and
(6) production of urea from amino groups and ammonia.

- ## Gall Bladder

The gall bladder stores excess bile for release at a later time. We can live without our gall bladders, in fact many people have had theirs removed. The drawback, however, is a need to be aware of the amount of fats in the food they eat since the stored bile of the gall bladder is no longer available.

Glycogen is a polysaccharidemade of chains of glucose molecules. In plants starch is the storage form of glucose, while animals use glycogen for the same purpose. Low glucose levels in the blood cause the release of hormones, such as glucagon, that travel to the liver and stimulate the breakdown of glycogen into glucose, which is then released into the blood(raising blood glucose levels).When no glucose or glycogen is available, amino acids are converted into glucose in the liver. The process of deamination removes the amino groups from amino acids. Urea is formed and passed through the blood to the kidney for export from the body. Conversely, the hormone insulin promotes the takeup of glusose into liver cells and its formation into glycogen.

**(A) Liver Diseases** Jaundice occurs when the characteristic yellow tint to the skin is caused by excess hemoglobin breakdown products in the blood, a sign that the liver is not properly functioning. Jaundice may occur when liver function has been impaired by obstruction of the bile duct and by damage caused by hepatitis.

**(B) Hepatitis** A, B, and C are all viral diseases that can cause liver damage. Like any viral disease, the major treatment efforts focus on treatment of symptoms, not removal of the viral cause.

- HepatitisAis usuallymild malady indicated by
- sudden fever, malaise, nausea, anorexia, and abdominal discomfort.
- The virus causing Hepatitis A is primarilly transmitted by fecal contamination, although contaminated food and water also can promote transmission.
- Hepatitis B may be transmitted by blood and blood products as well as sexual contact. The risk of HBV infection is high among promiscuous homosexual men although it is also transmitted hetereosexually. Correct use of condoms is thought to reduce or eliminate the risk of transmission.
- Individuals with chronic hepatitis B are at an increased risk of developing primary liver cancer.
- Hepatitis C affects approximately 170 million people worldwide. The virus is transmitted primarily by blood and blood products.

Sexual transmission can occur between monogamous couples (rare) but infection is far more common in those who are promiscuous.

In rare cases, Hepatitis C causes acute disease and even liver failure. with cirrhosis from Hepatitis C also bear increased chances of developing primary liver cancer.

**(C) Cirrhosis:** Cirrhosis of the liver commonly occurs in alcoholics, who place the liver in a stress situation due to the amount of alcohol to be broken down. Cirrhosis can cause the liver to become unable to perform its biochemical functions. Chemicals responsible for blood clotting are synthesized in the liver, as is albumin, the major protein in blood. The liver also makes or modifies bile components. Blood from the circulatory system passes through the liver, so many of the body's metabolic functions occur primarily there including the metabolism of cholesterol and the conversion of proteins and fats into glucose. Cirrhosis is a disease resulting fromdamage to liver cells due to toxins, inflammation, and other causes.

Liver cells regenerate in an abnormal pattern primarily forming nodules that are surrounded by fibrous tissue. Changes in the structure of the liver can decrease blood flow, leading to secondary complications.Cirrhosis has many cuses, including alcoholic liver disease, severe forms of some viral hepatitis, congestive heart failure, parasitic infections (for example schistosomiasis), and long term exposure to toxins or drugs.

- **The Pancreas**

The pancreas sends pancreatic juice, which neutralizes the chyme, to the small intestive through the pancreatic duct. In addition to this digestive function, the pancrease is the site of production of several hormones, such as glucagon and insulin.An recently recognized conditionwhich is known as prediabetes, in which the body gradually loses its sensitivity to insulin, leading eventually to Type II diabetesmedications, diet and behavior (in other words EXERCISE!!!) changes are thought to delay if not outright postpone the onset of diabetes if corrected soon enough.

### (D) The Large Intestine

The large intestine is made up by the colon, cecum, appendix, and rectum.Material in the large intestine ismostly indigestible residue and liquid.

Movements are due to involuntary contractions that shuffle contents back and forth and propulsive contractions that move material through the large intestine. The large intestine performs three basic functions in vertebrates:

(1) recovery of water and electrolytes from digested food;
(2) formation and storage of feces; and
(3) microbial fermentation:

The large intestine supports an amazing flora of microbes. Those microbes produce enzymes that can digest many of molecules indigestible by vertebrates. Secretions in the large intestine are an alkaline mucus that protects epithelial tissues and neutralizes acids produced by bacterial metabolism.

Water, salts, and vitamins are absorbed, the remaining contents in the lumen formfeces (mostly cellulose, bacteria, bilirubin). Bacteria in the large intestine, such as E. coli, produce vitamins (including vitamin K) that are absorbed.

## REGULATION OF DIGESTION

The hypothalamus in the brain has two centers controlling hunger. One is the appetite center, the other the satiety center. Gastrin, secretin, and cholecystokinin are hormones that regulate various stages of digestion: The presence of protein in the stomach stimulates secretion of gastrin, which in turn will cause increased stomach acid secretion and mobility of the digestive tract to move food. Food passing into the duodenum causes the production of secretin, which in turn promotes release of alkaline secretions from the pancreas, stops further passage of food into the intestine until the acid is neutralized. Cholecystokinin (CCK) is released fromintestinal epithelium in response to fats, and causes the release of bile from the gall bladder and lipase (a fat digesting enzyme) from the pancreas.

## NUTRITION

Nutrition deals with the composition of food, its energy content, and slowly (or not at all) synthesized organic molecules Chemotrophs are the organisms (mostly bacteria) that derive their energy from inorganic chemical reactions. Phototrophs convert sunlight energy into sugar or other organic molecules. Heterotrophs eat to obtain energy from the breakdown of organic molecules in their food. Macronutrients are foods required on a large scale each day. These include carbohydrates, lipids, and amino acids.Water is essential, correct water balance is a must for proper functioning of the body.

**Carbohydrate :** The diet should contain at least 100 grams of carbohydrate every day. Recently, however, new recommendations have been developed that suggest a lowering of the amount of carbohydrate.

**Protein:** Proteins are polymers composed of amino acids. Proteins are found in meat, milk, poultry, fish, cereal grains and beans. They are needed for cellular growth and repair. Twenty amino acids are found in proteins, of which humans can make eleven. The remaining nine are the essential amino acids which must be supplied in the diet. Normally proteins are not used for energy, however during starvation (or a low-carb diet) muscle proteins are broken down for energy. Excess protein can be used for energy or converted to fats.

**Lipids and fats:** Lipids and fats generate the greatest energy yield, so a large number of plants and animals store excess food energy as fats. Lipids and fats are present in oils, meats, butter, and plants (such as avocado and peanuts). Some fatty acids, such as linoleic acid, are essential and must be included in the diet. When present in the intestine, lipids promote the uptake of vitamins A, D, E, and K.

**Vitamins:** Vitamins are organicmolecules required for metabolic reactions. They usually cannot be made by the body and are needed in trace amounts. Vitamins may act as enzyme cofactors or coenzymes. Some vitamins are soluble in fats, some in water.

**Minerals:** Minerals are trace elements required for normal metabolism, as components of cells and tissues, and for nerve conduction and muscle contraction. They can only be obtained from the diet. Iron (for hemoglobin), iodine (for thyroxin), calcium(for bones), and sodium (nerve message transmission) are examples of minerals. There is a quantitative relationship between nutrients and health. Imbalances can cause disease. Many studies have concluded nutrition is a major factor in cardiovascular disease, hypertension, and cancer.

## DIGESTION IN ANIMALS

## FACTS FROM NCERT

- Starfish feeds on animals covered by half shells of calcium carbonate. After opening the shell, the starfish pops out its stomach through its mouth to eat the soft animals inside the shell. The stomach the goes back into the body and the food is slowly digested.
- The saliva breakdown the starch into sugar.
- Liver situated in the upper part of the abdomen on the right side. It is the largest gland in the body.
- In the process of digestion carbohydrates get broken down into simple sugars such as glucose. Fats into fatty acid and glycerol. Proteins into amino acid.
- Grass eating animals chewing continuously even when they are not eating because they quickly swallow the grass and store it in a separate part of the stomach called rumen. Here the food get partially digested and is called cud, later the cud returns to the mouth in small lumps and the animal chews it. This process is called rumination and these animals are called ruminants.
- The grass is rich in cellulose a type of carbohydrates human cannot digest cellulose.
- Amoeba is a microscopic single celled organism found in pond water. When it sense food, it pushes out one or more finger like projection (pseudopodia) around the food particles and engulf it and then the food becomes trapped in a food vacuole.

| Vitamin/minerals | Deficiency disease/disorder | Symptom |
|---|---|---|
| Vitamin A | Loss of vision Blindness | Poor vision, loss of vision in Night darkness, some time completes loss of vision. |
| VitaminB1 | Beribes | Weak muscles and very little energy to work. |
| Vitamin C | Scurvy | Bleeding gums, wounds take longer time to heal |
| Vitamin D | Rickets | Bones become soft and bent |
| Calcium | Bone and tooth decay | Weak bones, tooth decay |
| Iodine | Goiter | Glands in the neck appear swollen, mental disorder in children. |
| Iron | Anemia | weakness |

## IMPORTANT FACTS FROM HUMAN MACHINE

- Carbohydrates provide energy to our body moreover fats also gives us energy. If we compare, fats give much more energy than the same amount of Carbohydrates.
- Foods Containing proteins are needed for the growth and repair of our body. Foods containing proteins are often called body building foods.
- Vitamin A keeps our skin and eyes healthy vitamin C helps body to fight against many diseases, vitaminD helps our body to use calciumfor bones and teeth.stomach the goes back into the body and the food is slowly digested.
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- Dietary fibres are known as roughage it is mainly provided by plant products in our foods. Whole grains and pulses, potatoes, fresh fruits and vegetable are main sources of roughage. It did not provide any nutrient to our body, but is an essential component of our food and adds to its bulk. This helps our body get rid of undigested food.
- Water helps our body to absorb nutrients from food. It also helps in throwing out some wastes from body as Urine and Sweat.
- Vitamin C gets easily destroyed by heat during cooking.
- Deficiency of one or more nutrients can cause disease or disorders in our boy. Diseases that occur due to lack of nutrients over a long period are called deficiency diseases.

## Digestion in Human and Animals

The food inside the body passes through a continuous canal which begins at the buccal cavity and ends at the anus. The canal can be divided into various Compartments.

(i) Buccal Cavity
(ii) Food pipe or esophagus
(iii) Stomach
(iv) Small intestine
(v) Large intestine ending at the rectum
(vi) Anus

- These parts together form the alimentary canal (digestive tract).
- The inner walls of the stomach and the small intestine and the various glands such as salivary glands, the liver and the pancreas secrete digestive juices.
- The digestive Juices Convert Complex Substances of foods into simpler ones. The digestive tract and the associated glands together constitute the digestive System.
- The Swallowed food passes into the food pipe or esophagus. The food pipe runs along the neck and the chest. Food is pushed down by movement of the wall of the food pipe this movement takes place throughout the alimentary canal and pushes the food downwards.

- The stomach is a thick-walled bag. It shape is like a flattened U and it is the widest part of the alimentary canal. It receives food from the food pipe at one end and opens into the small intestine at the other. 8 The inner lining of the stomach secrets mucous, hydrochloric acid and digestive juices. The mucous protects the lining of the stomach. The acid kills many bacteria that enter along with the food andmakes the mediumin the stomach acidic. The digestive juices break down the proteins into simpler substances.
- The small intestine is highly coiled and is about 7.5 metres long. It receives secretions from the liver and the pancreas. Beside its wall also secretes juices.
- The liver is a reddish brown gland situated in the upper part of the abdomen on the right side. It is the largest gland in the body. It secrets bile juices that is stored in a Sac called the gall bladder. The bile plays an important role in the digestion of fats.
- The pancreas is a large cream coloured gland located just below the stomach. The Pancreatic Juice acts on Carbohydrates and proteins and changes them into simpler forms.
- The partly digested food now reaches the lower part of the small intestinewhere the intestinal juice completes the digestive of all Components of the food.
- The carbohydrates get broken into simple sugars such as glucose, fats into fatty acids and glycerol, and proteins into amino acids.
- The digested food can now pass into the blood vessels in the wall of the intestine. This process is called absorption. The inner walls of the small intestine have thousands of finger-like outgrowths. These are called villi (Singular villus)
- The villi increased the surface area for absorption of the digested food. Each villus has a network of thin and small blood vessels close to its surface. The surface of the villi absorbs the digestive food materials.
- The absorbed substances are transported via the blood vessels to different organs of the body where they are used to build Complex Substance such as the proteins required by the body. This is called assimilation.
- In the cells, glucose breaks down with the help of oxygen into Carbon dioxide and water, and energy is released. The food that remains under undigested and unabsorbed then enters into the large intestine.
- The large intestine is wider and shorter than small intestine. It is about 1.5 meter in length. Its function is to absorb water and some salts from the undigested food material.
- The remaining waste passes into the rectum and remains there as semi-solid faces. The faecal matter is removed through the anus from time to time. This is called egesting.
- Cows, buffaloes and other grass-eating animals chew continuously even when they are not eating grass. Actually, they quickly swallow the grass and store it in a separate part of the stomach called rumen.
- Here the food gets partially digested and is called cud. But later the cud returns to the mouth in small lumps and the animal chews it. This process is called rumination and these animals are called ruminants. The grass is rich in cellulose, a type of carbohydrate. Many animals, including humans, cannot digest cellulose.
- Ruminants have a large Sac-like structure between the small intestine and large intestine. The cellulose of the food is digested here by the action of certain bacteria which are not present in humans.
- Amoeba ismicroscopic single-cell organismfound in Pond water. Amoeba has a cell membrane, a rounded, dense nucleus and many small bubble— like vacuoles in its cytoplasm.
- Amoeba constantly changes its shape and position. It has one, or more finger–like projections called pseudopodia or false feet for movement and capture of food.
- Digestive juices are secreted into the food vacuole. They act on the food and break it down into simpler substances. Gradually the digested food is absorbed. The absorbed substances are used for growth, maintenance and multiplication. The undigested residue of the food is expelled outside by the vacuole.