CONTENTS

MATTER IN OUR SURROUNDINGS

INTRODUCTION There are a large number of things around us which we see and feel. For example, we can see a book in front of us. A book occupies some space. The space occupied by the book is called it **volume.** If we pick up the book, we can also feel its weight. So, we conclude that the book has some **mass.** We cannot see the air around us, yet if we fill a balloon with air and then weight it carefully, we will find that not only does air occupy space (bounded by the balloon), but is also has mass.

Things like a book and air are examples of matter. Other examples of matter are wood, cloth, paper, ice, steel, water, oil etc. Further, that matter offers resistance is borne out by the fact that we cannot displace an object from one place to another without applying some force. We have to apply force to pick up a stone from the ground. Thus, matter can be defined as follows -

Anything that occupies space, has mass and offer resistance is called matter.

SUBSTANCE : A substance is a kind of matter that cannot be **separated** into other kinds of matter by any physical process. For example, sugar dissolved in water can be separated from water by simply evaporating the water. Here sugar is a substance which cannot be broken into its components by any physical process.

PHYSICAL NATURE OF MATTER

(a) Matter is Made up of Particles :

(i) Everything around us is made up of many **tiny** pieces or particles.

(ii) Particles which make up the matter are constantly **moving.**

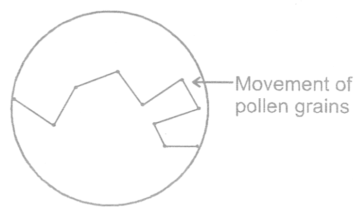
(iii) Particles which make up mater are atoms or molecules.

(i) Evidences for the presence of particles is matter : Most of the evidences for the existence of particles in matter and their motion come from the experiments of **diffusion and Brownian motion.**

(A) Dissolving a solid in a liquid : Potassium permanganate is a purple coloured solid substance and water is a liquid. We will take 2 - 3 crystals of potassium permanganate and dissolve them in 100 ml of water. Now we will take out 10 ml of this solution and put into another 90 ml of clear water. We will keep diluting the solution like this 5 to 8 times.

(B) Conclusion : This experiments shows that just a few crystals of potassium permanganate can colour a large volume of water. It means a crystal of $KMnO_4$ is made up of millions of tiny particles. They keep dividing themselves into smaller and smaller particles. Particles of $KMnO_4$ and particles of water spread into each other, it means they are moving. This movement of different particles among each other, so that they become mixed uniformly, is called diffusion.

(ii) Movement of pollen grains in water : The best evidence for the existence and movement of particles in liquids was given by **Robert Brown** in 1827. Robert Brown suspended extremely small pollen grains in water. On looking through the microscope, it was found that the pollen grains were moving rapidly throughout water in a very irregular way (**or zig - zag way).**



(A) Brownian motion : Zig - zag motion (in a very irregular way) of particles is known as Brownian motion. Brownian motion can also be observed in gases. Sometimes, when a beam of light enters a room, we can see tiny dust particles suspended in air which are moving rapidly in a very random way. This is an example of Brownian motion in gases. The tiny dust particles move here and there because they are constantly hit by the fast moving particles of air.

- Matter is made up of tiny particles.
- Particles of matter are constantly moving.

Brownian motion increases on increasing the temperature.

(b) Characteristics of Particles of Matter :

The important characteristics of particles of matter are the following :

(i) The particles of matter are very, very small : It can be explained by performing the following experiment. We will dissolve 2 or 3 drops of indigo dye in 100 ml of water. We will get a deep blue coloured solution. Now we will keep diluting the solution and we will observe that intensity of blue colour of indigo dye solution goes on decreasing.

(ii) The particles of matter have spaces between them :

(A) Experiment : We take about 100 ml of a water in a beaker and mark the level of water. We will also take 50 g of sugar. Now we will dissolve the sugar by stirring and we get 3 sugar solution.

(B) Conclusion : The level of sugar solution in the beaker is at the same mark where water level was initially in the beaker.

It shows that particles sugar go into the spaces between various molecule of water due to which there is no change in the volume. Thus, from this experiment it can be concluded that, the molecules in water are not tightly packed, they have spaces between them.

(iii) The particles of matter are constantly moving : This property can be explained by diffusion.

(A) Diffusion : "*Intermixing of particles of two different types of matter on their own is called diffusion.*" It is the phenomenon in which the movement of molecules or particles occur from their higher concentration towards their lower concentration.

e.g. : When a perfume bottle is opened in one corner of a room, its fragrance spreads in the whole room quickly. This happens because the particles of perfume move rapidly in all directions and mix with the moving particles of air in the room.

The particles of matter possess kinetic energy and so are constantly moving. As temperature rises, particles move faster.

(iv) Particles of matter attract each other : There are some forces of attraction between the particles of matter which bind them together.

(A) Cohesive Force : *The force of attraction between the particles of different substances is called adhesive force.*

e.g. : If we take a piece o chalk, a cube of ice and an iron nail and beat them with a hammer, chalk will easily break into smaller pieces, but more force will be required to break a cube of ice and iron nail will not break.

Reason : The reason for this is that force of attraction is quite weak in between the chalk particles, but force of attraction in between the particles of ice cube is a bit stronger, while force of attraction in between the particles of iron is very-very strong.

RIGID AND FLUID

(i) Rigid : Rigid means 'unbending' or inflexible. A solid is a rigid form of matter so that it maintains its shape when subjected to outside force.

(ii) Fluids : Fluids are the substances which have tendency to flow. A liquid is a fluid form of mater which occupies the space of the container. Liquids have a well defined surface.

A gas is a fluid form of matter which fills the whole container in which it is kept.

Liquid and gases are known as fluids.

CLASSIFICATION OF MATTER

On the basis of physical states, all matter can be classified into three groups :-

(a) Solids (b) Liquids (c) Gases

(a) Solids :

A solid is that state of matter which has definite shape, mass and volume.

e.g. : Ice, wood, coal, iron etc.

(i) Properties :

- Solids have a definite mass and definite volume.
- Solids have a definite shape.
- Solids have negligible compressibility.
- Solids have high densities.
- The intermolecular forces in solids are very strong.
- The dimensions of solid do not increase in large proportion on heating or cooling.
- Solids diffuse into one another very slowly.

(b) Liquids :

A liquid is a state of matter which has definite mass and volume but no definite shape.

e.g. : Water, alcohol, milk, mercury etc.

(i) Properties :

- Liquid have a definite mass and volume.
- Liquid do not have a definite shape.
- Liquids are slightly more compressible than that of solids.
- Density of liquids is lesser than that of solids.
- The force of attraction between the molecules of liquids is less than that of solids.
- Liquids expands far more than solids on heating.
- The particles of two different liquids can diffuse is one another easily.

(c) Gases :

A gas is a state of matter, which has definite mass, but no definite shape and no definite volume.

e.g. : O_2, N_2, H_2 etc.

(i) Properties :

- A gas contained in a vessel has a definite mass.
- Gases do not have definite shape and volume.
- Gases are highly compressible because intermolecular spaces between them are very - very large as compared to solids and liquids.
- Density of gases is extremely small as compared to solids and liquids.
- Intermolecular forces are negligible.
- Gases expands to large extent when heated.
- The gases diffuse in one another rapidly to form homogeneous mixture.

Comparison of the characteristics of three states of matter.

S.No.	Property	Solid state	Liquid state	Gaseous state
1	Interparticle spaces	Very small spaces	Comparatively large spaces	Very large spaces
2	Interparticles forces	Very strong	Weak	Very weak
3	Nature	Very hard and rigid	Fluid	Highly fluid
4	Compressibility	Negligible	Very small	Highy compressible.
5	Shape and volume	Definite shape and volume	Indenfinite shape, but definite volume	Indefinite shape as well as volume
6	Density	High	Les than the density in solid state	Very low density
7	Kinetic energy	Low	Comparatively high	Very high
8	Diffusion	Negligible	Slow	Very fast

(d) Gases are Highly Compressible therefore :

(i) LPG (Liquefied Petroleum Gas) is used in our home for cooking.

(ii) Oxygen cylinders supplied to hospitals contain liquid oxygen.

(iii) C.N.G. (Compressed Natural Gas) is used a fuel these days in vehicles.

Gaseous particles move randomly at high speed and hit each other and also walls of the container, so exert pressure.

EXERCISE

OBJECTIVE DPP - 1.1

1. The quantity of matter present in an object is called its -

(A) weight (B) volume (C) mass (D) Density

2. Which of the following is/are rigid(s) ?

(A) Solids (B) Liquids (C) Gases (D) Both (B) and (C)

3. Which of the following statements is/are correct ?

(A) Intermolecular forces of attraction is solids are maximum.

(B) Intermolecular forces of attraction is gases are minimum.

(C) Intermolecular spaces in solids are minimum.

(D) All of the above

4. What happens to the volume of the solution when small amount of sugar is dissolved in it ?

(A) Volume will increase. (B) Volume will decrease.

(C) Volume first increases then decreases. (D) No change in volume.

5. Which of the following is not correct for gases ?

(A) Gases have definite mass. (B) Gases have definite shape.

(C) Gases have definite volume (D) Both (B) and (C)

6. Which of the following is not an example of matter ?

(A) Air (B) Feeling of cold (C) Dust (D) None of these

7. Which of the following statements is correct ?

(A) Interparticle spaces are maximum in the gaseous state of a substance.

(B) Particles which constitute the matter follow a zig-zag path.

(C) Solid state is the most compact state of substance.

(D) All are correct

8. Which out of the following does not make sense.

(A) Solids have fixed shape and fixed volume.

(B) Liquids can be compressed easily, but not gases.

(C) The particles of solids have negligible kinetic energy.

(D) Property of diffusion is maximum in the gaseous state.

9. Which of the following is/are application(s) of high compressibility of gases ?

(A) L.P.G. is used as fuel in homes for cooking food.

(B) Oxygen cylinders are supplied to hospitals.

(C) C.N.G. is used as fuel in vehicles.

(D) All of these

10. Which of the following statements does not go with the liquid state ?

(A) Particles are loosely packed in the liquid state.

(B) Fluidity is the maximum in the liquid state.

(C) Liquids can be compressed.

(D) Liquids take up the shape of any container in which these are placed.

SUBJECTIVE DPP - 1.2

1. What is Brownian motion ?

2. Why do gases diffuse very fast ?

3. Arrange the following substances in the increasing order of interparticle forces. Water, common salt, nitrogen.

4. Out of solid, liquid and gas, which has -

(a) maximum interparticle spaces. (b) maximum particle motion.'

(c) definite volume but no definite shape. (d) least diffusion of the particles.

5. Give four characteristics associated with the gaseous state.

6. What is common in the three states of matter ?

7. A certain substance 'A' can be compressed to very less extent, but takes up the shape of any container in which it is placed. What will be its physical state ?

8. Solids are generally very heavy while gases are light. Explain.

MATTER IN OUR SURROUNDINGS

CL - 2

INTERCONVERSION OF STATES OF MATTER

The phenomenon of change of mater form one state to another state and back to original state, by altering the conditions of temperature and pressure, is called interconversion of matter.

The various states of matter can be interchanged into one another by altering the conditions of -

(a) Temperature (b) Pressure.

(a) Altering the Temperature of Matter :

(i) Interconversion of solid into liquid and vice versa : The solids can be converted into liquids by heating them. Similarly liquids can be cooled to form solids.

e.g. : Ice at 0^0C changes into water at 0^0C, when heat energy is supplied to it. The water at 0^0C changes into ice at 0^0C on freezing.

(A) Melting or Fusion : The process due to which a solid changes into liquid state by **absorbing heat energy** is called melting or fusion.

(B) Freezing or Solidification : The process due to which a liquid changes into solid state by **giving out heat energy** is called freezing or solidification.

(C) Melting Point : The constant temperature at which a solid changes into liquid state by absorbing heat energy is called it melting point.

(D) Freezing Point : The constant temperature at which a liquid changes into solid state by giving out heat energy is called freezing point.

The numerical value of freezing point and melting point is same. Melting point of ice = Freezing point of water = 0^0c (273.16 k).

Explanation : On increasing the temperature of solids, the kinetic energy (K.E.) of particles increases. Due to increases in K.E., the particles start vibrating with greater speed. The energy supplied by heart **overcomes the force of attraction** between the particles. Then, the particles leave their fixed positions and start moving freely and thus solid melts.

Latent Heat of Fusion : The amount of heat energy that is required to change 1 kg of solid into liquid at atmospheric pressure and its melting point is known as the latent heat of fusion. (In Greek Latent means Hidden)

Latent heat of fusion of ice = 3.34×10^5 J/kg.

Particles of water at 0^0C (273 K) have more energy as compared to particles in ice at the same temperature.

(ii) Interconversion of liquid into gaseous state and vice versa : Liquids can be converted into gases by heating them. Similarly, gases can be converted into liquids by cooling them.

e.g. : Water at normal pressure changes into gas (steam) at 100^0C by absorbing heat. Steam at 100^0C changes into water by giving out energy.

(A) Boiling or Vaporisation : The process due to which a liquid changes into gaseous state by **absorbing heat energy** is called boiling.

(B) Condensation or Liquefaction: The process due to which a gas changes into liquid state by **giving out heat energy** is called condensation.

(C) Boiling point : The constant temperature at which a liquid rapidly changes into gaseous state by absorbing heat energy at atmospheric pressure is called boiling point.

(D) Condensation Point : The constant temperature at which a gas changes into liquid state by giving out heat energy at atmospheric pressure is called condensation point.

The numerical value of condensation point and boiling point is same. Condensation point of vapour (water) = Boiling point of water = 100^0C (373 K).

Explanation : When heat is supplied to water, particles start moving faster. At a certain temperature, a point is reached when the particles have enough energy to **break the forces of attraction between** the particles. At this temperature the liquid starts changing into gas.

Latent heat of vaporisation : The amount of heat which is required to convert 1 kg of the liquid (at its boiling point) to vapour or gas **without any change** in temperature. Latent heat of vaporisation of water = 22.5×10^5 J/kg.

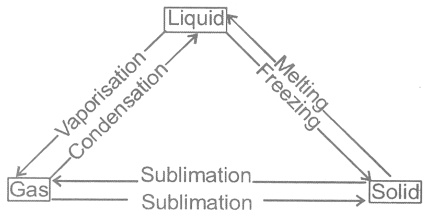
Particles in steam, that is water vapour at 373 K have more energy than water at the same temperature. Because steam have absorbed extra energy in the form of latent heat of vaporisation.

(iii) Direct interconversion of solid into gaseous state and vice versa : The changing of solid directly into vapours on heating and of vapours directly into solid on cooling is known as sublimation.

• The solid which undergoes sublimation is called **'sublime'.**

• The solid obtained by cooling the vapours of a solid is called '**sublimate'.**

e.g. : Ammonium Chloride (NH_4Cl), iodine, camphor, naphthalene (moth balls) and anthracene.



Interconversion of states of matter

EXERCISE

OBJECTIVE DPP - 2.1

1. On changing which of the following, the states of matter can be changed ?

(A) Temperature (B) Pressure (C) (A) & (B) both (D) None of these

2. Melting & freezing point of water -

(A) are same (B) have large difference between them.

(C) have close difference between them. (D) None of these

3. The boiling point of alcohol is 78^0C. What will be the temperature in Kelvin scale ?

(A) 373 K (B) 351 K (C) 375 K (D) 78 K

4. Latent heat of vaporisation of water is -

(A) 2.25×10^2 J/kg (B) 22.5×10^5 J/kg (C) 3.34×10^5 J/kg (D) 33.4×10^2 J/kg

5. S.I. unit of temperature is -

(A) Kelvin (B)Celsius (C) Both (D) None

6. In sublimation process -

(A) solid changes into liquid (B) liquid changes into gas.

(C) solid changes directly into gas. (D) None of these

7. When a liquid starts boiling, the further heat energy which is supplied -

(A) is lost to the surrounding as such.

(B) increasing the temperature of the liquid.

(C) increases the kinetic energy of the liquid.

(D) is absorbed as latent heat of vaporisation by the liquid.

8. 10^0C temperature is equal to -

(A) 163 K (B) 10 K (C) 183 K (D) 283 K

9. Which of the following will respond to sublimation ?

(A) Common salt (B) Sugar (C) Camphor (D) Potassium nitrate

10. Solids cannot be compressed because -

(A) constituent particles are very closely packed.

(B) interparticle attractive forces are weak.

(C) movement of constituent particles is restricted.

(D) constituent particles diffuse very slowly.

SUBJECTIVE DPP - 2.2

1. Define condensation.

2. What is latent heat of fusion ?

3. Name one property which is shown by naphthalene and not by sodium chloride.

4. Are the melting point of solid and the freezing point of liquid same or different.

5. The melting point of a substance is just below the room temperature. Predict its physical state.

6. When a solid melts, its temperature remains the same, so where does the heat energy go ?

7. Discuss the significance of the boiling point of liquid.

8. Explain the interconversion of states of matter.

➤➤➤ MATTER IN OUR SURROUNDINGS ◀◀◀

CL - 3

BY ALTERING PRESSURE

The difference in various states of matter is due to the different intermolecular spaces between their particles. So when a gas is compressed the intermolecular space between its particles decreases and ultimately it will be converted into liquid.

Pressure and temperature determine the state of a substance. So, high pressure and low temperature can liquefy gases.

e.g. : Carbon dioxide (CO_2) is a gas under normal conditions of temperature and pressure. It can be liquefied by compression it to a pressure 70 times more than atmospheric pressure.

Solid CO_2 is known as **'Dry ice'.** Solid CO_2 is extremely cold and used to 'deep freeze' food and to keep ice - cream cold.

Unit of pressure :

Atmosphere (atm) is a unit of measuring pressure exerted by a gas.

The unit of pressure is Pascal (Pa.)

1 atm = 1.01 × 10.5 Pa.

When pressure is lowered the boiling point of liquid is lowered. This helps in rapid change of liquid into gas.

EVAPORATION

The phenomenon of change of a liquid into vapours at any temperature below its boiling point is called evaporation.

Water changes into vapours below 100^0C. The particles of matter are always moving and are never at rest.

At a given temperature in any gas, liquid or solid, there are particles with different K.E.

In case of liquids, a small fraction of particles at the surface, having higher K.E., is able to break the forces of attraction of other particles and gets converted into vapour.

The atmospheric pressure at sea level is 1 atm.

(a) Factors affecting Evaporation :

(i) Temperature : With the increase in temperature the rate of evaporation increases.

$$\text{Rate of evaporation} \propto T$$

Reason : On increasing temperature more number of particles get enough K.E. to go into the vapour sate.

(ii) Surface Area : Rate of evaporation $\propto$ Surface area

Since evaporation is a surface phenomena, if the surface area is increased, the rate of evaporation increases. So, while putting clothes for drying up we spread them out.

(iii) Humidity of Air : Rate of evaporation $\propto \frac{1}{\text{Humidity}}$

Humidity is the amount of water vapour present in air. When humidity of air is low, the rate of evaporation is high and water evaporates more readily. When humidity of air is high, the rate of evaporation is low and water evaporates very slowly.

(iv) Wind Speed : Rate of evaporation $\propto$ Wind speed

With the increase in wind speed, the particles of water vapour move away with the wind. So the amount of water vapour decrease in the surroundings.

(v) Nature of substance : Substances with high boiling points will evaporate slowly, while substance with low boiling points will evaporate quickly.

Difference between evaporation and boiling

S.No.	Evaporation	Boiling
1	It is a surface phenomenon.	It is a bulk phenomenon.
2	It occurs at all temperatures below B.P.	It occurs at B.P. only.
3	It leaves the cooling effect.	It increases the temperature.

(b) Cooling Causes by Evaporation :

The cooling caused by evaporation is based on the fact that when a liquid evaporates, it draws (or takes) the **latent heat of vaporisation** from 'anything' which it touches.

For example :

- If we put a little of spirit (ether or petrol) on the palm of our hand then our hand feels very cold.
- Perspiration (or sweating) is our body's method of maintaining a constant temperature.

(c) We Wear Cotton Clothes in Summer :

During summer, we perspire more because of the mechanism of our body which keeps us cool. During evaporation, the particles at the surface of liquid gain energy from the surroundings or body surface. The heat energy equal to latent heat of vaporisation is absorbed from the body leaving the body cool. Cotton, being a good absorber of water helps in absorbing the sweat.

(d) Water droplets on the outer surface of a glass containing ice cold water :

If we take some ice cold water in a tumbler then we will observe water droplets on the outer surface of tumbler.

Reason : The water vapour present in air on coming in contact with cold glass of water, loses energy. So water vapour gets converted to liquid state, which we see as water droplets.

PLASMA

This state consist of super energetic and super excited particles. These particles are in the form of ionised gases.

For e.g : neon sign bulb and fluorescent tube

Neon sign bulb - Neon gas

Fluorescent tube - Helium gas

When electrical energy flows through gas, it gets ionised and hence plasma is created. Plasma glows with a special colour depending on nature of gas. Sun and the stars glow because of the pressure of plasma.

BOSE - EINSTIEN CONSENSATE (B.E.C.)

The B.E.C. is formed by cooling a gas of extremely low density, about one-hundred - thousandth the density of normal air, to super low temperature.

EXERCISE

OBJECTIVE DPP - 3.1

1. Dry ice means -

(A) solid ammonia (B) solid carbon dioxide

(C) solid sulphur dioxide (D) normal ice

2. On a hot humid day rate of evaporation -

(A) is more (B) is less

(C) initially more, later on less (D) remains same.

3. During evaporation, particles of a liquid change into vapours only -

(A) form the surface. (B) from the bulk.

(C) from both surface and bulk. (D) neither from surface nor from bulk.

4. Rate of evaporation depends upon -

(A) temperature (B) surface area (C) humidity (D) All of these

5. Pressure of air at sea level is -

(A) one atmosphere (B) 76 cm of Hg (C) 760 mm of Hg (D) All of these

6. One atmosphere is equal to -

(A) 1.01×10^5 Pa (B) 3.46×10^4 Pa (C) 1 Pa (D) 10 Pa

7. During evaporation of liquid -

(A) the temperature of the liquid falls.

(B) the temperature of the liquid rises.

(C) the temperature of the liquid remains unchanged.

(D) all statements are wrong.

8. As temperature increases rate of evaporation -

(A) increases (B) decreases.

(C) first increases, then decreases. (D) remains same.

9. A gas can be best liquefied -

(A) by increasing the temperature.

(B) by lowering the pressure.

(C) by increasing the pressure and reducing the temperature.

(D) None of these is correct.

10. In which phenomenon water changes into water vapour below its boiling point ?

(A) Evaporation (B) Condensation

(C) Boiling (D) No such phenomena exists

SUBEJCTIVE DPP - 3.2

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1. What is relation between pressure in atmospheres and pressure in pascals ?

2. Distinguish between boiling and evaporation.

3. Explain how gases can be liquefied ?

4. Clothes dry fast on a windy day. Why ?

5. Explain the factors affecting the rate of evaporation.

6. Why do we sweat more on a humid day ?

7. What is the purpose of sipping coffee from a saucer instead of sipping from a glass or cup ?

8. Why do we normally prefer cotton clothes during summer ?

ANSWER KEY

(OBJECTIVE DPP - 1.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	C	A	D	D	D	B	D	B	D	B

(SUBJECTIVE DPP - 1.2)

Sol.6 All of them occupy space and have mass.

Sol.7 The physical state of the substance 'A' is a liquid.

Sol.8 In the solids, the particles are very closely packed. As a result, the number of particles per unit volume is quite large. Therefore, the solids are normally quite heavy. In the gases, the particles are loosely packed. The number of particles per unit volume is comparatively small, Therefore, gases are light.

(OBJECTIVE DPP - 2.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	C	A	B	B	A	C	D	D	C	A

(SUBJECTIVE DPP - 2.2)

Sol.3 naphthalene undergoes sublimation upon heating and directly changes into vapours. Sodium chloride (common salt) does not undergo sublimation. It melts on strong heating.

Sol.4 Same

Sol.5 Liquid

Sol.7 The boiling point of the liquids help is comparing the magnitude or strength of the interparticle or intermolecular forces present in them. Greater these forces, more will be the boiling point of the liquid.

(OBJECTIVE DPP - 3.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	B	B	A	D	D	A	A	A	C	A

(SUBJECTIVE DPP - 3.2)

Sol. 1 atm = 1.01×10^5 Pa

IS MATTER AROUND US PURE

PURE SUBSTANCE

A **homogeneous** material which contains particles of **only one kind** and has a definite set of properties is called a **pure substance.**

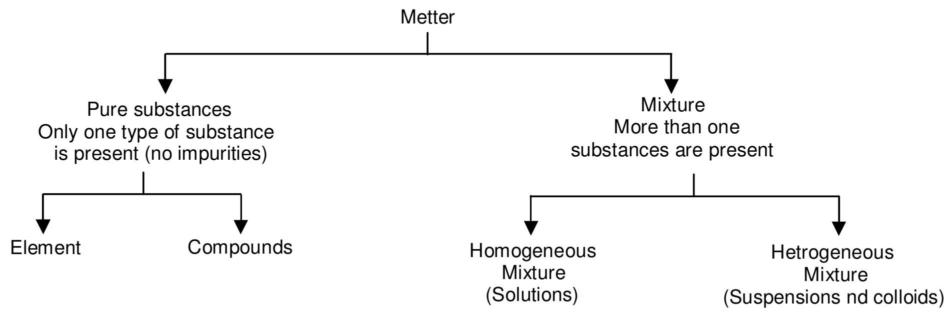
Example : Iron, silver, oxygen, sulphur, Carbon dioxide etc., are pure substances because each of them has only one kind of particles.

(a) Characteristics of A Pure Substance :

(i) A pure substance is **homogeneous in nature.**

(ii) A pure substance **has a definite set of properties.** These properties are **different** from the properties of **other substances.**

(iii) The composition of a pure substance ***cannot be altered*** by any physical means.



(b) Elements :

A pure substance, which cannot be subdivided into two or more simpler substances by any chemical means is called an **element.**

(i) Example : Hydrogen, oxygen, nitrogen, copper, zinc, tin, lead, mercury, etc. are all elements as they cannot be subdivided into simpler parts by any **chemical means.** A substance made up of the atoms with same atomic number is called an **element.**

(ii) Classification of elements :

(A) On the basis of **physical states,** all elements can be classified into three groups :-

(1) Solids **(2)** Liquids **(3)** Gases

It has been found that :

- Two element exist as **liquids** at room temperature. They are **mercury and bromine.**
- Eleven elements exist as **gases** at room temperature. They are hydrogen, nitrogen, oxygen, fluorine, chlorine, helium, neon, argon, krypton, xenon and radon.
- Remaining 102 elements are **solids** at room temperature.

(B) Elements can be classified as **metals and non - metals.** There are 22 non - metals and 93 metals.

- amongst the metals, only **mercury is liquid metal.** All other metals are solids.
- Amongst the 22 non - metals : 10 non - metals are **solids.** They are boron, carbon, silicon, phosphorus, sulphur, selenium, arsenic, tellurium, iodine and astatine. 1 non-metal, **bromine,** is a liquid. Find non-metals, *hydrogen, nitrogen, oxygen, fluorine* and *chlorine* are **chemically active gases.** Six non-metals, helium, neon, argon, krypton, xenon and radon are **chemically inactive gases.** These are also called **noble gases** or **rare gases.**

MATALLOIDS :

There are a few elements which show some properties of metals and other properties of non - metals. For example they look like metals but they are brittle like non - metals. They are neither conductors of electricity like metals nor insulators like non-metals, they are semiconductor. The elements which show some properties of metals and some other properties of non-metals are called metalloids. Their properties are intermediate between the properties of metals and non-metals. Metalloids are also sometimes called semi-metals. The important examples of metalloids are : Boron (B), Silicon (SI) and Germanium (Ge).

Hydrogen is the lightest element.

(C) Elements can be classified as **normal elements** and **radioactive elements.** The elements which do not give out harmful radiations are called **normal elements.** Elements from atomic number 1 to atomic number 82 are normal elements. The elements which given out harmful radiation are called **radioactive elements.** Elements from atomic number 83 to atomic number 112 and 114, 116 and 118 are radioactive in nature.

(c) Compounds :

A pure substance, which is composed of **two or more elements, combined chemically in a definite ratio,** such that it can be broken into elements only by **chemical means** is called **compound.**

The two or more elements present in a compound are called **constituents or components** of the compound. For example, **water** is a compound of hydrogen and oxygen, combined together in the **ratio of 1 : 8 by weight.** The water can be broken into its **constituents** only by **electro-chemical method,** i.e., by passing electric current through it.

The compounds can be further classified as acids, bases and salts. Sulphuric acid, nitric acid, hydrochloric acid, formic acid, etc. are the compounds which can be classified as acids.

Sodium hydroxide, potassium hydroxide, zinc hydroxide and calcium hydroxide can be classified as bases. Ammonium chloride, zinc sulphate, lead nitrate and calcium carbonate can be classified as salts. It must be pointed out that salts are formed by the chemical reaction between acids and bases.

MIXTURES

Most of the materials around us are not pure substances, but contain more than one substances, elements or compounds. Such materials are called **mixtures.**

(a) Definition :

When two or more substances (elements, compounds or both) are mixed together in any proportion, such that they do not undergo any chemical change, but retain their individual characteristics, the resulting product is called a **mixture.**

(b) Types of Mixture :

(i) Homogeneous Mixture : A mixture in which different constituents are mixed uniformly is called a homogeneous mixture.

Examples : All solutions, such as solutions of common salt, copper sulpahte, sugar etc. are examples of homogeneous mixtures. Similarly, alloys such as brass, bronze etc. are homogeneous solid solutions of metals.

(ii) Heterogeneous Mixture : A mixture in which different constituents are not mixed uniformly is called a heterogeneous mixture.

Example : A mixture of sand and salt, iron powder and sulphur powder, soil etc. are examples of heterogeneous mixtures.

DIFFERENCES BETWEEN MIXTURES AND COMPOUNDS.

Mixtures	Compounds
1. Nature In a mixture, two or more elements or compounds are mixed, such that they do not combine chemically.	**1. Nature** In a compound, two or more elements unit chemically.
2. Structure Mixture does not have a definite structure.	**2. Structure** Compounds have a definite structure.
3. Composition In case of mixture, their constituents can be present in any ratio, i.e., they have variable composition.	**3. Compositions** In case of a compound the constituents are present in a fixed ratio by weight.
4. Properties The constituents of a mixture retain their individual physical and chemical properties.	**4. Properties** The properties of a compound are entirely different from the properties of its constituents.
5. Separation of constituents The constituents of a mixture can be separated by physical means.	**5. Separation of constituents** The constituents of a compound can not be separated by physical means.
6. Energy changes During the formation of mixtures, no energy changes take place, i.e., it is a result of physical change.	**6. Energy changes** During the formation of a compound energy is either absorbed or released, i.e., compound is the result of a chemical change.

REASONS FOR REGARDING AIR AS A MIXTURE

(i) Composition of air is not same at all places. The percentage of oxygen decreases in the air at higher altitudes. Similarly, the air in industrial areas has more amount of carbon dioxide gas and other polluting gases as compared to air in the countryside.

(ii) The main constituents of air can be separated by physical methods, such as liquefaction and **fractional distillation.**

(iii) No chemical action takes place when the constituents of air, i.e., *oxygen, nitrogen, water vapour and carbon dioxide are* mixed. Thus, no heat or light energy is evolved or absorbed, when its constituents are mixed.

(iv) Each of the constituent of air retains its physical and chemical properties. For example, oxygen helps in combustion, carbon dioxide lowly turns limewater milky, etc.

REASONS FOR REGARDING WATER AS A COMPOUND.

(i) The composition of pure water is same throughout. It always contains one part of hydrogen and eight parts of oxygen by weight.

(ii) The constituents of water cannot be separated by **physical means.** However, by electrochemical means water can be decomposed into hydrogen and oxygen.

(iii) Chemical reaction takes place with the liberation of heat and light energy when one part of hydrogen combines with the eight parts of oxygen by weight.
(iv) The properties of water are entirely different from the properties of its constituents. For example, hydrogen is a combustible gas, oxygen in supporter of combustion, but their compound water extinguishes fire.

REASONS FOR REGRDING ALLOYS AS MIXTURES

Though the alloys are **homogeneous** mixture of metals which cannot be separated by any physical means, yet they are regarded mixtures on account of the following reasons :
(i) The composition of constituent metals can be varied in an alloy. For example, **brass** is an alloy of **copper and zinc.** If an alloy has 60% of copper and rest of zinc or 58% of copper and rest of zinc, in either case it is brass.
(ii) The individual metals in any alloy retain their chemical and physical properties. For example, if brass is treated with dilute sulphuric acid, then zinc in it reacts to form zinc sulphate and hydrogen, but copper does not react

SOLUTIONS

A homogeneous mixtures of two or more substance is called **a solution.** Usually we think of a solution as a liquid that contains either a solid or a liquid or a gas dissolved in it. However, this is not true. We can also have a solid have a solid solution as in the case of alloys.

(a) Components of a Solution :

The substances present in a homogeneous solution are called components of the solution. A solution basically has two components, i.e., a **solvent** and a **solute.**

(i) **Solvent :** The component of a solution which is present in large proportion, is called **solvent.**

Usually, a solvent is the LARGER component of the solution.

For example : In the solution of copper sulphate in water, **water** is the solvent. Similarly, in paints, turpentine **oil** is the solvent.

(ii) Solute : The component of the solution which is present is small proportion is called **solute.**

For example : In the solution of common salt in water, the **common salt** is solute. Similarly, in carbonated drinks (soda water), **carbon dioxide** gas in the solute.

Usually, solute is the SMALLER component of the solution.

(b) Examples of Solutions :

(i) Solid - Solid solutions : All alloys are solid solutions of metals. Brass is a solid solution of approximately 30% of zinc and 70% of copper. In this solid solution, copper (larger component) is solvent and zinc (smaller component) is solute. Similarly, Bell Metal is a solid solution of 80% of copper and 20% of tin, in which copper is the solvent and tin is the solute.

(ii) Solid - Liquid solutions : Sugar solution is an example, in which sugar is the solute and water is the solvent. Similarly, common salt solution is an example, in which common salt is the solute and water is the solvent. In case of tincture of iodine, iodine is the solute and ethyl alcohol is the solvent.

(iii) Liquid - Liquid solutions : In case of an alcoholic drink, ethyl alcohol is solute and water is solvent. Similarly, in case of vinegar, acetic acid is solute and water is solvent.

(iv) Liquid - Gas solutions : In case of aerated drinks (soda water), carbon dioxide is the solute and water is the solvent.

(v) Gas - Gas solutions : Air is a homogeneous mixtures of two main gases, i.e., 78% of nitrogen and 21% of oxygen. In this mixture, nitrogen is solvent and oxygen is solute. Similarly, the petrol fed into the engines of automobiles is a mixture of petrol vapour and air.

(c) Types of Solution :

(i) Saturated solution : A solution, which at a given temperature dissolves as much solute as it is capable of dissolving, is said to be a saturated solution.

(ii) Unsaturated solution : When the amount of solute contained in a solution is less than the saturation level, the solution is said to be an unsaturated solution.

(iii) Super saturated solution : A solution, which contains more of the solute than required to make a saturated solution, is called a super saturated solution.

TRUE SOLUTION

A solution in which particles of the solute are broken down to such a fine state, that they cannot be seen under a powerful microscope is called a **true solution.**

(a) Characteristics of a True Solution :

(i) A true solution is always clear and transparent, i.e., light can easily pass through it without scattering.

(ii) The particles of a solute break down to almost molecular size and their diameter is of the order of **1 nm (10^{-9} m)** or less.

(iii) A true solution can completely pass through a filter paper as particle size of solute is far smaller than the size of pores of filter paper.

(iv) A true solution is **homogeneous** in nature.

(v) In a true solution, the particles of solute do not settle down, provided temperature is constant.

(vi) From a true solution, the solute can easily be recovered by evaporation or crystallisation.

(b) Concentration of a Solution :

It is defined as the *amount of solute present* in a given quantity of the solution. The most common method for expressing the concentration of a solution is called **percentage method.** The concentration of solution refers to the **percentage of solute** present in solution. Furthermore, the percentage of solute can be expressed in terms of :

(i) mass of the solute

(ii) volume of the solute.

(i) Concentration of a solution in terms of mass percentage of solute : If a solution is formed by dissolving a solid solute in a liquid solvent then the concentration of solution is expressed in terms of **mass percentage of solute** and is defined as under :

The concentration of solution is the mass of the solute is grams, which is present in 100 g of a solution.

It is very important to keep in mind that the percentage concentration of a solution refers to mass of solute in 100 g of solution and not 100g of solvent, i.e., water.

The concentration of a solution in terms of mass percentage of solute is calculated by the formula given below :

Concentration of solution $= \dfrac{\text{Mass of solute (in grams)}}{\text{Mass of solution (in grams)}} \times 100$

$$= \frac{\text{Mass of solute (in grams)}}{[\text{Mass of solute + Mass of solvent}]\,(\text{in grms})} \times 100$$

(ii) Concentration of a solution in terms of volume percentage of solute : If a solution is formed by dissolving a liquid solute in a liquid solvent, then the concentration of the solution is expressed in terms of **volume percentage of solute.** The concentration of a solution is the volume of the solute in milliners, which is present in 100 milliliters of a solution.

It is very important to keep in mind that the percentage concentration of solution refers to volume of solute in 100 ml of solution and not 100 ml of solvent, i.e., water.

The concentration of a solution in terms of volume percentage of the solute is calculated by the formula given below :

Concentration of solution $= \dfrac{\text{Volume of solute (in ml)}}{\text{Volume of solution (in ml)}} \times 100$

$$= \frac{\text{Volume of solute (in ml)}}{[\text{Volume of solute + Volume of solvent}]\,(\text{in ml})} \times 100$$

The concentration of a solution is a pure percentage number and has NO UNITS.

(c) Examples :

1. What is the meaning of 15% solution of NaCl ?

Sol. 15% solution of NaCl is a solution 100 g of which contains 15 g of NaCl and 85 g of water.

2. Calculate the amount of glucose required to prepare 250 g of 5% solution of glucose by mass.

Sol. % of solute $= \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$

$$5 = \frac{\text{Mass of solute}}{250} \times 100$$

Mass of solute $= \frac{5 \times 250}{100} = \frac{125}{10} = 12.5$ g

3. A solution contains 50 mL of alcohol mixed with 150 mL of water. Calculate concentration of this solution.

Sol. This solution contains a liquid solute (alcohol) mixed with a liquid solvent (water), so we have to calculate the concentration of this solution in terms of volume percentage of solute (alcohol). Now, we know that :

Concentration of solution $= \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$

Here, Volume of solute (alcohol) = 50 mL

And. Volume of solvent (water) = 150 mL

So, Volume of solution = Volume of solute + Volume of solvent

= 50 + 150 = 200 mL

Now, putting these values of 'volume of solute' and 'volume of solution' in the above formula we get :

Concentration of solution $= \frac{50}{200} \times 100 = \frac{50}{2} = 25$ percent (by volume)

Thus, the concentration of this alcohol solution is 25 per cent or that it is a 25%.

4. How much water should be added to 16 ml acetone to make its concentration 48% ?

Sol. Concentration of solution $= \frac{\text{Vol. of solute}}{\text{Vol. of solution}} \times 100$

$$\frac{16}{x} \times 100 = 48$$

$x = \frac{16}{48} \times 100 = 33.33$ ml

Volume of solvent = 33.33 - 16 = 17.33 ml.

EXERCISE

OBJECTIVE DPP - 4.1

1. Which of the following provides an example of a true solution ?

(A) Blood (B) Milk (C) Starch solution (D) Sugar solution

2. Which of the following can be classified as a pure substance ?

(A) Milk (B) Sea - water (C) Ice (D) Cast iron

3. Which of the following is a compound ?

(A) air (B) Milk (C) Iodine (D) Water

4. The particle size of solute in true solution is of the order of -

(A) 10^{-6} m (B) 10^{-7} m (C) 10^{-8} m (D) 10^{-9} m

5. Which of the following statement is not true about true solution?

(A) It can pass through filter paper.

(B) It is homogeneous in nature.

(C) At constant temperature, particles of solute settle down.

(D) From a true solution, the solute can easily be recovered by evaporation or crystallisation.

6. The concentration of solution is the mass of the solute in grams, which is present in -

(A) 10 gm of solvent (B) 10 gm of solution

(C) 100 gm of solvent (D) 100 gm of solution

7. A solution, which at a given temperature dissolves as much solute as it is capable of dissolving, is said to be a -

(A) saturated solution (B) semi saturated solution

(C) unsaturated solution (D) super saturated solution

8. Which of the following is not a compound ?

(A) Marble (B) Washing soda (C) Quick lime (D) Brass

9. The elements which given out harmful radiation are called -

(A) normal elements (B) representative elements

(C) radioactive elements (D) none of these

10. Air is regarded as a -

(A) compound (B) mixture (C) element (D) electrolyte

SUBJECTVIE DPP - 4.2

1. Classify the following into elements and compounds :

Iron, Iron sulphide, Oxygen, Carbon, Urea, Sodium, Chalk, Washing soda and Gold.

2. Give the main points of distinction between a compound and a mixture.

3. What is meant by homogeneous mixtures ? Give two examples.

4. How much water should be added to 15 grams of salt to obtain 15 percent salt solution ?

5. Explain why, water is a compound and not a mixture ?

IS MATTER AROUND US PURE

SUSPENSIONS

A heterogeneous mixture of insoluble particles of solute, spread throughout a solvent, is called a **suspension.** The particle size (diameter) in a suspension is more than 10^{-5} cm. The particles has a tendency to **settle down** at the bottom of the vessel and can be filtered out, because their size is bigger than the size of the pores of the filter paper.

(a) Example :

(i) Muddy water, in which particles of sand and clay are suspended in water.

(ii) Slaked lime suspensions used for white - washing has particles of slaked lime suspended in water.

(iii) Paints in which the particles of dyes are suspended in turpentine oil.

(b) Characteristics of Suspensions :

(i) The size of particles is more than 10^{-5} cm in diameter.

(ii) The particles of suspension can be separated from solvent by the process of filtration.

(iii) The particles of suspensions settle down, when the suspension is kept undisturbed.

(iv) A suspension is heterogeneous in nature.

(v) More scattering takes place in suspensions, because of bigger size of particles.

The process of settling of suspended particles under the action of gravity is called sedimentation.

COLLODIAL SOLUTION

A heterogeneous solution in which the particle size is in between 10- cm to 10^{-5} cm, such that the solute particles neither dissolve nor settle down in a solvent is called **colloidal solution.**

In a colloidal solution, relatively large suspended particles are called ***dispersed phase*** and the solvent in which the colloidal particles are suspended in called ***continuous phase*** or **dispersing medium.**

(a) Examples of Colloidal Solutions :

Few examples of colloidal solutions are as follows :

- **blood**
- **Milk**
- **Writing ink**
- **Jelly**
- **Starch solution**
- **Gum solution**
- **Tooth paste**
- **Soap solution**
- **Liquid detergents**
- **Mist and fog.**

(b) Characteristics of Colloidal Solutions :

(i) The size of colloidal particles is in between **10^{-7} cm and 10^{-5} cm.**

(ii) The particles of a colloidal solution are **visible** under a powerful microscope.

(iii) The particles of a colloidal solution **do not settle down with the passage of time.**

(iv) The particles of a colloidal solution can easily **pass through filter paper.**

(v) The particles of a colloidal solution scatter light, i.e., when strong beam of light is passed through the colloidal solution, the path of beam becomes **visible.**

(vi) Colloidal solutions are not transparent, but **translucent** in nature.

(vii) The particles of a colloidal solution are **electrically charged.**

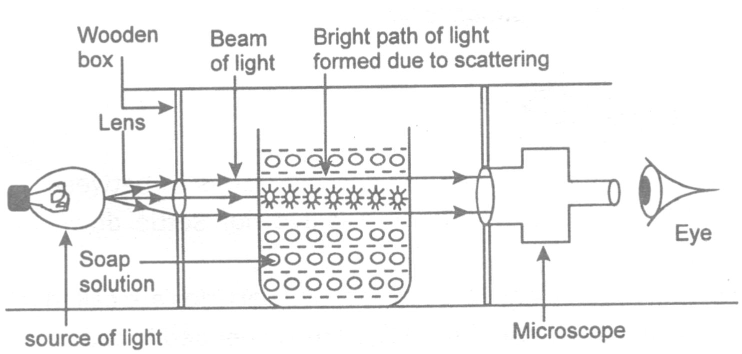
(viii) The colloidal solutions are **heterogeneous** in nature.

TYNDALL EFFECT : The phenomenon in which light is scattered by colloidal particles and path of light becomes visible as a **Tyndall cone** is called **Tyndall effect.**

Experiment :

Take a wooden box, which is fitted with a convex lens on one side and a microscope on the other side, such that convex lens and the objective lens of microscope face each other as shown in the figure.

Place a beaker containing soap solution inside the wooden box. Place a powerful bulb on the side of the convex lens and move it backward or forward till a narrow parallel beam of light is formed. Looking through the microscope. We will observe individual colloidal particles, surrounded by a cone of bluish light. The bluish cone of light is called **Tyndall cone.**



Experiment showing Tyndall effect

(c) Classification of Colloids :

The colloids are classified according to the state of **dispersed phase** (solid, liquid or gas) and the state of **dispersing medium.** A few examples are shown in the table :

Dispersing Medium	Dispersed Phase	Type of Colloidal Solution	Examples
Gas	Liquid	Aerosol	Fog. Mist, clouds
Gas	Solid	Aerosol	Smoke
Liquid	Gas	Foam	Shaving cream
Liquid	Liquid	Emulsion	Milk, face cream
Liquid	Solid	Sol	Milk of magnesia, blood
Solid	Liquid	Gel	Jelly, cheese, butter, honey
Solid	Solid	Solid Sol	Coloured gem Stones, milky glass

Colloidal solutions can be separated by the process of CENTRIFUGATION.

DIFFERENCES BETWEEN TRUE SOLUTIONS AND COLLOIDAL SOLUTIONS

True Solutions	Colloidal Solutions
1. The particle size is les than 10^{-9} cm.	1. The particle size is in between 10^{-7} cm to 10^{-5} cm
2. The particles are not visible under powerful optical microscope.	2. The particles are visible under a microscope.
3. The particles of a true solution can be recovered by evaporation and crystallization.	3. The particles of a colloidal solution cannot be recovered by evaporation and crystallization.
4. The particles of a true solution do not scatter light.	4. The particles of a colloidal solution scatter light.
5. True solutions are clear and transparent.	5. Colloidal solutions are translucent.
6. True solutions are homogeneous in nature.	6. Colloidal solutions are heterogeneous in nature.

DIFFERENCES BETWEEN TRUE SOLUTIONS AND COLLIDAL SOLUTIONS

Colloidal Solutions	Suspensions
1. The size of particles of solute is in between 10^{-7} cm to 10^{-5} cm.	1. The size of particles of solute is more than 10^{-5} cm.
2. The particles of soute do not settle down when a colloidal solution is allowed to stand.	2. The particles of suspension settle down when a suspension is allowed to stand.
3. The particles of solute cannot be filtered out.	3. The particles of suspension can easily be filtered out.
4. The particles of solute are not visible to unaided eye.	4. The particles of suspension are visible to unaided eye.

EXERCISE

OBJECTIVE DPP - 5.1

1. Which of the following is/are example of suspension ?

(A) Muddy water (B) Slaked lime (C) Paints (D) All

2. Which of the following statement is not true about suspension ?

(A) The particles of suspension can be separated from solvent by the process of filtration.

(B) When the suspension is kept undisturbed the particles of suspension settle down.

(C) A suspension is homogeneous in nature.

(D) Scattering of light take place in suspension.

3. Fog is an example of -

(A) foam (B) emulsion (C) aerosol (D) gel

4. Which of the following statement is not true about colloidal solution ?

(A) These are visible under powerful microscope.

(B) Their particles do not settle down with passage of time

(C) Their particles are electrically charged.

(D) These are homogeneous in nature.

5. Which of the following is an example of emulsion ?

(A) Face cream (B) Shaving cream (C) Honey (D) Smoke

6. Soap solution is an example of -

(A) true solution (B) suspension (C) colloidal solution (D) none of these

7. When a beam of light is passed through a colloidal solution, it gets -

(A) reflected (B) absorbed (C) scattered (D) refracted

8. Which of the following is an example of gel ?

(A) Coloured gem (B) Jelly (C) Smoke (D) Shaving cream

9. Which of the following will show Tyndall effect ?

(A) Starch solution (B) Sodium chloride solution

(C) Copper sulphate solution (D) Sugar solution

10. Colloidal particles can be normally seen by

(A) naked eye (B) optical microscope

(C) electron microscope (D) telescope

SUBJECTIVE DPP - 5.2

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1. Write the differences between colloid , suspension and true solutions.

2. Define Aerosol and Emulsion.

3. Explain Tyndall effect briefly.

4. Give an example of each of the following :

Emulsion, Gel, Aerosol and Foam

5. What are the properties of colloidal solution ?

IS MATTER AROUND US PURE

SEPRATION OF HETEROGENEOUS MIXTURES

Heterogeneous mixtures can be separated into their respective components by simple *physical methods such as handpicking, sieving, filtration.*

Generally following physical properties are considered in the separation of the constituents of a mixture.

(i) Density of the constituents of the mixture.

(ii) Melting points and boiling points of the constituents of the mixture.

(iii) Property of volatility of one or more constituents of the mixture.

(iv) Solubility of the constituents of the mixture in different solvents.

(v) Ability of the constituents of the mixture of **sublime.**

(vi) Ability of the constituents of the mixture to **diffuse.**

However, for separating homogenous mixtures special techniques are employed depending upon the difference in our or more physical properties of the constituents of the mixture.

TECHNIQUES USED FOR SEPARATING THE COMPONENTS OF A MIXTURE

(a) By Evaporation :

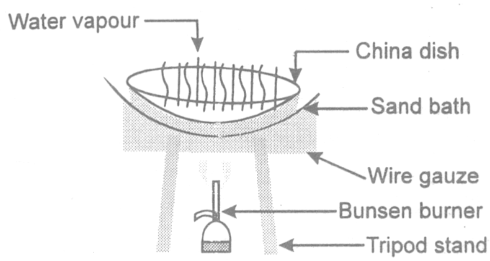
(i) Separation of coloured components (due) from blue black ink : The process of evaporation is suitable for the separation of non-volatile soluble solid (dye) from its liquid solvent (water).

(ii) Method :

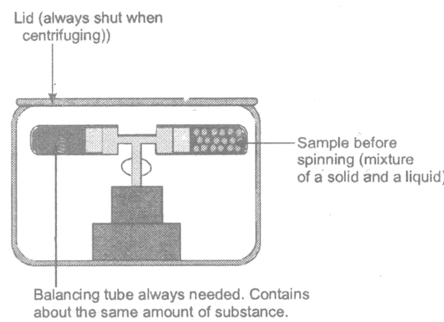
● Heat sand in an iron vessel by placing it over a tripod stand. This arrangement is called sand bath.

● Place a china dish on the sand bath. Pour about 5 cc of the ink into the china dish.
● Heat gently evaporates water from the ink such that it does not boil. In a few minutes the water evaporates leaving behind dry blue black ink. Method of evaporation is suitable for the following solid-liquid mixtures.

Solid liquid Mixture	Non-volatile Solid	Liquid
Common salt and water	Common salt	Water
Sodium nitrate and water	Sodium nitrate	Water
Copper sulphate and water	Copper sulphate	Water



(b) By Centrifugation :
The method of separating finely suspended particles in a liquid, by whirling the liquid at a very high speed is called centrifugation.
(i) Separation of cream from milk : The process of centrifuging in employed in separating cream from milk. This process is generally employed in separating colloidal solutions which easily pass through the filter paper.
(ii) Principle of centrifugation : It is based on the principle that when a very fine suspension or a colloidal solution is whirled rapidly, then the heavier particles are forced towards the bottom of liquid and the lighter stay at the top.



(ii) Method :
● Pour full cream milk in the test tube with a pivot in your laboratory centrifuge.
● Shut the lid of the centrifuge and switch on the current. When the centrifuge starts working, the tub containing milk swings out in the horizontal position and whirls around its axis at a high speed.
● The centrifuge pull (the outward pull) pushes the heavier particles outward, i.e., towards the bottom of the mixture. Thus, the heavier particles of the proteins, carbohydrates, etc. are pushed towards the bottom of the tube, but the lighter particles of the fat stay near the top of the tube and hence separate.
(iv) Applications of centrifugation :
● It is employed in milk dairies to separate cream from the milk.
● It is employed in diagnostic laboratories in testing urine samples.
● It is employed in blood banks to separate different constituents of blood.
● It is used in drying machines to squeeze out water from the wet clothes.

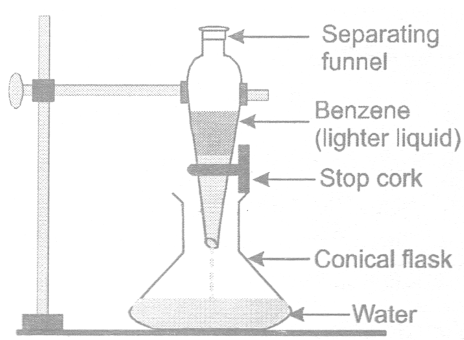
(c) By Separating Funnel :

(i) Separation of mixture of two immiscible liquids : The separation of two immiscible liquid is based on the difference in their densities. The apparatus used for separation is separating funnel. It is a long glass tube provided with a tap at is bottom. The tale bellow shows different immiscible liquids which can be separated by separating funnel.

Immiscible Liquid-liquid Mixture	Heavier Liquid	Lighter Liquid
Benzene and water	Water	Benzene
Kerosene oil and water	Water	Kerosene oil
Turpentine oil and water	Water	Turpentine oil
Chloroform and water	Chloroform	Water
Mustard oil and water	Water	Mustard oil

(ii) Method :

- Close the tap of separating funnel and clamp it in a vertical position in an iron stand.
- Pour the immiscible liquid mixture (say benzene-water mixture) in the separating funnel. Allow the mixture to stand for half an hour or more.
- The immiscible components of the mixture, i.e., benzene and water separate out into two distinct layers. The benzene forms the lighter layer on the top and the water forms the heavier layer at the bottom.
- Place a conical flask or a beaker under the nozzle of the separating funnel. Turn the tap gently so that the water trickles in the flask or the beaker drop by drop. Once the water is drained out, close the tap.
- Now place another conical flask or a beaker under the nozzle of separating funnel. Open the to drain out benzene.



Separation by separating funnel

(iii) Applications :

• This method is used for separating any two immiscible liquids.

• This method is used in separation of stag (a waste material) form the molten metals during their extraction. For example, during the extraction of iron from its ore, the molten iron and slag collect at the base of blast furnace. The slag being less dense floats up the surface of molten iron. They are topped out from two different outlets.

(d) By Sublimation :

The changing of slid directly into vapours on heating and of vapours into directly solid on cooling is known as sublimation.

(i) Separation of a mixture of common salt and ammonium chloride : This method is used in the separation of such solid-solid mixtures where one of the components sublimes on heating. However, it is useful only if the components of the mixture do not react chemically on heating. The tale shows the list of mixtures which can be separated by the process of sublimation.

Solid-Solid Mixture	Sublimable Solid
Common salt and ammonium chloride	Ammonium chloride
Sand and iodine	Iodine
Common salt and iodine	Iodine
Sodium sulphate and benzoic acid	Benzoic acid
Iron fillings and naphthalene	Naphthalene

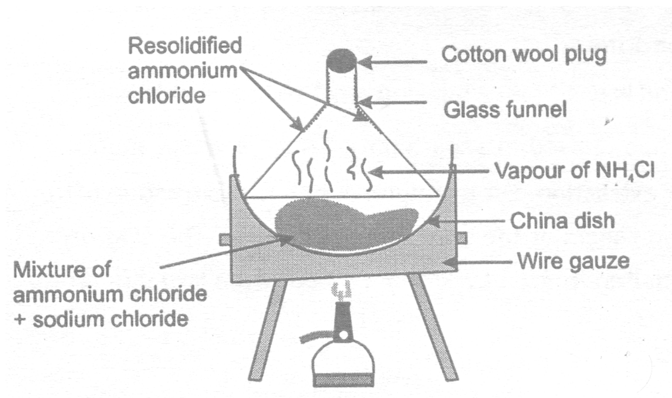
(ii) Method :

• Place the mixture of common slat and ammonium chloride in a china dish and heat it over a low Bunsen flame.

• Place a clean glass funnel in an inverted position in the china dish and close the mouth of its stem with cotton wool.

• The ammonium chloride in the mixture sublimes to form dense white fumes. These fumes condense on the cooler sides of the funnel in the form of fine white powder.

• When the mixture gives off no more white fumes, lift the funnel, scrap the fine white powder from its sides on a piece of paper. This is pure ammonium chloride. The residue left behind in the funnel is sodium chloride.



Separation by sublimation

Dry ice (solid CO_2), naphthalene, Anthracene, Iodine etc. are sublimable solids.

(e) By Chromatography :

The process of separation of different dissolved constituents of a mixture by absorbing them over an appropriate absorbent material is called chromatography.

The adsorbent medium is generally magnesium oxide, alumina or filter paper. The solvent generally used for dissolving a mixture of two or more constituents is water or alcohol. The different constituents of a mixture get absorbed differently on the same absorbent material, because they have different rates of movement. The rate of movement of each adsorbed material depends upon :

- The relative solubility of the constituents of mixture in a given solvent.

- The relative affinity of the constituents of mixture for the adsorbent medium. If a filter paper is used as an adsorbent material for the separation of various constituents of a mixture, then this method of separation of mixture is called paper chromatography. Paper chromatography is very useful in separating various constituents of coloured solutes present in a mixture of lime, ink, dyes etc.

Kroma means colour in Greek language and technique of chromatography was first applied for the separation of colours, so this name was given.

(i) Separation of coloured constituents present in a mixture of ink and water.

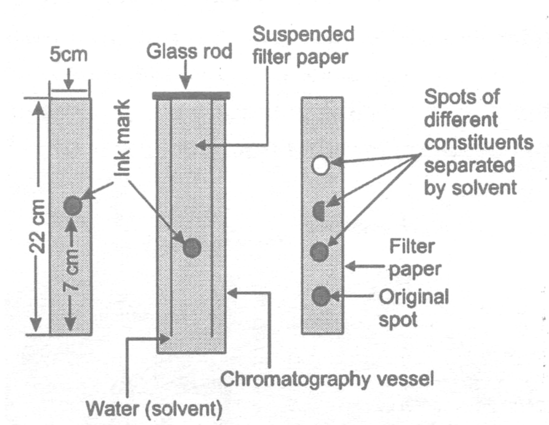
(ii) Method :

• Take a filter paper 22 cm long, 5 cm broad and stick its smaller end to a glass rod with the help of gum. On the other end, measure a distance of 2 cm from lower end and mark a small point. On this point pour one or two drop of the ink.

• Suspend this filter paper in a wide and tall cylinder as shown in Figure. Gradually, pour water into the cylinder till the lower end of filter paper slightly dips in the water. Cover the cylinder with a glass lid to prevent any evaporation and leave the apparatus undisturbed for an hour. The water rises up the filter paper and reaches the ink mark. This water then dissolves various constituents of the ink, gets absorbed by the filter paper in different amounts. More the constituent gets absorbed, the lesser it moves upward and vice versa.

• When the solvent (water) reaches near the top of filter paper, the filter paper is removed from water and dried. On the filter paper will be seen a band of colours, of various constituents.

• A filter paper with separated bands of various constituents of a coloured substance is called chromatogram.



(iii) Advantages :

• It can be carried out with a very small amount of material.

• The substances under investigation do not get wasted in chromatographic separation.

(iv) Applications :

• It is used to separate colours from dye.

• It is used in the separation of amino acids.

• It is used in the separation of sugar from urine.

• It is used in the separation of drugs from the samples of blood.

(f) By Distillation :

Distillation is the process of heating a liquid to form vapour and then cooling the vapour to get the back liquid.

Distillation can be represented as :

Liquid ⇌ Vapour (or Gas) (above the arrow: भ्मंजपदह; below the arrow: ब्ववसपदह)

The liquid obtained by condensing the vapour in the process of distillation is called DISTILLATE.

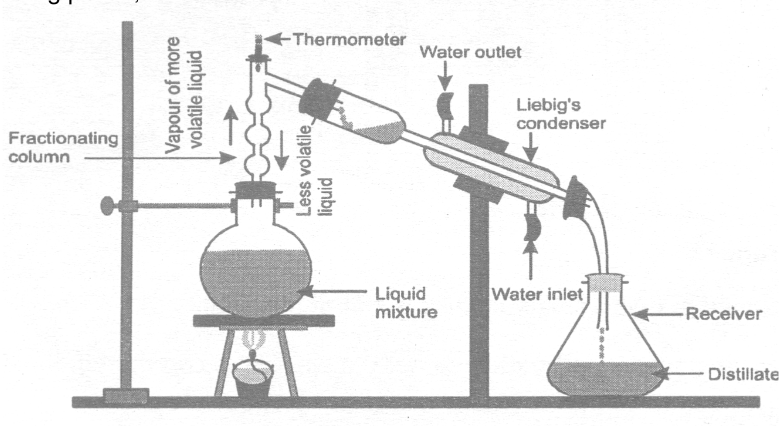
(i) Liebig condenser : Liebig condenser is a water condenser. It is a long glass tube surrounded by a wider glass tube (called water jacket) having an inlet and outlet for water. During distillation, cold water form tape is circulated through the outer tube of condenser. This water takes away heat from the hot vapour passing through the inner tube of condenser and causes it condensation.

Process of simple distillation is used to recover both salt as well as water, from a salt - water mixture (or salt solution) and to separation of components of a mixture containing two miscible liquids that boil without decomposition and have sufficient difference in their boiling points.

(ii) Fractional distillation : Separation of mixture of two miscible liquids for which the difference in the boiling points in less : In case of two liquids which have very close boiling points, both the liquids tends to distil over in different proportions. It means lesser the boiling point of a liquid, more is the proportion of it distilling over.

The above problem can be avoided by using a fractionating column. it gives the effect of repeated distillation by offering resistance to the passage of vapour.

The process of separation of two miscible liquids by the process of distillation, making use of their difference in boiling points, is called fractional distillation.



The process of fractional distillation is useful only, if the difference in the boiling points of the two miscible liquids is less than 10^0C.

(A) Method :

● The process of fractional distillation is similar to the process of distillation, except that a fractionating column is attached.

● The design of a fractionating column is such that the vapours of one liquid (with a higher boiling point) are preferentially condensed a s compared to the vapours of the other liquid (with lower boiling point).

● Thus, the vapours of the liquid with low boiling point, pass on to the Leibig's condenser where they condense. The liquid so formed is collected in receiver.

● The thermometer shows a constant reading as long as the vapour of one liquid are passing to Liebig's condenser. As soon s the temperature starts rising, the receiver is replaced by another receiver to collect second liquid.

Miscible liquid-liquid mixture	Component which distils over
Ethyl alcohol (bop. 78^0 C) + Water (bop. 100^0 C)	Ethyl alcohol
Methyl alcohol (bop. 64.5^0 C) + Ethyl alcohol (bop. 78^0 C)	Methyl alcohol
Acetone (bop. 56.5^0 C) + Water (bop. 100^0 C)	Acetone
Acetone (bop. 56.5^0 C) + Ethyl alcohol (bop. 78^0 C)	Acetone
Methyl alcohol (bop. 64.5^0 C) + Acetone (bop. 56.5^0 C)	Acetone

SEPARATION OF GASES FROM AIR

In order to separate the major components of air, it is first purified, then liquefied and finally fractionally distilled. The steps involved in the process are as follows -

(a) Purification of Air :

(i) Air generally contains carbon dioxide gas, hydrogen sulphide gas and sulphur dioxide gas as impurities. In addition to it there are dust particles also.

(ii) First of all air is washed by passing it through water, where the dust particles are removed.

(iii) The washed air is passed through dilute caustic soda solution, where the gases like carbon dioxide, sulphur dioxide and hydrogen sulphide are removed.

(iv) The purified air, however, contains moisture. The moist air is passed through pipes, maintained at a temperature below - 20^0 C, where vapour present in it freezes and hence, air becomes dry.

(v) The air leaving the cooling pipes is free from all impurities.

(b) Liquefaction of Air :

(i) The cool air, free from all impurities is compressed to a pressure 200 times more than the atmospheric pressure. The compression raises the temperature of the air.

(ii) The hot compressed air is then passed through cooling tank in which cold water enters from one end and warm water leaves from the other end.

(iii) The compressed and cooled air is passed through a spiral pipe, placed in a vacuum flask. The end of spiral pipe is provided with a fine jet.

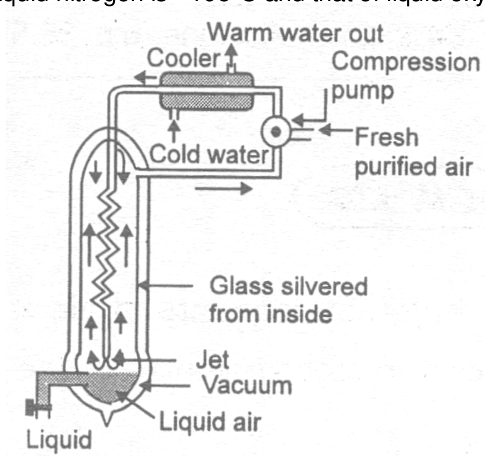
(vi) When compressed air suddenly escapes from the jet, its pressure suddenly falls. Thus, its molecules move wide apart. When the molecules move wide apart, they need energy. This energy is taken by the molecules from themselves and hence their temperature drops.

(v) The air so cooled, is now at a pressure equal to that of atmosphere. This cooled air rises up and in the process further cools the incoming compressed air in spiral tube. The air is then sucked again by the compression pump and the cycle is repeated. With every cycle, the temperature of air drops, till it liquefies.

(c) Fractional Distillation of Air :

(i) The liquid air mainly of nitrogen and oxygen, and is at a temperature of - 200^0C.

(ii) The boiling point of liquid nitrogen is - 195^0C and that of liquid oxygen is - 183^0 C.



(iii) The liquid is gradually warmed to -195^0 C, when nitrogen starts boiling off from the liquid air. The nitrogen gas so formed, is compressed and filled is steel cylinders.

(iv) The liquefied oxygen left behind, is also changed to gas and then filled in compressed state in steel cylinders.

CITY WATER SUPPLY

River water is normally used to supply drinking water to big cities. This water is unfit for drinking purposes as it contains a large amount of suspended impurities and harmful micro-organisms, such as bacteria and germs. The river water is purified in the following stages -

(a) Sedimentation :

The water is allowed to stand in big tanks where heavier suspended impurities settle down. To increase the rate of sedimentation, alum is added to it (loading). The impurities settle down at the bottom.

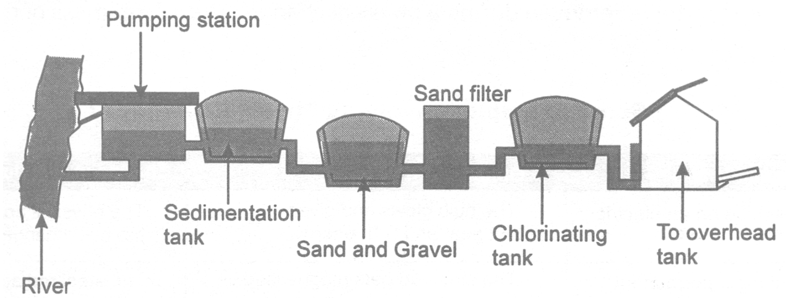
(b) Filtration :

The semi - clear water is allowed to pass through beds of sand, charcoal and gravel to remove suspended impurities. After that water is passed through sand filter.

(c) Removal of harmful Micro-Organism or Sterilisation :

The harmful bacteria in filtered water can cause very serious diseases such as typhoid, cholera, jaundice, dysentery, etc.

Thus, to the filtered water bleaching powder or chlorine gas is added. This kills the micro-organisms and hence the water becomes fit for drinking. This water is directly pumped into overhead tanks for supply to a city.



PHYSICAL AND CHEMICAL CHANGES

Some kind of change always takes place in the matter when it is subjected to every changes. Almost all the changes (except nuclear changes) taking place in the matter can be classified under two heading, these are as follows -

(a) Physical Changes :

Definition : A change which alters some specific physical property of the matter, like its state, texture, magnetic or electrical conditions or its colour, without causing any change in the composition of its molecules, is called physical change, provided it get reversed, if the cause producing the change is removed.

Following points need special consideration :

(i) Now new or different product is formed : The composition of molecules of the substance remains unaltered.

Example : ice melts to form water. In this example only the appearance (state) of matter has changed from solid to liquid. However, the composition of the molecules of ice or water remains same, i.e., for every 1 g of hydrogen there is 8 g of oxygen required. Thus, only a physical change has occurred.

(ii) The change is temporary and reversible : It means the change can be reversed by altering the causes which produce the change.

Example : The water formed from ice can be changed back to ice by placing it in a freezing mixture (a mixture of ice and common salt).

On altering the experimental conditions, the change which gets reversed, is a physical change.

(iii) There is no net gain or loss of energy : The amount of energy required to bring about a physical change is generally equal to the amount of energy required to reverse the change. Thus, there is not net energy change involved.

Example : If 1 g of water of 100^0 C on changing into steam needs 2260 J of heat energy, then 1 g of steam at 100^0 c on changing into water at 100^0 C, gives out 2260 J of h eat energy. Thus, the net energy change is zero.

(iv) There is no change in the weight of substance : During a physical change it is only the energy which is added or removed. No matter is added during a physical change. Similarly, no matter is removed during a physical change. Therefore, mass of the substance remains same.

Some Examples Involving Physical Changes :

Physical Change	Observation	Change in Physical Property
1. Switching on an electric bulb	The bulb glows and gives out heat and light energy.	The physical appearance of the bulb changes.
2. Rubbing a permanent magnet on a steel rod.	The steel rod gets magnetized. If it is brought near iron nails, they get attracted.	The steel rod acquired the property of attracting pieces of iron.
3. Action of heat on iodine	The brownish grey crystals of iodine change to form violet vapours. On cooling the vapours condense on cooler parts on the test tube to form crystals.	Change in state and colour.
4. Dissolving of common salt in water	The white crystalline salt disappears in water. However, the water tested exactly like common salt. Moreover, common salt can be recovered by evaporation.	Change of state.

Some Common Examples of Physical Changes :

- Formation of dew.
- Evaporation of water.
- Crystallisation of sugar from its solution.
- Ringing of an electric bell.
- Breaking of a glass pane.
- Making of ice cream.
- A rock rolling down a hill.
- Bending of a glass tube by heating.
- Melting of wax.
- Sublimation of camphor.

(b) Chemical Change :

Definition : A change which alters the specifies properties of a material by bringing about a change in its molecular composition, followed by a change in state, is called a chemical change.

Following points needs special consideration :

(i) A chemical change results in the formation of one or more new products : The products formed have different properties than the original substance. Thus, the composition of the molecules of products is different from the original substance.

Example : Heating of sugar

When sugar is gently heated in a test tube, it melts. It gradually changes to brown colour, giving a large amount of steamy fumes. In the end a black mass is left which consists of carbon. Thus, new substances, viz. carbon and water (steam)m are formed. In this change, the arrangement between the molecules of carbon, hydrogen and oxygen breaks. The hydrogen and oxygen atoms separate from carbon atoms and join together to form water. The carbon atoms are set free and are left as black residue.

Sugar $\xrightarrow{\text{heat}}$ carbon + Steam

(ii) The weight of the substance undergoing chemical change usually changes :

Example : During the heating of sugar, the weight of the black residue is far less than the actual weight of the sugar. However, this is an apparent change in weight. If we take the weight of steam into account and add to it the weight of carbon, then total weight will be equal to the weight of sugar crystals. Thus, strictly speaking, total weight of substances taking part in a chemical change remains constant.

(iii) The chemical change is permanent and irreversible : It means the change will not reverse by altering the experimental conditions.

Example : The sugar, which has decomposed on heating to form carbon and steam will not change to sugar on cooling.

(iv) During chemical change energy is either absorbed or given out : The various atoms in a chemical compound are joined by attractive forces commonly called bonds. The making or breaking of the bonds always requires exchange of energy. Thus, some amount of heat is either absorbed or given out during a chemical change.

Some Examples Involving Chemical Changes :

Chemical Change	Observation	Equation
1. Burning of magnesium in air	When a magnesium ribbon is heated in a flame of Bunsen burner, it catches fire and burns with a dazzling white flame to form white ash.	Magnesium + Oxygen $\rightarrow$ Magnesium oxide
2. Rusting of iron	When iron (silver grey) is left exposed to moist air for a few days, reddish brown powdery mass (rust) is found on its surface	Iron + Oxygen (from air) + Water vapour $\rightarrow$ Rust
3. Burning of LPG	When LPG (Liquefied Petroleum Gas) is burnt, it burns with a pale blue flame and liberates colourless gas carbon dioxide along with steam.	Butane (LPG) + Oxygen $\rightarrow$ Carbon dioxide + Water

Some Common Examples of Chemical Changes :

- Burning of wood or charcoal
- Digestion of food
- Formation of biogas (Gobar gas)
- Smoking of cigarette
- Rusting of iron
- Clotting of blood
- Baking of cake
- Formation of wine
- Burning of candle
- Curdling of milk
- Burning of petrol or diesel
- Drying of paint
- Ripening of fruit
- Fading of the colour of a dyed cloth
- Photosynthesis
- Butter turning rancid
- Decomposition of water into hydrogen and oxygen.
- Formation of water from hydrogen and oxygen

(c) Difference Between Physical and Chemical Changes

Physical change	Chemical Change
1. The change takes place only in the state, texture, colour, electrical or magnetic properties of solubility, etc. However, molecular properties (composition) do not change.	1. The change takes place in the state, texture, colour, electrical or magnetic properties along with the change in its molecular properties (i.e. its molecular arrangement changes).
2. The specific properties of the substance remain unaltered after the physical change.	2. The specific properties of the substance change completely after the chemical change.
3. Now new substances are produced.	3. Always new substances are produced.
4. There is no change in weight, if a substance is undergoing a physical change.	4. There is always a change in apparent weight, when a substance undergoes a chemical change.
5. There is no net absorption or release of energy (such as heat or light energy) during a physical change.	5. There is always a net absorption or release of energy during a chemical change.
6. It is temporary change and is usually reversed by removing the cause of the change.	6. It is a permanent change and cannot be reversed by removing the cause of the change.

EXERCISE

OBJECTIVE DPP - 6.1

1. Which of the following substances when mixed with sand cannot be separated by sublimation ?
(A) NaCl (B) NH_4Cl (C) Camphor (D) Iodine

2. Which of the following is a physical change ?
(A) Evaporation of alcohol (B) Melting of ice
(C) Rusting of iron (D) Both (A) & (B)

3. What will be the sublimate, when a mixture of sand, sulphur, common salt and iodine is sublimed ?
(A) Sand (B) Iodine (C) Sulphur (D) Common salt

4. Mixture of sand and camphor can be purified by -
(A) distillation (B) filtration (C) sedimentation (D) sublimation

5. A mixture of alcohol and water can e separated by
(A) separating funnel (B) fractional distillation
(C) simple distillation (D) sublimation

6. To separate the various coloured pigments present in a substance which method is used ?
(A) sublimation (B) Chromatography (C) Centrifugation (D) Evaporation

7. Carbon burns in oxygen to form carbon dioxide. The properties of carbon dioxide are -
(A) similar to carbon
(B) similar to oxygen
(C) totally different from both carbon and oxygen
(D) much similar to both carbon and oxygen

8. A mixture of ammonium chloride and sodium chloride can be separated by
(A) chromatography (B) hand picking (C) by sublimation (D) centrifugation

9. Which of the following is not a chemical change ?
(A) Rusting of iron (B) Cooking of food (C) Freezing of water (D) Digestion of food

10. Which of the following method is used for separation of different components of petroleum ?
(A) Fractional distillation (B) Sublimation
(C) Chromatography (D) Simple distillation

SUBJECTIVE DPP - 6.2

1. What is chromatography ?

2. Write applications of centrifugation.

3. How will you separate iron fillings, ammonium chloride and sand from their mixture ?

4. What is fractional distillation ? Draw a labeled diagram of the apparatus used for separating a mixture of alcohol and water.

ANSWER KEY

(OBJECTIVE DPP 4.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	D	C	D	D	C	D	A	D	C	B

(OBJECTIVE DPP - 5.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	D	C	C	D	A	C	C	B	A	B

(OBJECTIE DPP - 6.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	A	D	B	D	B	B	C	C	C	A

ATOMS AND MOLECULES

INTRODUCTION

It was proposed by Indian philosopher, maharishi Kanad, that if we go on dividing matter, we will get **smaller and smaller particles** of matter. Finally, we will get the **smallest particle** of matter, which **cannot be divided** further. ***John Dalton*** called these particles by the name **atom,** which means **'indivisible'.** It was further proposed that the particles of matter **(atoms)** normally exists in a **combined form** and various combination of particles give u s **various kind** of matter. This combined form of atoms is called **molecules.**

All matter is made up of small particles called atoms and molecules. Different kind of atoms and molecules have different properties due to which different kind of matter also show different properties.

LAWS OF CHEMICAL COMBINATION

The laws of chemical combination are the **experimental laws** which led to the idea of **atoms being the smallest unit of matter.** The laws of chemical combination played a significant role in the development of Dalton's atomic theory of matter.

There are two important laws of chemical combination. These are :

(i) Law of conservation of mass

(ii) Law of constant proportions

(a) Law of Conservation of Mass or Matter :

This law was given by ***Lavoisier*** in 1774. According to the law of conservation of mass, matter can neither be created nor be destroyed in a chemical reaction.

The law of conservation of mass means that in a chemical reaction, the total mass of products in equal to the total mass of the reactants. There is **not change in mass** during a chemical reaction.

Suppose we carry out a chemical reaction between A and B and if the products formed are C and D then,

$$A + B \longrightarrow C + D$$

Suppose ‘a’ g of A and ‘b’ g ob B react to produce ‘c’ g of C and ‘d’ g of D. Then, according **to the law of conservation of mass,** we have,

$$a + b = c + d$$

Example :

We calcium Carbonate **($CaCO_3$)** is heated, a chemical reaction takes place to form Calcium Oxide **(CaO)** and Carbon Dioxide **(CO_2).** It has been found by experiments that if **100 grams** of calcium carbonate is decomposed completely, then **56 grams of** Calcium Oxide and **44 grams** of Carbon dioxide are formed.

$$CaCO_3 + \text{Heat} \longrightarrow CaO + CO_2$$

(100 gm) 56g 44g

65g + 44g = 100g

Since the total mass of products (100g) is equal to the total mass of the reactants (100g), there is **no change in the mass** during this chemical reaction. The mass remains same of conserved.

Maharishi kanad told that if we keep dividing matter on and on, we will get the smallest particles called as paramanu.

(b) Law of constant Proportion / Law of Definite Proportions :

Proust, in **1779,** analysed the chemical composition (types of elements present and percentage of elements present) of a large number of compounds and came to the conclusion that the proportion of each element is a compound is constant (or fixed). According to the law of constant proportions : A chemical compound always consists of the same elements combined together in the same proportion by mass.

The chemical composition of a pure substance is not dependent on the source from which it is obtained.

Example :

Water is a compound of **hydrogen and oxygen.** It can be obtained from **various sources (like river, sea, well etc.)** or even **synthesized in the laboratory.** From whatever source we may get it, 9 parts by weight of water is always found to contain 1 part by weight of hydrogen and 8 parts by weight of oxygen. Thus, in **water,** this proportion of **hydrogen and oxygen** always **remains constant.**

The converse of Law of definite proportions that when same elements combine in the same proportion, the same compound will be formed, is not always true.

DALTON'S ATOMIC THEORY

Dalton put forward his **atomic theory** of matter in 1808. The various **postulates** (or assumptions) of **Dalton's atomic theory of matter** are as follows :

(i) Al the matter is made up of very small particles called **"atoms".**

(ii) Atoms **cannot be divided.**

(iii) Atoms can **neither be created nor be destroyed.**

(iv) Atoms are of **various kinds.** There are as many kinds of atoms as are elements.

(v) All the atoms of given element are **identical** in every respect, having the **same mass, size and chemical properties.**

(vi) Atoms of **different elements differ in mass, size and chemical properties.**

(vii) Chemical combination between **two** (or more) **elements** consist of the joining together of atoms of chemical elements to form **molecules of compounds.**

(viii) The **number and kind of atoms** in a given compound is **fixed.**

(ix) During chemical combination, atoms of different elements combine in **small whole numbers** to form compounds.

(x) Atoms of the same elements can combine in **more than one ratio** to form more than one compound.

Dalton's atomic theory provides a simple explanation for the laws of chemical combination and was the first modern attempt to describe the behaviour of matter in terms of atoms.

E.g. he postulate of **Dalton's atomic theory** that "*atoms can neither be created nor be destroyed"* was a result of the **law of conservation of mass** and the postulate of **Dalton's** atomic theory that *"the elements consist of atoms having fixed mass,* and that the number and kind of atoms in a given compound is fixed," came from the **law of constant proportions.**

EXERCISE

OBJECTIVE DPP - 7.1

1. Which postulate of Dalton's Atomic theory suggests the law of conservation of mass ?

(A) Atoms cannot be divided.

(B) All the meter is made up of very small particles called atoms.

(C) Elements consist of atoms combined in a fixed ratio.

(D) Atoms can neither be created nor be destroyed.

2. The elements present in baking soda are -

(A) sodium, carbon and oxygen (B) sodium, carbon and hydrogen

(C) sodium, carbon, hydrogen and oxygen (D) potassium, carbon and oxygen.

3. All samples of carbon dioxide contain carbon and oxygen in the mass ratio 3 : 8. This is in agreement with the law of

(A) conservation of mass (B) constant proportions

(C) (A) and (B) both (D) none of these

4. When 5 g of Calcium is burnt in 2 g of Oxygen then 7 g of Calcium oxide is produced. What mass of calcium oxide will be produced when 5 g of calcium reacts with 20 g of oxygen ?

(A) 7 g (B) 2 g (C) 25 g (D) 4 g

5. The law of conservation of mass was given by

(A) John Dalton (B) Proust (C) Lavoisier (D) None of these

6. If the mass of reactants is equal to the mass of products then which of the following statements is true ?

(A) Law of conservation of mass holds good.

(B) Mass can neither be created nor be destroyed.

(C) There is no change in mass during a chemical reaction.

(D) All the above

7. Hydrogen & Oxygen combine in the ratio of 1 : 8 by mass to form water. What mass of oxygen gas would be required to react completely with 3 g of hydrogen gas ?

(A) 24 g (B) 27 g (C) 21 g (D) 3 g

8. Which postulate of Dalton's atomic theory explains the law of constant proportion ?

(A) Atoms cannot be divided.

(B) All the matter is made up of very small particles called atoms.

(C) Elements consist of atoms combined in a fixed ratio.

(D) Atoms can neither be created nor be destroyed.

9. The term 'Paramanu' for the smallest particles of matter (padarth) was given by -

(A) Dalton (B) Maharishi Kanad (C) Proust (D) Lavoisier

10. When calcium carbonate is heated, it gives -

(A) CaO & CO (B) Ca & CO_2 (C) CaO & CO_2 (D) None of these

SUBJECTIVE DPP - 7.2

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1. "If 100 grams of pure water taken from different sources is decomposed by passing electricity, 11 grams of hydrogen and 89 grams of oxygen are always obtained." Which chemical law is illustrated by this statement ?

2. Dalton's atomic theory says that atoms are indivisible. In this statement still valid ? Give reasons for your answer.

3. Potassium chlorate decomposes on heating to form potassium chloride and oxygen. When 24.5 g of potassium chlorate is decomposed completely then 14.9 g potassium chloride is formed. Calculate the mass of oxygen formed. Which law of chemical combination have you used in solving this problem ?

4. In an experiment 1.288 g of copper oxide was obtained from 10.3 g of Cu. In another experiment 3.672 g of copper oxide gave on reduction 2.938 g of copper. Which law of chemical combination can be illustrated by this example ?

ATOMS AND MOLECULES

ATOMS

All the **matter** is made up of **atoms.** An atom in the **smallest particle** of an element that can **take part** in a **chemical reaction.** Atoms of most of the elements are **very reactive** and **do not exist in the free state** (as single atoms). They exist in **combination** with the atoms of the **same element or another element.**

Atoms are **very, very small** in size. The size of an atom is indicated by its **radius** which is called **"atomic radius"** (radius of an atom). Atomic radius is measured in **"nanometers"** (nm). **1 metre = 10^9 nanometers or 1 nm = 10^{-9} m.**

Atoms are so small that we cannot see them under the most powerful optical microscope.

Hydrogen atom is the smallest atom of all, having an atomic radius 0.037 nm.

(a) Symbols of Elements :

A symbol is a short hand notation of an element which can be represented by a sketch or letter etc.

Alton was the first to use symbols to represent elements is a short way but Dalton's symbols for elements were difficult to draw and inconvenient to use, so **Dalton's** symbols are only of historical importance. They are not used at all.

Element	Dalton's symbol
Hydrogen	○
Carbon	●

It was J.J. Berzelius who proposed the modern system of representing en element. The **symbol** of an element is the **"first letter"** or the **"first letter and another letter"** of the **English name** or the **Latin name** of the element.

Eg. The symbol of **Hydrogen** is H.

The symbol of **Oxygen** is O.

There are some elements whose **names begin** with the **same letter.** For example, the names of elements *Carbon, Calcium, Chlorine* and *Copper* and Copper all begin with the letter C. In such cases, one of the elements is given a "**one letter**" symbol but all other elements are given a **"first letter and another letter"** symbol of the **English or Latin name** of the element. This is to be noted that "another letter" may or may not be the "second letter" of the name. Thus,

The symbol of **Carbon** is C.

The symbol of **Calcium** is Ca.

The symbol of **Chlorine** is Cl.

The symbol of **Copper** is Cu (from its Latin name **Cuprum)**

It should be noted that in a **"two letter"** symbol, the **first letter** is the **"capital letter"** but the **second letter** is the **'small letter'**

Symbol of Derived from English Names	
English name of the Element	**Symbol**
Hydrogen	H
Helium	He
Lithium	Li
Boron	B
Carbon	C
Nitrogen	N
Oxygen	O
Fluorine	F
Neon	Ne
Magnesium	Mg
Aluminium	Al
Silicon	Si
Phosphorous	P
Sulphur	S
Chlorine	Cl
Argon	Ar
Calcium	Ca

Symbols Derived from Latin Names

English name of the Element	Symbol	Latin Name of the Element
Sodium	Na	Natrium
Potassium	K	Kalium

(b) Significance of The Symbol of an Element :

(i) Symbol represents name of the element.

(ii) Symbol represents one atom of the element.

(iii) Symbol also represents one mole of the element. That is, symbol also represent 6.023×10^{23} atoms of the element.

(iv) Symbol represent a definite mass of the element i.e. atomic mass of the element.

Example :

(i) Symbol H represents hydrogen element.

(ii) Symbol H also represents one atom of hydrogen element.

(iii) Symbol H also represents one mole of hydrogen atom.

(iv) Symbol H also represents one gram hydrogen atom.

(c) Atomic Mass of an Element :

Actual masses of the atoms of the elements are **very, very small.** For example, one atoms of **hydrogen** (H) has mass of **1.673×10^{-24} gram.** To avoid the inconvenience in using such small and complicated figures in our calculation, it was necessary to define atomic mass in such as way that we get simple figures for them. **Carbon -12 atom** is that atom of carbon which has 6 protons and 6 neutrons in its nucleus, so that its mass number is 12.

Carbon -12 atom has been assigned an atomic mass of exactly 12 atomic mass units, written as **12 u.**

Definition of atomic mass : Atomic mass express as to how many time an atom of a substance is heavier than $\frac{1}{12}$th mass of the carbon - 12 atom.

Atomic Mass Unit (u) = One - twelfth the mass of a Carbon - 12 atom or $1u = 1.6605 \times 10^{-24}$ g.

One atomic mass unit (1u) is defined as exactly one-twelfth the mass of an atom of Carbon-12. The **atomic mass** of an element is the **relative mass** of its atom as compared with the mass of a Carbon-12 atom taken as 12 units.

(d) How Do Atoms Exist ?

The atoms of only a few elements called **noble gases** (such as helium, neon, argon and krypton etc.) are **chemically uncreative** and exist in the **free state** (as single atoms). Atoms of most of the elements are **chemically very reactive and do not exist in the free state** (as single atoms).

Atoms usually exist in two ways :

(i) in the form of **molecules** and

(ii) in the form of **ions.**

When atoms form molecules or ins, they become **stable** (because in doing so they acquire the stable electron arrangements of noble gases).

MOLECULES

A molecule **is an electrically neutral group of two (or more) atoms chemically bonded together by means of attractive forces.**

OR

A molecule is the **smallest particle** of a substance (element or compound) which has the properties of that substance and can exist in the free state. Molecules can be formed either by the combination of atoms of the **"same element"** or of **"different elements"**/

Every compound is a molecule, but every molecule is not a compound.

There are two types of molecules : molecules of **elements** and molecules of **compounds.**

(a) Molecules of Elements :

The molecule of an element contains two (or more) similar atoms chemically bonded together. For example, a molecule of hydrogen element contains 2 hydrogen atoms combined together and it is written as $\mathbf{H_2}$ representing Hydrogen gas. Similarly, **Ozone gas** has 3 oxygen atoms combined together, so ozone exists in the form of $\mathbf{O_3}$**.** The noble gases like *helium, neon, argon and krypton* etc., exist as single atoms *He, Ne, Ar and Kr* respectively. So, their atoms and molecules are just the same.

Atomicity of phosphorus is 4 and sulphur is 8.

(b) Molecules of Compounds :

The molecule of compound contains two (or more) different types of atoms chemically bonded together. For example, the molecule of hydrogen chloride (HCl) contains one atom of hydrogen (H) chemically bonded with one atom of chlorine (Cl). Some more example of the molecules of compounds are : sulphur dioxide (SO_2), methane, (CH_4) and ammonia (NH_3).

(c) Atomicity :

The number of atoms present in one molecule of an element or compound is called it **atomicity.** For example, the atomicity of noble gases is 1, that of hydrogen, nitrogen, oxygen etc. is 2 each and of ozone is 3. Thus, **noble gases, hydrogen and ozone are** respectively **monatomic, diatomic, and triatomic** molecules.

A compound which consists of molecules and not ions, is called a molecular compound.

MOLECULAR MASS

The **molecular mass** of a substance may be defined as the relative mass of its molecule as compared to the mass of an atom of carbon (carbon - 12) taken as 12 units.

Molecular mass expresses as to how many times a molecular of a substance is heavier than $1/12^{th}$ of the mass of an atom of carbon (carbon -12).

Eg. A molecule of water is 18 times heaver than $1/12^{th}$ of the mass of carbon atom. Therefore, the molecular mass of water is **18u**. Similarly, the molecular mass of CO_2 is **44u.**

Calculation : The molecular mass is equal to sum of the atomic masses of all the atoms present in one molecule of the substance.

Eg. The molecular mass of **Sulphuric Acid (H_2SO_4)** can be calculated as follows :

Molecular mass of H_2SO_4 = Mass of 2 H atoms + Mass of 1 S atom + Mass of 4 O atoms

$$= (2 \times 1) + (1 \times 32) + (4 \times 16) = 2 + 32 + 64 = 94u.$$

Thus, the molecular mass of **Sulphuric acid is 98u.**

Atoms are the components of molecules and the molecules are the components of elements or compounds.

EXERCISE

OBJECTIVE DPP - 8.1

1. The number of atoms present in a molecule of element is called its -

(A) molecularity (B) atomicity (C) valency (D) reactivity

2. Which of the following is symbol of copper ?

(A) Ca (B) Cu (C) Co (D) None of these

3. The symbol of element oxygen is -

(A) O (B) O_2 (C) O_3 (D) None of these

4. 1 u is equal to

(A) 1.6605 g (B) 1.6605×10^{24} g (C) 1.6605×10^{-24} g (D) 1 g

5. The atoms of which one of the following element exist in free state ?

(A) Nitrogen (B) Helium (C) Hydrogen (D) Oxygen

6. Atoms can exist in the form of -

(A) molecules (B) Ions (C) Both A & B (D) None of these

7. A molecule of hydrogen is represented as -

(A) H (B) 2H (C) H_2 (D) All of these

8. The first scientist to use the symbols of elements was -

(A) Dalton (B) Berzilius (C) Kanad (D) Proust

9. Molecular mass of H_2SO_4 is -

(A) 89 U (B) 98 U (C) 49 U (D) 198 U

10. Molecular formula of sulphur is -

(A) S_4 (B) S_2 (C) S_8 (D) S_{18}

SUBJECTIVE DPP - 8.2

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1. State whether the following statement is correct or not any why ?

The symbol of element cobalt is CO.

2. An element X has a valency of 4 whereas another element Y has a valency of 1. What will be the formula of the compound between X and Y ?

3. The valencies (or charges) of some of the ions are given below -

Ion	**Valency**	**Ion**	**Valency**
Sodium ion	+1	Bromide ion	-1
Ammonium ion	+1	Hydroxide ion	-1
Calcium ion	+2	Sulphate ion	-2
Lead ion	+2	Phosphate ion	-3

Using this information, write down the formulae of the following compounds -

(i) Sodium phosphate (B) Ammonium sulphate

(iii) Calcium hydroxide (D) Lead bromide

4. What is the difference between the molecule of an element and the molecule of a compound ? Give one example of each.

5. What is the significance of the symbol of an element ? Explain with the help of examples.

6. Write the relation between nanometer and metre.

ATOMS AND MOLECULES

IONS

An **ion** is a **positively or negatively charged** atom or group of atoms.

Every atom contains **equal number of electron (negatively charged) and protons** (positively charged). Both charges balance each other, hence atom is **electrically neutral.**

(a) Cation :

If an atom has **less electrons** than a **neutral atom,** then it gets **positively charged** and a positively charged ion is known as **cation.**

E.g. Sodium ion (Na^+), Magnesium ion (Mg^{2+}) etc.

A cation bears that much **units of positive charge as are the number of electrons lost** by the neutral atom to form that cation.

E.g. An aluminum atom loses 3 electrons to form aluminum ion, so **aluminum ion** bears 3 units of positive charge and it is represented as Al^{3+}.

All metal elements form cations.

(b) Anion :

If an atom has **more number of electrons than that of neutral atom,** then it gets negatively charged and a **negatively charged** iron is known as **union.**

E.g. Chloride ion (Cl^-), oxide ion (O^{2-}) etc.

All non-metal elements form anions (except hydrogen).

An anion bears that much **units of negative charge as are the number of electrons gained** by the neutral atom to form that anion.

E.g. A nitrogen atom gains 3 electrons to form nitride ion, so **nitride ion** bears 3 units of negative charge and it is represented as N^{3-}.

Size of a cation is always smaller and anion is always greater than that of the corresponding neutral atom.

MONOATOMIC IONS AND POLYATOMIC IONS

Monoatomic ions : Those ions which are formed form **single atoms** are called **monoatomic ions or simple ions.**

E.g. Na^+, Mg^{2+} etc.

Polyatomic ions : Those ions which are formed from **group of atoms** joined together are called **polyatomic ions or compound ions.**

E.g. Ammonium ion (NH_4^+), hydroxide ion (OH^-) etc. which are formed by the joining of two types of atoms, nitrogen and hydrogen in the first case and oxygen and hydrogen in the second.

IONIC COMPOUNDS

Those compounds which are **made up of ions (cations and anions)** and are held together by **strong electrostatic forces of attraction** are called **ionic compounds.**

The forces which **hold the ions together** in an ionic compound are known **as ionic bonds or electrovalent bonds.**

E.g. Calcium nitrate $Ca(NO_3)_2$ is an ionic compound, whose one molecule is made up of one calcium ion (Ca^{2+}) and two nitrate ions (NO_3), making the overall charge on calcium nitrate zero.

Overall charge on an ionic compound is always zero.

(a) Formula Unit of Ionic Compounds :

The **simplest combination of ions** that produces and **electrically neutral unit,** is called **a formula unit** of the **ionic compound.** Molecular formula of ionic compounds cannot be determined because they consist of large no. of ions. So ionic compounds are represented by formula unit.

Eg. Sodium chloride is an ionic compound which consists of **a large number of Na^+ and Cl^- ions** (but they should be equal in number). So, the **actual formula** of sodium chloride should be **$(Na^+)_n(Cl^-)_n$ or $(Na^+Cl^-)_n$,** where 'n' is a large number. **Nacl is the simplest formula** of sodium chloride and thus, the formula unit of sodium chloride is NaCl.

FORMULA MASS

The formula mass of an ionic compound is the relative mass of its formula unit as compared with the mass of a carbon atom (carbon - 12) taken as 12 units.

E.g. To find the formula mass of **potassium carbonate (K_2CO_3).**

Formula mass of K_2CO_3 = mass of 2 K atoms + Mass of 1 C atom + Mass of 3 O atoms

$$= (2 \times 39) + (1 \times 12) + (3 \times 16)$$
$$= 78 + 12 + 48$$
$$= 138 \text{ u}.$$

Hence, the formula mass of K_2CO_3 is 138 u.

CHEMICAL FORMULA /MOLECULAR FORMULA

The **chemical formula** of a compound or an element represent the **composition** of a **molecule** of the compound or an element, in terms of the **symbols of elements and the number of atoms** of each element present in one molecule of the substances.

(a) Formulae of Elements :

The **chemical formula** of an element is a representation of the **composition of its molecule** in which **symbol** represents the **element** and **subscript** represents, how many **atoms** are present in one molecule.

E.g. One molecule of hydrogen element contains **Two atoms** of hydrogen, therefore, the formula of hydrogen is H_2. It should, however, be noted that **2H** represents **two separate atoms** of hydrogen, while $\mathbf{H_2}$ represents **one molecule** of hydrogen.

(b) Formulae of Compounds :

The **chemical formula** of a compound is representation of the **composition of its molecule** in which **symbol** represents, which **elements** are present and the **subscript** shows us how many **atoms of each element** are present in one molecule of a compound. **E.g.** One **molecule of water** contains **2 atoms of hydrogen** and **1 atom of oxygen.** Hence, the formula of water is H_2O.

(i) In the **chemical formula** of a compound, the elements present are **denoted by their symbols and the number of atoms** of each element are denoted by writing their number as **subscripts** to the symbols of the respective elements.

E.g. Water is a compound whose one molecule is made up of 2 atoms of hydrogen and 1 atom of oxygen and hence, its **chemical formula is** $\mathbf{H_2O}$.

(ii) While writing the formula of an ionic compound, the metal is written on the left hand side, while the non metal is written on the right hand side.

E.g. Magnesium oxide is written as MgO, Sodium chloride is written as NaCl etc.

The name of the metal remains as such, but that of the non-metal is changed to have the ending 'ide'.

(iii) Molecular compounds, formed by the combination between **two different non - metals,** are written in such a way that the less electronegative element is written on the left hand side, while the more electronegative element is written on the right hand side. In naming molecular compounds, the name of the **less negative non-metal is written as such** but the name of the **more electronegative element is changed** to have the **ending 'ide'.**

E.g. H_2S is named as hydrogen sulphide and HCl is named as hydrogen chloride.

(iv) When there are **more than one atoms** of an element present in the formula of the compound, then the **number of atoms are indicated by the use of appropriate prefixes (mono for 1, di for 2, tri for 3, tetra for 4 atoms etc. respectively)** in the name of the compound.

E.g. CO is named as **carbon monoxide,** CO_2 is named s **carbon dioxide** and CCl_4 is named as **carbon tetrachloride.**

(v) The **prefixes** are needed in naming those **binary compounds** in which the two **non-metals** form more than one compounds (by having different number of atoms).

E.g. Two non-metals, nitrogen and oxygen, combine to form different compounds like nitrogen monoxide (NO), nitrogen dioxide (NO_2), dinitrogen trioxide (N_2O_3) etc.

(vi) If **two non-metals** form only **one compound,** then **prefixes are not used** in naming such compounds.

E.g. Hydrogen and sulphur combine to form only one compound H_2S. So, **H_2S is named as hydrogen sulphide and not as hydrogen monosulphide.**

In a chemical formula higher electronegative element is written on the right side.

WRITTING THE FORKULA OF MOLECULAR COMPOUND

If we **know the valencies** of the **elements involved in a compound,** then we can write the **formula** of the compound by **balancing the valencies** of different elements. The steps to be followed for writing the formula of molecular compounds are :

(i) First, **write the symbols** of the elements constituting the compound.

(ii) Then, **below each symbol,** write its corresponding **valency.**

(iii) Finally, we **exchange the valencies of the** combining atoms, i.e. with first atom, we write the valency of the second atom and second atom, we write the valency of the first atom. The valencies are to be written **as subscripts** to the symbols.

(iv) If the valencies have any **common factor,** then the formula is **divided by that common factor.** This gives the required formula of the compound.

Writing the formula of carbon dioxide as an example : Following steps are used to write the formula of carbon dioxide

• **Carbon dioxide** is a compound composed of two elements, **carbon and oxygen**. So, we first write their symbols C and O respectively.

• The **valency of carbon is 4** and the **valency of oxygen is 2.** Now, these valencies are to be **written under** the corresponding symbols of elements.

Symbols : C O

Valencies : 4 2

• Now, the **valencies** of carbon and oxygen are to be **exchanged.** So, the **subscript** corresponding to **C is 2** and that corresponding to **O is 4.** Hence, the formula of the **compound becomes C_2O_4.**

• But, the valancies 2 and 4 have a **common factor 2.** So, on dividing the whole formula by 2, we get the simplest formula CO_2. Thus, the **formula of carbon dioxide is CO_2.**

VALLENCY OF IONS

The **valency of an ion is same as the charge** present on the ion.

if an ion has 1 unit of positive charge, its valency is +1 and it is known as a **monovalent cation.** If an ion has 2 units of negative charge, its valency is -2 and it is known as a **divalent anion.**

LIST OF COMMON ELECTROVALENT POSITIVE RADICALS

Monovalent Electropositive	**Bivalent Electropositive**	**Trivalent Electropositive**	**Tetravalent Electropositive**
1. Hydrogen H^+	1. Magnesium Mg^{2+}	1. Aluminium Al^{3+}	1. Stannic [Tin (IV)] Sn^{4+}
2. Ammonium NH_4^+	2. Calcium Ca^{2+}	2. Ferric [Iron (III)] Fe^{3+}	2. Plumbic [Lead (IV)] Pb^{4+}
3. Sodium Na^+	3. Zinc Zn^{2+}	3. Chromium Cr^{3+}	
4. Potassium K^+	4. Plumbous [Lead (II)] pb^{2+}		
5. Cuprous [(Copper (I)] Cu^+	5. Cupric [(Cupper) (II)] Cu^{2+}		
6. Argentous [Silver (I)] Ag^+	6. Argentic [(Silver (II)] Ag^{2+}		
7. Mercurous [Mercury (I)] Hg^+	7. Stannous [Tin (II)] Sn^{2+}		
	8. Famous [Iron (II)] Fe^{2+}		
	9. Mercuric [Mercury (II)] Hg^{2+}		
	10. Barium Ba^{2+}		

LIST OF COMMON ELECTROVALENT NEGATIVE RADICALS

Monovalent Electropositive	**Bivalent Electropositive**	**Trivalent Electropositive**	**Tetravalent Electropositive**
1. Fluoride F^-	1. Sulphate SO_4^{2-}	1. Nitride N^{3-}	1. Carbide C^{4-}
2. Chloride Cl^-	2. Sulphite SO_3^{2-}	2. Phosphide P^{3-}	
3. Bromide Br^-	3. Sulphite S^{2-}	3. Phosphite PO_3^{2-}	
4. Iodide I^-	4. Thiosulphate $S_2O_3^{2-}$	4. Phosphate PO_4^{3-}	
5. Hydride H^-	5. Zincate ZnO_2^{2-}		
6. Hydroxide OH^-	6. Oxide O^{2-}		
7. Nitrite NO_2^-	7. Peroxide O_2^{2-}		
8. Nitrate NO_3^-	8. Dichromate $Cr_2O_7^{2-}$		
9. Bicarbonate or Hydrogen carbonate HCO_3^-	9. Carbonate CO_3^{2-}		
10. Bisulphite or Hydrogen sulphite HSO_3^-	10. Silicate SiO_3^{2-}		
11. Bisulphide or Hydrogen sulphide HS^-			
12. Bisulphate or Hydrogen sulphate HSI_4^-			
13. Acetate CH_3COO^-			

Cation contains less no. of electrons and anion contains more no. of electrons than the no. of protons present in them.

WRITING THE FORMULA OF IONIC COMPOUNDS

Steps :

(i) First, write the **symbols of the ions** from which the ionic compound is made. As a convention, the **cation** is written on the **left side,** while the **anion** is written on the **right side.**

(ii) Them the respective **valencies** of the respective cation and anion are **written below their symbols.**

(iii) Then, the **valencies** of the cation and anion are **exchanged.** The **number of cations and anions** in the formula of the compound are **adjusted** in such a way that **total positive charge of cations become equal to the total negative charge of the anions** making the ionic compound **electrically neutral.**

(iv) The final **formula of the ionic compound is then written** but the **charges** present on the cation and the anion are **not shown.**

E.g. Two write the formula for aluminum sulphate

First, write the symbols of aluminum ion and sulphate ion and write their respective valencies below their symbols as shown :

Symbols : Al $\nwarrow\nearrow$ SO_4

Valencies : +3 $\times$ -2

(Charges)

Now, we exchange the valencies. So, -2 gets associated with Al and +3 gets associated with SO_4, So, the final formula of the compound aluminum sulphate is $Al_2(SO_4)$ after removing the charges associated with aluminum ion and sulpahte ion.

Ionic compound is electrically neutral as it contains equal number of positive and negative charges.

GRAM ATOMIC MASS AND GRAM MOLECULAR MASS

(a) Gram Atomic Mass

The amount of a substance in grams which is numerically equal to the atomic mass of that substance, is known as gram atomic mass of that substance. If we want to write the gram atomic mass of a substance, we write its atomic mass, remove the atomic mass unit u, and add grams to the numerical value of the atomic mass.

$$\textbf{Number of gram atoms} = \frac{\text{Mass of the element in grams}}{\text{Atomic mass of the element in grams}}$$

E.g. Atomic mass of nitrogen, (N) = 14 u

So, gram atomic mass of nitrogen = 14 grams

(b) Molar Mass :

The **molar mass** of a substance is the **mass of 1 mole, i.e. 6.023 × 10^{23} particles,** of that substance. Its unit is gram per mole, **i.e. g/mol.** The molar mass of an element is its atomic mass expressed in g/mol and the molar mass of a compound is its molecular mass expressed in g/mol.

E.g. The atomic mass of sodium (Na) is 23 u, so the molar mass of the element sodium (Na) is 23 g/mol.

(c) Gram Molecular Mass:

The **amount of a substance** in grams which is numerically **equal to the molecular mass of that substance,** is known as **gram molecular mass** of that substance. If we want to write the gram molecular mass of a substance, we write its molecular mass, remove the molecular mass unit u, and add grams to the numerical value of the molecular mass.

E.g. gram molecular mass of oxygen gas (O_2) is 32 g.

$$\textbf{Number of gram molecules} = \frac{\text{Mass of the substnce in grams}}{\text{Molecular mass of the substance in grams}}$$

Gram molecular mass should not be confused with the mass of one molecule of the substance in grams. The mass of one molecule of a substance is known as its actual mass or molecular mass.

EXERCISE

OBJECTIVE DPP - 9.1

1. Which of the following represents a polyatomic ion ?

(A) Sulphide (B) Chloride (C) Sulphate (D) Nitride.

2. The formula mass of NaCl is -

(A) 56.5 u (B) 36.5 u (C) 58.5 u (D) 55.5 u

3. Which of the following set of ions is present in potassium sulphate (K_2SO_4) ?

(A) K^4, SO_4^{-2} (B) K^{+4}, SO^{-2} (C) K^{+2}, SO_4^- (D) K^+, SO_4^-

4. Two elements A (atm. wt. 75) and B (atm wt. 16) combine to yield a compound. The percentage by weight of A in the compound was found to be 75.08. The formula of the compound is -

(A) AB (B) AB_2 (C) A_2B (C) A_2B_3

5. In the molecular mass of a compound is 74.5 then the compound is -

(A) KCl (B) HCl (C) NaCl (D) LiCl

6. The overall charge on an ionic compound is equal to -

(A) the charge of the cation (B) zero

(C) the charge of the anion (D) none of these

7. Which one of the following is a trivalent anion ?

(A) Aluminum ion (B) Phosphide ion (C) Ferric ion (D) Calcium ion

8. In a chemical formula more electronegative element is written on the -

(A) right side (B) left side (C) either side (D) None of these

9. Which of the following is the formula of nitrate ion ?

(A) N_3^- (B) NO_3^- (C) NO^+ (D) NO_2^+

10. Symbol of ferric ion is -

(A) Fe^{++} (B) Fe^{+++} (C) Fe (D) F^-

SUBJECTIVE DPP - 9.2

1. The molecular formula of glucose is $C_6H_{12}O_6$. Calculate its molecular mass.

2. What do we call those particles which have -

(a) more electrons than the normal atoms ?

(b) less electrons than the normal atoms ?

3. Calculate the formula mass of Al_2O_3

4. Name of following compounds. Also write the symbols and formulae of the ions present in them.

(a) $CuSO_4$ (b) $(NH_4)_2SO_4$ (c) Na_2O

(d) Na_2CO_3 (e) $CaCl_2$

5. An element A forms an oxide A_2O_5. Then answer the following -

(a) What is the valency of element A ?

(b) What will be the formulae of chloride of A ?

ATOMS AND MOLECULES

MOLE CONCEPT

For the counting of articles, the unit dozen or unit gross is commonly used irrespective of their nature.

E.g. One dozen pencils = 12 pencils

One gross books = 144 books

In a similar way, for counting of **atoms, molecules, ions** etc. chemists use the unit **"mole".**

A mole is the amount of a substance that contains the same number of entities (i.e. atoms, molecules or ions) as there are atoms in 12 grams of the carbon $^{12}_{6}C$.

Mole is a collection of 6.023 × 10^{23} particles (may it be atoms, molecules or ions) of a substance.

E.g. 1 mole of oxygen **atoms (O)** = 6.023 × 10^{23} atoms of oxygen.

1 mole of **oxygen molecules (O_2)** = 6.023 × 10^{23} molecules of oxygen.

The number, 6.023 × 10^{23}, which represents the number of particles in a mole, is known as Avogadro Number (N_A).

(a) Moles of Atoms :

(i) 1 mole atoms of any element occupy a mass which is equal to the **gram atomic mass** of that element.

(ii) The **symbol of an element** represents **6.023 × 10^{23} atoms (**1 mole of atoms) of that element.

E.g. Symbol **N** represents **1 mole** of nitrogen atoms and **2N** represents **2 moles** of nitrogen atoms.

Store in your memory

The terms mole was introduced by Ostwald in 1896.

(b) Moles of Molecules :

(i) 1 mole molecules of any substance occupy a mass which is equal to the **gram molecular mass** of that substance.

E.g. 1 mole of water (H_2O) molecules weight equal to the gram molecular mass of water (H_2O), i.e. 18 grams.

(ii) The **formula of compound** represents **6.023 × 10^{23} molecules** (1 mole of molecules) of that compound.

E.g. Symbol H_2O represents 1 more of water molecules and 2 H_2O represents 2 moles of water molecules.

NOTE : The symbol H_2O does not represent 1 mole of H_2 molecules and 1 mole of O atoms. Instead, it represents 2 moles of hydrogen atoms and 1 mole of oxygen atoms.

The SI unit of the amount of a substance is Mole.

(c) Mole in Terms of Volume :

Volume occupied by **1 gram molecular mass** or **1 mole** of a gas under standard conditions of temperature and pressure (273 K and 1 atm) is called **gram molecular volume.** Its value is **22.4 litres** for each gas.

1 Mole = 1 Gram molecular mass

= 22.4 litre (at NTP)

= 6.023 × 10^{23} molecules

SOME IMPORTANT RELATIONS REGARDING MOLES OF ATOMS

1. Mass of 1 mole of atoms = Gram atomic mass

2. 1 mole of atoms = 6.023 × 10- atoms

3. Gram atomic mass = Mass of 6.023 × 10^{23} atoms

E.g. to calculate the number of moles in 16 grams of sulphur (Atomic mass of sulphur = 32 u).

Solution :

1 mole of atoms = Gram atomic mass.

So, 1 mole of sulphur atoms = Gram atomic mass of sulphur = 32 grams.

Now, 32 grams of sulphur contains = 1 mole of sulphur

So, 16 grams of sulphur will contain = (1/32) × 16

= **0.5 mole**

Thus, 16 grams of sulphur constitute 0.5 mole of sulphur.

Mole is the Latin word meaning heap or pile.

SOME USEFUL FORMULAE

(i) Number of moles of atoms = $\frac{\text{Mass of element in grams}}{\text{Gram atomic mass of the element}}$

(ii) Number of moles = $\frac{\text{No. of atoms of element}}{\text{Avogadro' no of atoms}} = \frac{N}{N_A}$

(iii) Number of moles of molecules = $\frac{\text{Mass of substance in grams}}{\text{Gram molecular mass of substance}}$

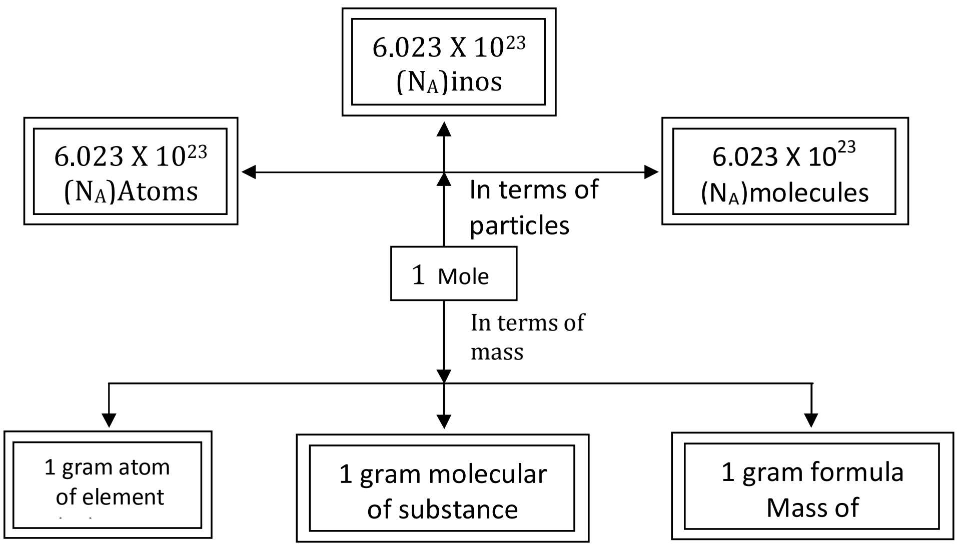
(iv) Number of moles of molecules = $\frac{\text{No. of molecules of element}}{\text{Avogadro' no. of molecules}} = \frac{N}{N_A}$

SOME USEFUL FORMULAE

(i) 1 mole of molecules = Gram molecular mass

(ii) 1 mole of molecules = 6.023×10^{23} molecules

(iii) Gram molecular mass = 6.023×10^{23} molecules



SOME USEFUL FORMULAE

Example : Calculate the mass of the following :

(i) 0.5 mole of O_2 gas

(ii) 0.5 mole of O atoms

(iii) 3.011×10^{23} atoms of O

(iv) 6.023×10^{23} molecules of O_2.

(Given : Gram atomic mass of oxygen = 16 g, gram molecular mass of oxygen (O_2) = 32 g).

Solution : (i) 0.5 mole of O_2 gas

No. of moles = $\frac{\text{Mass of } O_2 \text{ in grams}}{\text{Gram molecular mass}} = \frac{m}{M}$

$\therefore$ Mass of O_2 in grams (m) = No. of moles $\times$ M

$= 0.5 \times (32g) = 16g$

(ii) 0.5 mole of oxygen (O) atoms

No. of moles = $\dfrac{\textbf{Mass of oxygen (O) in grams}}{\textbf{Gram atomic mass}} = \dfrac{\textbf{m}}{\textbf{M}}$

Mass of oxygen (O) in grams (m) = No. of moles × M

= 0.5 × (16g) = 8g.

(ii) **3.011 × 10^{23} atoms of oxygen (O)**

Step I : Calculation of no. of gram atoms of oxygen

No . of gram atoms = $\dfrac{\textbf{No. of atoms of oxygen}}{\textbf{Avogadro no. of atoms}} = \dfrac{\textbf{N}}{\textbf{N}_\textbf{A}}$

$$= \frac{3.011 \times 10^{23}}{6.022 \times 10^{23}} = 0.5 \text{ gram atoms}$$

Step II : Calculation of mass of oxygen (O) atoms

Mass of oxygen (O) atoms = Gram atomic mass of oxygen x No. of gram atoms of oxygen.

= 16 × 0.5 = **8g.**

(iv) 6.023 × 10^{23} molecules of oxygen (O_2) -

Step I : Calculation of no. of moles of oxygen.

No. of moles = $\dfrac{\textbf{No. of molecules oxygen}}{\textbf{Avogadro no. of molecules}} = \dfrac{\textbf{N}}{\textbf{N}_\textbf{A}}$

$$= \frac{6.023 \times 10^{23}}{6.023 \times 10^{23}} = 1 \text{mole}$$

Step II : Calculation of mass of oxygen (O_2) molecules.

Mass of oxygen (O_2) molecules = Gram molecular mass of oxygen x No. of moles of oxygen.

= 32 × 1 = 32 g

EXERCISE

OBJECTIVE DPP - 10.1

1. Which of the following has the smallest mass ?

(A) 4 g of He (B) 6.023×10^{23} atoms of He

(C) 1 atom of He (D) 1 mole atoms of He

2. The number of carbon atoms in 1 g of $CaCO_3$ is -

(A) 6.023×10^{23} (B) 6.023×10^{21} (C) 3.0125×10^{22} (D) 1.204×10^{23}

3. 6.023×10^{20} atoms of silver (Atomic mass = 108 u) weight -

(A) 108×10^3 g (B) 108 g (C) 0.108 g (D) 10.8 g

4. Which of the following has largest number of molecules ?

(A) 8 g of CH_4 (B) 4.4 g of CO_2

(C) 34.2 g of $C_{12}H_{22}O_{11}$ (D) 2 g of H_2

5. Which of the following contains one mole molecules of the substance ?

(A) 16 g Oxygen (B) 7 g Nitrogen (C) 2 g Hydrogen (D) 36 g Water.

6. The number of molecules in 16.0 g of oxygen is -

(A) 6.02×10^{23} (B) 6.02×10^{-23} (C) 3.01×10^{-23} (D) 3.01×10^{23}

7. The volume of one mole of a gas at normal temperature and pressure is -

(A) 11.2 litres (B) 22.4 litres (C) 100 litres (D) None of these

8. The number of gram atoms in 8 g of he are -

(A) 2 (B) 1.204×10^{24} (C) 3.1×10^{23} (D) None of these

9. The percentage of hydrogen in H_2O is -

(A) 8.88 (B) 11.12 (C) 20.60 (D) 80.0

10. The charge in coulombs of 1 gram ion of N^{3-} is (the charge on an electron is 1.602×10^{-19} C) -

(A) 2.894×10^5 C (B) 3.894×10^5 C (C) 2.894×10^6 C (D) None of these

11. The mass of oxygen contained in 1 kg of potassium nitrate (KNO_3) will be-

(A) 478.5 g (B) 485.5 g (C) 475.2 g (D) 488.2 g

12. 1 mole of a compound contains 1 mole of carbon and 2 moles of oxygen. The molecular weight of the compound is -

(A) 3 (B) 12 (C) 32 (D) 44

SUBJECTIVE DPP - 10.2

1. Define the term mole.

2. What is the mass of 0.2 mole of oxygen atoms ?

3. Calculate the mass of 10.044×10^{25} molecules of oxygen.

4. If 1 g of oxygen element contains X atoms, what will be the number of atoms in 1 g of aluminum ? (Atomic mass : O = 16 u, Al = 27 u)

5. Calculate the number of aluminum ions present in 0.051 g of aluminum oxide (Al_2O_3). [Atomic mass : Al = 27 u ; O = 16 u]

6. What weight of oxygen gas will contain the same number of molecules as 56 g of nitrogen gas ?
(A) Atomic mass : O : = 16 u ; N = 14u)

7. Calculate the number of atoms and volume of 1g He gas at NTP.

8. What is the mass of 4.0×10^{-3} mol of glucose, ($C_6H_{12}O_6$) ? How many carbon atoms are there is 4.0×10^{-3} mole of glucose ?

9. How many molecules of water are present in one ml of water vapours at NTP ?

10. If one takes one second to count five wheat grains, calculate the time taken is counting one mole of wheat grains.

ANSWER KEY

(Objective Dpp 7.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	D	C	B	A	C	D	A	C	B	C

2. The formula of baking soda is $NaHCO_3$.

(Subjective DPP - 7.2)

1. La of content proportion

3. Mass of oxygen = 9.6 gm, Law of conservation of mass.

(Objective Dpp 8.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	B	B	A	C	B	C	C	A	B	C

(Subjective DPP - 8.2)

2. Formula of the compound = XY_4

3. (i) Na_3PO_4 (ii) $(NH_4)_2SO_4$ (iii) $Ca(OH)_2$ (iv) $PbBr_2$

6. 1nm = 10^{-9} m

(Objective Dpp 9.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	C	B	C	D	A	B	B	A	B	

(Subjective Dpp 9.2)

1. 180 u **3.** 102 u

5. (a) Valency of A = + 5 (b) Formula of chloride of A = ACl_5

(Objective Dpp 10.1)

Qus.	1	2	3	4	5	6	7	8	9	10	11	12
Ans.	C	B	C	D	C	D	B	A	B	A	C	D

2. 3.2 g **3.** 5.33 kg **4.** $\frac{16X}{27}$ atoms **5.** 6.023×10^{20}

6. 64 g **7.** 1.5055×10^{23}, 5.6 L **8.** 0.72 g, 1.445×10^{22}

9. 0.0268×10^{21} molecules **10.** 1.2046×10^{23} sec

STRUCTURE OF ATOM

INTRODUCTION

(i) The idea of tiniest unit of matter (Anu and Parmanu) was propounded by **maharishi Kanad** in Vedic period in our country.

(ii) Democritus, a Greek philosopher also proposed that matter is made up of extremely small particles, the "atom". The name atom comes from Greek language.

(iii) John Dalton in **1808** published theory of atom assuming that atoms are the ultimate indivisible particles of matter.

(iv) Later the works f **William Crookes (1878) , J.J. Thomson** (1897) and **Goldstein** proved that atom of any element contains smaller particles which are either positively charged or negatively charged.

(v) Work of **Rutherford and Neils Bohr** confirmed that an atom consists of three subatomic particles, that are electrons, protons and neutrons.

(vi) It has been established that the central core of an atom consists of protons and neutrons and is commonly called **nucleus.** The electrons revolve around the nucleus.

(vii) The atom as a whole is **electrically neutral** as the number of protons in it, is equal to the number of electrons.

The smallest indivisible particle or unit of an element is called an atom, which can take part in a chemical reaction and may or may not exist independently.

An element is a pure substance which cannot be subdivided into two or more new substances by any means.

The word "ATOM" is given by "John Dalton".

FUNDAMENTAL PARTICLES OF AN ATOM

(a) Electron :

Electron has a **negative charge** on it, its mass is **1/1837** times the **mass of one atom of hydrogen.** It is denoted by the symbol $_{-1}^{0}\theta$, , where 0 denotes its mass and -1 denotes its charge. Electrons in the outer most shell are called **valence electrons.**

(b) Proton :

Proton has a **unit positive charge,** it is denoted by the symbol $_{+1}^{1}p$, where 1 denotes it atomic mass and +1 denotes its charge.

(c) Neutron :

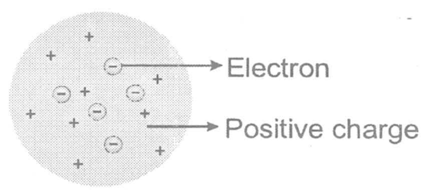
Neutron has **no electric charge** on it. Its mass is almost equal to the **mass of one atom of hydrogen.** it is denoted by the symbol $_{0}^{1}n$, , where 1 denotes its atomic mass and 0 denotes its charge.

In the neutral atom the total number of protons in the nucleus is equal to the number of electrons revolving round the nucleus.

Property	Electron	Proton	Neutron
1. Discovery	J.J. Thomson	E. Goldstein	James Chadwick
2. Symbol	e	p	n
3. Nature	Negatively charged	Positively charged	Neutral
4. Relative charge	-1	+1	0
5. Absolute charge	1.602×10^{-19} C	1.602 × 10-19 C	0
6. Relative mass	$\frac{1}{1837}$	1	1
7. Absolute mass	9.109×10^{-28} g	1.6725×10^{-24} g	1.6748×10^{-24} g

THOMSONS MODEL OF AN ATOM

After the discovery of electrons and protons **J.J. Thomson (1898)** tried to explain the arrangement of electrons and protons within the tom. **He proposed that an atom consists of a sphere of positive electricity in which electrons are embedded like plum in pudding or seeds evenly distributed in red spongy mass in watermelon.** The radius of the sphere is of the other 10^{-8} cm which is equal to the size of the atom. Although Thmoson's model could explain the electrical neutrality of an atom but this model could not satisfy experimental facts proposed by Rutherford and hence was discarded.



"Proton is a sub - atomic particle having a unit positive charge ($+1.602 \times 10^{-19}$ kg) & mass (1.6725×10^{-27} kg) which is about 1837 times greater than the mass of an electron."

RUTHERFORD'S MODEL OF AN ATOM

(a) Rutherford's Alpha Scattering Experiment :

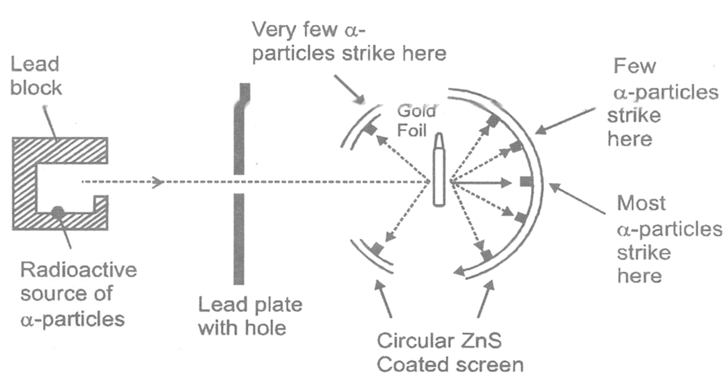
Ernest Rutherford and his coworkers performed numerous experiments in which $\alpha-$ **particles** emitted from a **radioactive element** such as polonium were allowed to strike thin sheets of metals such as **gold and platinum.**

(i) A beam of α-particles (He^{2+}) we obtained by placing polonium in a **lead box** and letting the alpha particles come out of a pinhole in the lead box. This beam of α-rays was directed against a thin **gold foil (0.00004 cm).** A circular screen coated with **zinc sulphide** was placed on the other side of the foil.

(ii) About **99% of the** $\alpha-$ **particles** passed **undeflected** through the gold foil and caused **illumination of zinc sulphide screen.**

(iii) Very few α-particles underwent small and large deflections after passing through the gold foil.

(iv) A very few (**about 1 in 20,000)** were deflected backward on their path at an angle of 180^0.



Rutherford was able to explain these observations as follows :

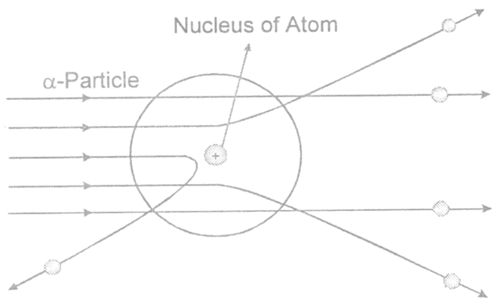
(i) Since a large number of α-particles pass through the atom **undeflected,** hence, there must be **large empty space within the atom.**

(ii) As some of the α- particles got **defleted,** therefore, there must be something **massive and positively charged present in the atom.**

(iii) The number of α**-particles** which got deflected is very small, therefore, **the whole positive charge in the atom is conventratted in a very small space.**

(iv) Some of the α-particles **retracted** their path i.e. **came almost straight back towards the sources as a result of their direct collisions with the heavy mass.**

α- particles are made up of two protons and two neutrons and are He nuclei.



The positively charged heavy mass which occupies only a small space as compared to the total space occupied by the atom is called nucleus.

(b) Rutherford's Nuclear Model of Atom :

Rutherford proposed a new picture of the structure of the atom. **Main feature of this model are as follows**

-

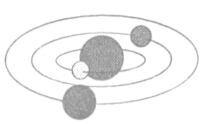
(i) The atom of an element consists of a small **positively charged "Nucleus"** which is situated at the **centre of the atom** and which carries almost the entire mss of the atom.

(ii) The **electrons** are distributed in the empty space of the atom **around the nucleus** in different **concentric circular paths (orbits).**

(iii) The number of electrons in the orbits is equal to the total number of protons in the nucleus.

(iv) Volume of nucleus is very small as compared to the volume of atom.

(v) Most of the space in the atom is **empty.**



The stability of such a system in which negatively charged electrons surround a positively charged nucleus was explained by proposing that **the electrons revolve around the nucleus at very high speed in circular orbits.** This arrangement is just like our **solar system.** The **high sped** of the moving electrons given them a **centrifugal force acting away from the nucleus.** The centrifugal force balance the electrostatic force of attraction acting between the nucleus and the electrons.

(c) Defects in Rutherford's Model :

(i) Rutherford did not specify the number of electrons in each orbit.

(ii) According to **electromagnetic theory,** if a **charged particle (electron)** is accelerated around another **charged particle (nucleus)** then there would be **continuous radiation of energy.** This **loss of energy** would slow down the **speed of electron** and eventually the **electron would fall into the nucleus.** But such a collapse does not occur. Rutherford's model could not explain this theory.

EXERCISE

OBJECTIVE DPP - 11.1

1. Where are protons located in an atom ?

(A) Around the nucleus (B) Inside the nucleus

(C) Both (A) & (B) (D) None of these

2. Which of the following statements is true ?

(A) A proton is 1837 times heavier than an electron.

(B) A proton is 1/1837 times heavier than an electron.

(C) A proton is 1/1837 times lighter than an electron.

(D) Proton has the same mass as an electron.

3. When alpha particles are sent through a thin metal foil, most of them go straight through the foil because -

(A) alpha particles are much heavier than electrons.

(B) alpha particles are positively charged.

(C) most part of the atom is empty.

(D) alpha particles move with high velocity.

4. Rutherford's scattering experiment is related to the size of -

(A) nucleus (B) atom (C) electron (D) neutron

5. The mass of a proton is -

(A) 1.00728 amu (B) 1.673×10^{-24} gm (C) 1.673×10^{-27} kg (D) all of these

6. Rutherford performed his alpha scattering experiment using -

(A) silver (B) gold (C) mercury (D) diamond

7. A proton is usually represented as -

(A) ${}_{1}^{1}p$ (B) ${}_{1}^{1}H$ (C) ${}_{2}^{4}He$ (D) both (A) & (B)

8. The protons and neutrons are collectively called -

(A) deuterons (B) positrons (C) mesons (D) nucleons

9. contains ${}_{11}^{23}Na$ -

(A) 22 protons (B) 22 neutrons (C) 12 neutrons (D) None of these

10. The credit of discovering neutron goes to -

(A) Rutherford (B) Thomson (C) Goldstein (D) Chadwick

SUBJECTIVE DPP - 11.2

1. Why were protons discovered ?

2. What is the difference between the charge & mass of a proton and an electron ?

3. Why was Thomson's atomic model discarded ?

4. Show the different observations of Rutherford's alpha scattering experiment by a diagram only.

STRUCUTRE OF ATOM

BOHR'S MODEL OF AN ATOM

Rutherford's model of the atom was unable to explain certain observations with regard to the atom i.e. stability of the atom and the occurrence of the atomic spectra. **Neils Bohr** accepted Rutherford's idea that the **positive charge** and most of the **mass** of the atom is concentrated in its **nucleus** with the **electrons** present at some distance away.

According to Bohr's theory -

(i) Electrons revolve around the nucleus in well defined **orbits or shells,** each shell having a **definite amount of energy** associated with the electrons in it. Therefore, these shells are also called **energy levels.**

(ii) The **energy** associated with the electrons in an orbit **increases** as the **radius of the orbit** increases. These shells are known as **K, L, M, N** etc. starting from the one closest to the nucleus.

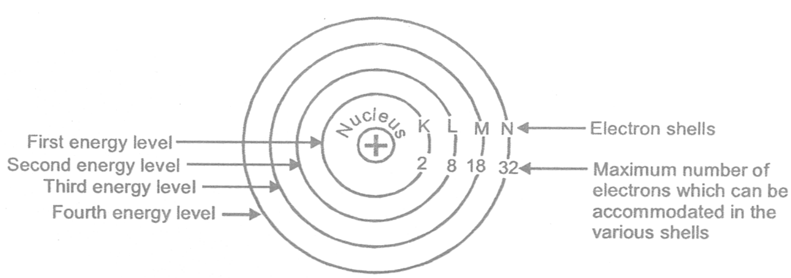
(iii) An electron in a shell can more to a higher or lower energy shell by absorbing or releasing a fixed amount of energy.

(iv) The amount of **energy absorbed** or **emitted** is given by the **difference of energies** associated with the two energy levels.

Energy absorbed, $\Delta E = E_2 - E_1 = h\nu$

Energy emitted, $\Delta E = E_2 - E_1 = h\nu$

Where h is Plank's constant ($h = 6.62 \times 10^{-34}$ Js) and ν is the frequency of the radiation.



ATOMIC STRUCTURE

An atom consists of two parts :

(a) Nucleus :

Nucleus is situated in the centre of an atom. All the **protons & neutrons are situated in the nucleus,** therefore, the entire mass of an atom is almost concentrated in the nucleus. The overall **charge of nucleus** is positive due to the **presence of positively charged protons** (neutrons present have no charge). The **protons & neutrons** are collectively called **nucleons.** The **radius** of the nucleus of an atom is of the order of 10^{-15} m.

(b) Extra nuclear region :

In extra nuclear part or in the region outside the nucleus, **electrons** are present which revolve around the nucleus in orbits of fixed energies. These orbits are called **energy levels.** These energy levels are designated as **K, L, M, N and so on.**

The maximum number of electrons that can be accommodated in a shell is given by the formula $\underline{2n^2}$ (where n = number of shell i.e. 1, 2, 3--)

Shell	n	$2n^2$	max. no. of e^-
K	1	$2(1)^2$	2
L	2	$2(2)^2$	8
M	3	$2(3)^2$	18
N	4	$2(4)^2$	32

Each energy level is further divided into subshells designated as ***s.p.d.f.***

1st shell (K) contains 1 subshell (s)
2nd shell (L) contains 2 subshells (s,p)
3rd shell (M) contains 3 subshells (s,p,d)
4th shell (N) contains 4 subshells (s,p,d,f).

ORBITALS

Like shells are divided into subshells, subshells further contain orbitals.
An orbital may be defined as a

"Region in the three - dimensional space around the nucleus where the probability of finding an electron is maximum. The maximum capacity of each orbital is that of two electrons."

Subshell	Orbital (s)	Max. no. of electrons
s	1	2
p	3	6
d	5	10
f	7	14

The total number of nucleons is equal to the mass number (A) of the atom.

EXERCISE

OBJECTIVE DPP - 12.1

1. The formula that gives the maximum number of electrons in a particular shell is -

(A) n^2 (B) $2n^2$ (C) 2n (D) $\frac{n^2}{2}$

2. The radius of an atomic nucleus is of the order of -

(A) 10^{-10} cm (B) 10^{-13} cm (C) 10^{-15} cm (D) 10^{-8} cm

3. A p-orbital can accommodate upto -

(A) 4 electrons (B) 2 electrons (C) 6 electrons (D) 3 electrons

4. Energy levels are designated as -

(A) K, L, M, N and so on

(B) k, ℓ, m, n and so on

(C) I, II, III, IV and so on

(D) All of these

5. A neutron is represented as -

(A) ${}^{0}_{0}n$ (B) ${}^{1}_{1}n$ (C) ${}^{1}_{0}n$ (D) ${}^{1}_{-1}n$

6. The different subshells in an atom are represented as -

(A) s,p,d,f (B) S,P,D,F (C) 1,2,3,4 (D) All of these

7. The maximum number of electrons is N shell is -

(A) 2 (B) 8 (C) 18 (D) 32

8. The maximum number of electrons is f - subshell is -

(A) 5 (B) 6 (C) 14 (D) 10

9. The maximum number of electrons that can be accommodated in the valence shell of an atom is -

(A) 5 (B) 6 (C) 7 (D) 8

10. The maximum number of orbitals in f - subshell are -

(A) 1 (B) 3 (C) 5 (D) 7

SUBJECTIVE DPP - 12.2

1. How did Bohr's atomic model explain the stability of an atom ?

2. Form what observations do you derive the following inferences ?

(a) The most of the space inside the atom is empty.

(b) The volume of the nucleus is very small.

3. An atom has 2K and 8L electrons. Write down its electronic configuration and indicate in it -

(a) the number of subshells.

(b) the number of orbitals.

STRUCTURE OF ATOM

ELECTRONIC CONFIGUATION OF AN ATOM

(i) Each of the orbits can accommodate a **fixed number of electrons. Maximum number of electrons** in an orbit is equal to **$2n^2$**, where 'n' is the number of the orbit.

If **$n = 1$ then $2n^2 = 2$**

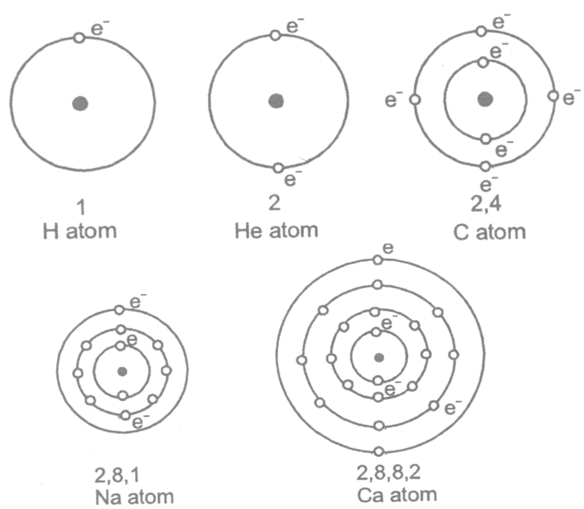
$n = 2$ then $2n^2 = 8$

$n = 3$ then $2n^2 = 18$

$n = 4$ then $2n^2 = 32$

(ii) In the outermost shell of any atom, the maximum possible number of electrons is 8, except in the first shell which can have at the most 2 electrons.

(iii) The arrangement of the electrons is different shells is known as the **electronic configuration** of the element. The pictorial representations of Bohr's model o hydrogen, helium, carbon, sodium and calcium atoms having 1, 2, 6, 11 and 20 electrons respectively are shown in the figure where the centre of the circle represents the nucleus.



If the outermost shell has 8 electrons it is said to be an octet. If the first shell has its full quota of 2 electrons, it is said to be duplet.

ELECTRONIC CONFIGURATION OF ELEMENTS UPTO ATOMIC NUMBER 30-

Atomic number	Symbols of the element	Name of the element	Electronic configuration
1	H	Hydrogen	1
2	He	Helium	2
3	Lo	Lithium	2,1
4	Be	Beryllium	2,2
5	B	Boron	2,3
6	C	Carbon	2,4
7	N	Nitrogen	2,5
8	O	Oxygen	2,6
9	F	Fluorine	2,7
10	Ne	Neon	2,8
11	Na	Sodium	2,8,1
12	Mg	Magnesium	2,8,2
13	Al	Aluminium	2, 8,3
14	Si	Silicon	2 ,8, 4
15	P	Phosphorus	2, 8,5
16	S	Sulphur	2,8,6
17	Cl	Chlorine	2,8,7
18	Ar	Argon	2,8,8
19	K	Potassium	2,8,8,1
20	Ca	Calcium	2,8,8,2
21	Sc	Scandium	2,8,9,2
22	Ti	Titanium	2,8,10,2
23	V	Vanadium	2, 8,11,2
24	Cr	Chromium	2,8,12,2
25	Mn	Manganese	2,8,13,2
26	Fe	Iron	2,8,14,2
27	Co	Cobalt	2,8,15,2
28	Ni	Nickel	2,8,16,2
29	Cu	Copper	2,8,17,2
30	Zn	Zinc	2,8,18,2

VALENCY

Valency of an element is the combining capacity of the atoms of the element with atoms of the same or different elements. The combining capacity of the atoms of other elements was explained in terms of their tendency to attain a fully - filled outermost shell (stable octet or duplet).

The number of electrons gained, lost or contributed for sharing by an atom of the element gives us directly the combining capacity or valency of the element.

Valency of an element is determined by the number of valence electrons in an atom of the element.

The valency of an element = number of valence electrons
(when number of valence electrons are from 1 to 4)

The valency of an element = 8 - number of valence electrons.
(when number of valence electrons are more than 4)

eg. Na has 1 valence electron, thus, its valency is 1.
Cl has 7 valence electrons, thus, its valency is 8 - 7 = 1.

ATOMIC NUMBER (Z)

The number of protons is the nucleus of an atom of a given element is called the atomic number of that element.

or

Atomic number is the number of protons present in the atom of an element. It is **denoted. by “Z”**

Atomic number = Number of protons = Number of electrons

(in a neutral atom)

Atomic number = Number of protons

(in an ion)

e.g. $_{11}Na$

-Atomic number of sodium is 11

-Nucleus of sodium has 11 protons.

- Nucleus of sodium has 11 units of positive charge.

- There are 11 electrons, revolving round the nucleus of sodium.

The atomic number is represented on the LHS of the symbol of the element as subscript.

MASS NUBER (A)

Mass number is the number of protons and neutrons present in the atom of an element. It is denoted by “A”. The mass number is represented either on the left hand side (LHS) or on the right hand side (RHS) of the symbol of the element as superscript.

Mass number = Number of protons + Number of neutrons.

e.g. $^{27}_{13}Al$

-Mass number of aluminum is 27.

-The total number of protons and neutrons is the nucleus of aluminum is 27.

-Number of protons is 13.

-Number of neutrons is = 27 - 13 = 14.

Each element has a unique atomic number which is its identity.

(a) Relation between Z, A and N

A = Z + N

Z = Number of Protons

N = Number of neutrons

A = Mass number

$\therefore$ N = A - Z

ISOTOPES

(a) Atoms of same element having the same chemical properties, but differing in mass are known as isotopes.

The isotopes of an element have the same atomic number but different atomic masses. Isotopes have the same electrical charges means same number of protons. The difference in their masses is due to the presence of different number of neutrons.

e.g. (a) Isotopes of hydrogen

Hydrogen Characteristics \ isotopes	Protium $^{1}_{1}H$	Deuterium $^{2}_{1}H$	Tritium $^{3}_{1}H$
1. Atomic number	**1**	**1**	**1**
2. No. of protons	**1**	**1**	**1**
3. No. of electrons	**1**	**1**	**1**
4. No. of neutrons	**0**	**1**	**2**
5. Mass number	**1**	**2**	**3**

(b) Isotopes of oxygen

Characteristics \ Oxygen isotopes	$^{16}_{8}O$	$^{17}_{8}O$	$^{18}_{8}O$
1. Atomic number	**8**	**8**	**8**
2. No. of protons	**8**	**8**	**8**
3. No. of electrons	**8**	**8**	**8**
4. No. of neutrons	**8**	**9**	**10**
5. Mass number	**16**	**17**	**18**

All the isotopes of an element have identical chemical properties.

(b) Characteristics of Isotopes :

(i) The **physical properties** of the isotopes of an element are **different number of neutrons** in their nuclei. Hence **mass, density and other physical properties of the isotopes of an element are different.**

(ii) All the **isotopes** of an element contains the **same number of electrons.** So, they have the same electronic configuration with the same number of valence electrons. Since the chemical properties of an element are determined by the number of valence electrons in its atom, all the isotopes of an element have **identical chemical properties.**

(c) Reason for the fractional atomic masses of elements :

The **atomic masses** of many elements are in **fraction** and not whole number. The fractional atomic masses of elements are due to the existence of their isotopes having different masses.

e.g. :

The **atomic mass of chlorine** is **35.5 u.** Chlorine has two isotopes $^{35}_{17}Cl$ and $^{37}_{17}Cl$ with abundance of 75% and 25% respectively. Thus the average mass of a chlorine atom will be 75% of Cl - 35 and 25% of Cl-37, which is 35.5 u.

i.e., average atomic mass of chlorine $= 35 \times \frac{75}{100} + 37 \times \frac{25}{100}$

$= \frac{2625}{100} + \frac{925}{100}$

$= 26.25 + 9.25$

$=$ **35.5 u.**

Thus, the average atomic mass of chlorine is 35.5 u.

Similarly, average atomic mass of copper is 63.5 u.

(d) Applications of Radioactive isotopes :

(i) In agriculture : Certain elements such as **boron, cobalt, copper, manganese, zinc and molybdenum** are necessary is very minute quantities for **plant nutrition.**

By radioactive isotopes we van identify the presence and requirements of these element in the nutrition of plants.

(ii) In industry : Coating on the arm of clock to seen in dark. To identify the **cracks in metal casting.**

(iii) In medicine : Thyroid, bone diseases, brain tumours and **cancer** and diagnosed, controlled or destroyed with the help of radioactive isotopes like $^{60}_{27}Co$, $^{24}_{21}$**Na, iodine, phosphorus** etc.

(iv) Determination of the mechanism of chemical reaction : by replacing an atom or molecule by its isotope.

(v) In carbon dating : Will and Libby (1960) developed the technique of **radiocarbon dating** to **determine the age of plants, fossils and archeological samples.**

Isotopes (Like Uranium - 238) are used in nuclear reactor to produce energy and power.

ISOBARS

the atoms of different elements with different atomic numbers, but same mass number are called isobars.

e.g. ${}^{14}_{6}C$ and ${}^{14}_{7}N$ are isobars ${}^{40}_{20}Ca$ and ${}^{40}_{18}Ar$ are isobars

Characteristics \ Isobars	${}^{40}_{18}Ar$	${}^{40}_{20}Ca$
1. Atomic number	18	20
2. Mass number	40	40
3. No. of electrons	18	20
4. No. of protons	18	20
5. No. of neutrons	22	20
6. Electronic configuration	2.8.8	2,8,8,2

ISOTONES

The isotones may be defined as the atoms of different elements containing same number of neutrons.

e.g. ${}^{13}_{6}C$ and ${}^{14}_{7}N$

Number of neutrons (N) = A - Z

For ${}^{13}_{6}C$ N = 13 - 6 For ${}^{14}_{7}N$ N = 14 - 7

Other example ${}^{30}_{14}Si$, ${}^{31}_{15}P$ and ${}^{32}_{16}S$

ISOELECTRIC

Ion or atom or molecule which have the same number of electrons are called as isoelectronic species.

e.g.	Cl^-	**Ar**	K^+	Ca^{+2}
No. of electrons	**18**	**18**	**18**	**18**

Isobars contain different number of electrons, protons and neutrons.

SOLVED EXAMPLES

1. Calculate the number of electrons, protons and neutrons in the following species.
(i) Phosphorus atom (ii) Phosphide ion (P^{3-}) (iii) Magnesium ion (Mg^{2+})
Mass number : P = 31, Mg = 24
Atomic numbers : P = 15, Mg = 12

Sol. (i) **Phosphorus atom**
Number of electrons = Atomic number = 15
Number of protons = Atomic number = 15
Number of neutrons = Mass number - Atomic number = 31 - 15 = 13.
(ii) Phosphide ion (P^{3-}).
Phosphide ion (P^{3-}) = Phosphorus atom + 3 electrons
$P^{3-} \equiv P + 3e^-$
Thus, phosphide ion has same number of protons and neutrons as phosphorus atom but has three electrons more.
Number of electrons = 15 + 3 = 18
Number of protons = 15
Number of neutrons = 31 - 15 = 16
(iii) Magnesium ion (Mg^{2+})
Mg^{2+} ion is formed by the loss of two electrons by Mg atom. Therefore, it has two electrons less than the number of electrons is Mg atom.
Number of electrons = 12 - 2 = 10
Number of protons = 12
Number of neutrons = (24 - 12_ = 12

2. The number of protons in the nucleus of an atom of mass number 97 is 41. What will be the number of neutrons in its isotope of mass number 99 ?

Sol. The atomic number of isotopes is same. Therefore, the number of protons in both the atoms is same.
Mass number = Number of protons + Number of neutrons
∴ Number of neutrons = Mass number - Number of protons
= 99 - 41 = 58

3. Give number of protons and neutrons in $^{238}_{92}U$.

Sol. From the given symbol it is clear that the atomic number of uranium is 92 and its mass number is 238.
Now, number of protons = Atomic number = 92
Number of neutrons = Mass number - Atomic number
= 238 - 92 = 146

4. Calculate the atomic number of an element whose mass number is 31 and number of neutrons is 13. What is the symbol of the element ?

Sol. We know that, mass number = Number of protons + Number of neutrons
But number of protons is equal to the atomic number.
∴ **Mass number = Atomic number + number of neutron**
or Atomic number = Mass number - number of neutron = 31 - 16 = 15
The element with atomic number 15 is **phosphorus** which has symbol **P.**

5. If bromine atom is available in the form o f, say two isotopes $^{79}_{35}Br$ (49.7%) and $^{81}_{35}Br$ (50.3%), calculate the average atomic mass of bromine atom.

Sol. % of Br (79) = 49.7 ; % of Br (81) = 50.3

Atomic mass of Br = $\dfrac{79 \times 49.7 + 81 \times 50.3}{100}$

= 80.0

Thus, **atomic mass of bromine is 80.0**

6. An isotope has atomic number 17 and mass number 37. What is the arrangement of electrons in the shells of this isotope ? State nuclear composition of this isotope.

Sol. Number of electrons = Atomic number = 17

Number of protons = Atomic number = 17

Number of neutrons = Mass number - Atomic number = 37 - 17 = 20

Electronic configuration of the isotope is

K	L	M
2	8	7

Nucleus of the isotope contains **17 protons** and **20 neutrons.**

7. An element has 2 electrons is the M-shell. What is the electronic configuration of the element and what is its atomic number ?

Sol. The 2 electrons in M-shell indicates that the K and L - shell must be full. K - shell can accommodate a maximum of 2 electrons while L-shell can accommodate a maximum of 8 electrons. Thus, the electronic configuration of the element may be written as :

K	L	M
2	8	2

The total number of electrons is an atom of the element is 2 + 8 + 2 = 12

Therefore, **atomic number of element** is 12.

8. How will you find the valency of chlorine, sulphur and magnesium ?

Sol. (i) The atomic number of Cl is 17. Its electronic configuration is

K	L	M
2	8	7

Cl has 7 electrons in the valence shell. It needs one more electron to complete its octet. Hence, its **valency is 1.**

(ii) The atomic number of S is 16. Its electronic configuration is

K	L	M
2	8	6

S has 6 electrons is the valence shell. It requires two more electrons to complete its octet. Hence, its **valency is 2.**

(iii) The atomic number of Mg is 12. Its electronic configuration is

K	L	M
2	8	2

Mg has only 2 electrons in the valence shell. By losing these 2 electrons it can attain octet of electrons in its outer most shell. Hence, it **valency is 2.**

EXERCISE

OBJECTIVE DPP - 13.1

1. The number of valence electrons in Na is -
(A) 1 (B) 2 (C) 3 (D) 4

2. The valency of $_{10}Ne$ = 2, 8 is -
(A) 10 (B) 8 (C) 2 (D) 0

3. Which of the following has the same number of protons, electrons & neutrons ?
(A) $^{54}_{27}X$ (B) $^{55}_{27}X^{+1}$ (C) $^{54}_{26}X$ (D) $^{55}_{28}X^{+}$

4. In an atom there are four orbits, the maximum number of electrons in this atom will be -
(A) 30 (B) 36 (C) 32 (D) 62

5. Isotones of an element have -
(A) same number of electrons (B) same number of protons
(C) same number of neutrons (D) same number of neutrons & protons

6. An isotone of $^{76}_{32}Ge$ is -

(A) $^{77}_{32}Ge$ (B) $^{77}_{33}As$ (C) $^{77}_{34}Se$ (D) $^{79}_{34}Se$

7. Many element have non - integral masses because -

(A) they have isobars.

(B) their isotopes have non - integral masses.

(C) they have isotopes.

(D) the constituents neutrons, protons & electrons combine to give fractional masses.

8. A deuteron contains -

(A) a neutron & a positron. (B) a neutron & a proton.

(C) a neutron & 2 protons (D) 2 neutrons & a proton.

9. The triad of nuclei that is isotonic is -

(A) $^{14}_{6}C, ^{15}_{7}N, ^{17}_{19}F$ (B) $^{12}_{6}C, ^{14}_{7}N, ^{19}_{9}F$ (C) $^{14}_{6}C, ^{14}_{7}N, ^{17}_{9}F$ (D) $^{14}_{6}C, ^{14}_{7}N, ^{19}_{9}F$

10. Pick out the isoelectronic structures from the following -

(I) CH_3^+ (II) H_3O^+ (III) NH_3 (IV) CH_3^-

(A) I and II (B) III and IV (C) I and III (D) II, III, IV

11. Two atoms of the same element are found to have different number of neutrons in their nuclei. These two atoms are -

(A) isomers (B) isotopes (C) isobars (D) allotropes

12. Members of which of the following have similar chemical properties ?

(A) Isotopes (B) Isobars

(C) Allotropes (D) Both isotopes & allotropes

13. An atom which as a mass number of 14 & 8 neutrons is an -

(A) isotope of oxygen (B) isobar of oxygen

(C) isotope of carbon (D) isobar of carbon

14. The electronic configuration of Mn^{+2} is -

(A) 2, 8, 13 (B) 2, 8, 11, 2

(C) 2, 8, 13, 2 (D) None of these

15. The number of electrons in the L - shell of phosphorus is not equal to that in the -

(A) L - shell of neon (B) M - shell of potassium

(C) M - shell of chromium (D) M - shell of argon

SUBEJCTEIVE DPP - 13.2

1. Why is the valency of inert gases zero ?
2. Find out the number of electrons, protons and neutrons in the following -

   (a) oxygen atom (b) oxide ion (O^{-2}) (c) oxygen molecule
3. Which isotope of hydrogen is present in heavy water ?
4. Ar (40) & Ca (40) have the same mass number but their properties are entirely difference. Why ?
5. Mention three applications of radioactive isotopes.

ANSWER KEY

(OBJECTIVE DPP - 11.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	B	A	C	A	D	B	D	D	C	D

2. Charge of a proton = 1.602×10^{-19} C

Charge of an electron = 1.602×10^{-19} C

Mass of a proton = 1.6725×10^{-24} g

Mass of a electron = 9.109×10^{-28} g

(OBJECTIVE DPP - 12.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	B	B	B	A	C	A	D	C	D	D

3. The electronic configuration of the given atom is 2, 8.s
(a) 3 (b) 5

(OBJECTIVE DPP - 13.1)

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	A	D	A	B	C	B	C	B	A	D
Qus.	11	12	13	14	15					
Ans.	B	D	C	A	C					

2. (a) 8,8,8 (b) 10,8,8 (c) 16,16,16 **3.** D_2O