



# MATRIX OLYMPIAD

The Most Innovative Talent Recognition Exam

# CHEMISTRY

Class - IX



# MATRIX

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## *Few words for the Readers*

Dear Reader,

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The above thought has been our guiding principle while designing and collating the study material for **Matrix Olympiad** . And hence, we hope that this particular material will be helpful towards your preparation for **Matrix Olympiad**.

Our team at **MATRIX** has put in their best efforts for making this particular module interesting and relevant for you. Additional efforts have been made to ensure that the content is easy to understand and error free to the extent possible. However, there might remain some inadvertent errors in answer keys and theoretical portion and we would welcome your valuable feedback regarding the same.

If there are any suggestions for corrections, please write to us at [smd@matrixacademy.co.in](mailto:smd@matrixacademy.co.in) and we would be highly grateful.

Finally, we would like to end this message by a famous quote by Ernest Hemingway - *"There is no friend as loyal as a book."* So, please give your study material the time and attention it deserves, and it will surely help you reach newer heights in your fight with competition examinations.

With love and best wishes !

Team MATRIX

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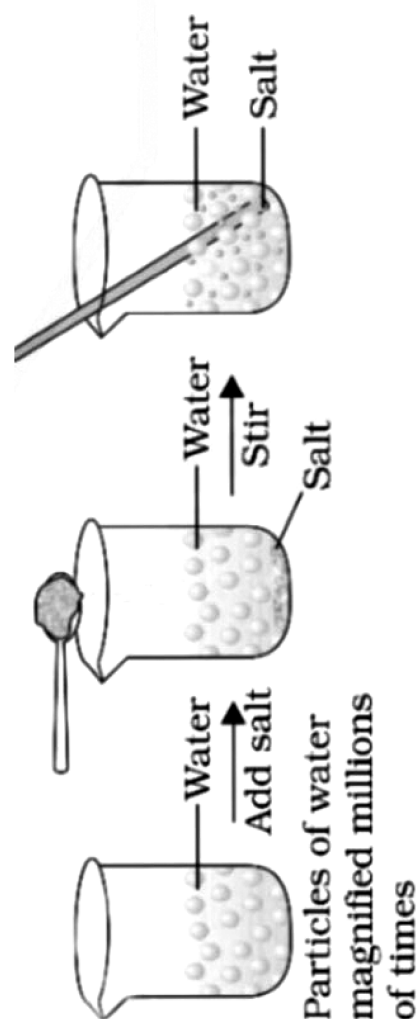
# MATTER IN OUR SURROUNDINGS

# 1

## Concepts

### Introduction

1. Physical Nature of Matter
2. Characteristics of Particles of Matter
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## 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 its 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 weigh it carefully, we will find that not only does air occupy space (bounded by the balloon), but it 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 offers resistance is called matter.

### 1. PHYSICAL NATURE OF MATTER

From a long time there were two views about the physical nature of matter.

**(a) Continuous nature**, Like a block of wood or sheet of glass.

**(b) Particulate nature**, that matter is made up of particles like sand.

To understand whether the matter is continuous or particulate in nature hold a sheet of glass in your hand, it appears continuous. Now throw it on the floor, it breaks into small or tiny particles. This shows that matter is not continuous but is made up of small particles. In fact, all matter in this universe is made up of small particles. These particles which make up all the matter around us are either atoms or molecules however these particles differ from one kind of matter to the other.

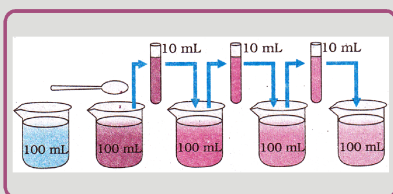
Thus Matter is made up of a large number of particles and size of these particles are very small.

### LAB TIME

Let's Do & Learn



- **Objective** : To demonstrate that the particles of a matter are very small.
- **Preparation Materials** : Potassium permanganate crystals, water and beakers.
- **Procedure** :
  1. Take a 2-3 crystals of potassium permanganate and dissolve in 100 mL of water.
  2. Take 10 mL of this purple solution and mix with 90 mL of fresh water in second beaker.
  3. Take 10 mL of this second solution and mix with 90 mL of fresh water in third beaker.
  4. Take 10 mL of this third solution and mix with 90 mL of fresh water in fourth beaker. Dilute the solution five to six times.



- **Observation** : The water in the last beaker is still coloured and is light pink now.
- **Conclusion** : Just 2-3 crystals of potassium permanganate produce purple colour in large volume of water. It shows that the particles of matter are very small.

## 2. CHARACTERISTICS OF PARTICLES OF MATTER

### (a) The particles of matter have spaces between them

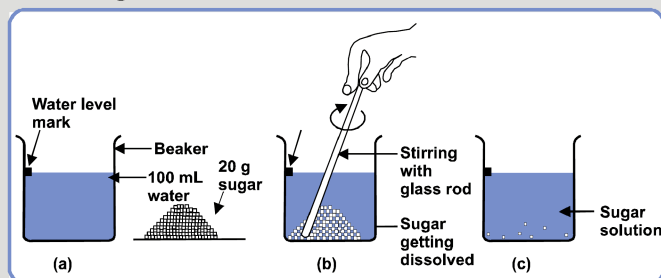
The particles of matter have some spaces between them. It can be understood by following activity.

### LAB TIME

Let's Do & Learn



- **Objective :** To demonstrate that the particles of a matter have spaces between them
- **Preparation Materials Required :** Salt or sugar, Beaker and water
- **Procedure :**
  1. Take a beaker and fill it half with water.
  2. Mark the level of water
  3. Dissolve some salt or sugar in it.



- **Observation :** Water level remains the same as earlier.
- **Conclusion :** When sugar or salt is dissolved in water, the particles of sugar or salt get into the spaces between particles of water.

### (b) The particles of matter are constantly moving

The particles of matter move constantly. This property can be explained by following activity.

### LAB TIME

Let's Do & Learn



- **Objective :** To demonstrate that the particles of a matter are continuously moving.

#### Experiment –1

- **Preparation Materials Required :** Incense stick and match Box
- **Procedure :** Light an incense stick (agarbatti) in one corner of a room.
- **Observation :** The fragrance spreads in the entire room quickly
- **Conclusion :** The vapours of incense stick get mixed with air and move rapidly in the room.  
Thus particles of matter are in continuous motion.

#### Experiment –2

- **Preparation Materials Required :** Crystals of copper sulphate , water and beakers.
- **Procedure :** Put a few crystals of copper sulphate in a beaker containing water. Do not stir.
- **Observation :** The water of the whole beaker turns blue after some time.
- **Conclusion :** The spreading of blue colour of copper sulphate is due to the movement of copper sulphate and water particles.



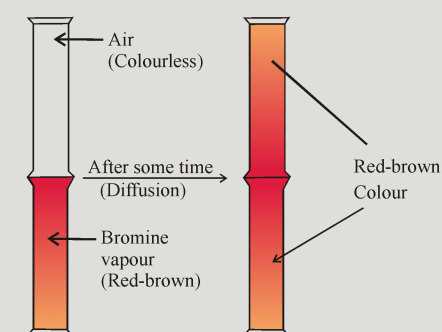
## Focus Point

**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.

**Experiment** : We take a gas jar full of bromine vapours and invert another gas jar containing air over it, then after some time, the red-brown vapours of bromine spread out into the upper gas jar containing air.

**Conclusion** : In this way, the upper gas jar which contains colourless air in it, also turns red-brown. The mixing is due to the diffusion of bromine vapours (or bromine gas) into air.



**Figure : Diffusion of bromine vapour into air**

**(c) The particles of matter attract each other** : There are some forces of attraction between the particles of matter which bind them together. It can be understood by following activity.

## LAB TIME

Let's Do & Learn



- **Objective** : To demonstrate the strength of attractive forces between particles of different kinds of matter.
- **Materials Required** : Iron nail, piece of chalk, ice cube and hammer.
- **Procedure** : Take an iron nail, a piece of chalk and a cube of ice. Try to break each of them by beating with a hammer.
- **Observation** : It is very easy to break the piece of chalk into smaller particles. It requires more force to break a cube of ice whereas the iron nail does not break at all.
- **Conclusion** : The force of attraction between particles of chalk is weaker than that of ice while the force of attraction between particles of iron is very strong.



## Focus Point

- **Cohesive Force** : The force of attraction between the particles of same substances is called cohesive force.
- **Adhesive Force** : The force of attraction between the particles of different substances is called adhesive force

### 3. STATES OF MATTER

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

(i) Solids (ii) Liquids (iii) Gases

#### 3.1 THE SOLID STATE

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

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

**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 on cooling.
- Solids diffuse into one another very slowly.

#### 3.2 THE LIQUID STATE

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

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

**Properties :**

- Liquids have a definite mass and volume.
- Liquids 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 expand far more than solids on heating.
- The particles of two different liquids can diffuse in one another easily to form homogeneous mixture.

#### 3.3 THE GASEOUS STATE

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.

**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.

- (v) Intermolecular forces are negligible.
- (vi) Gases expand to large extent when heated.
- (vii) Gases diffuse in one another rapidly to form homogeneous mixture



### Focus Point

- RIGID AND FLUID

**(a) 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.

**(b) Fluids :** Fluids are the substances which have tendency to flow. A liquid is a fluid form of matter 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.

- Liquids and gases are known as fluids.

## 4. FOURTH AND FIFTH STATE OF MATTER

### 4.1 PLASMA

It is the fourth state of matter. Scientists are reported to have discovered a new state of matter which is called plasma state. This state does not fit into any of the known three states of matter. Hence, it is often called the fourth state of matter. Plasma state consists of highly ionized gas in which the particles exist in super energetic and super excited states.

The discovery of plasma has found some practical applications. We very well know about fluorescent tubes and neon sign bulbs. The fluorescent tubes contain helium or some other gas. When electric current is passed through the gas, it produces glowing plasma, having a characteristic colour depending upon the nature of the gas.

Plasma is produced in the sun and in the stars due to high temperature. It is the presence of plasma that makes them glow.

### 4.2 BOSE-EINSTEIN CONDENSATE

It is the fifth state of matter.

In 1920, the noted Indian scientist Satyendra Nath Bose on the basis of his statistical calculations gave the concept of the fifth state of matter. Einstein too predicted the possibility of such a state. Later three American scientists succeeded in obtaining this state by supercooling a gas of extremely low density, The process is called Bose-Einstein condensation, and this state of matter is called Bose-Einstein Condensate (BEC).

## 5. COMPARISON OF THE CHARACTERISTICS OF THREE STATES OF MATTER

Property	Solid state	Liquid state	Gaseous state
Interparticle spaces	Very small spaces	Comparatively large spaces than solids	Very large spaces
Interparticle forces	Very strong	Weak	Very weak
Nature	Very hard and rigid	Fluid	Highly fluid
Compressibility	Negligible	Very small	Highly compressible.
Shape and volume	Definite shape and volume	Indefinite shape, but definite volume	Indefinite shape as well as volume
Density	High	Less than solid state	Very low density
Kinetic energy	Low	Comparatively high than solids	Very high
Diffusion	Negligible	Slow	Very fast



## Focus Point

- Gases are Highly Compressible therefore :
  - (1) LPG (Liquefied Petroleum Gas) is used in our home for cooking.
  - (2) Oxygen cylinders supplied to hospitals contain liquid oxygen.
  - (3) These days C.N.G. (Compressed Natural Gas) is used as fuel in vehicles.
- Gaseous particles move randomly at high speed and hit each other and also walls of the container, so exert pressure.

## 6. CAN MATTER CHANGE ITS STATE

We all know from our observation that water can exist in three states of matter—solid as ice, liquid as the familiar water and gas as water vapour .

A substance may exist in three states of matter i.e. solid, liquid or gas depending upon the conditions of temperature and pressure. By changing the conditions of temperature and pressure, all three states could be obtained.

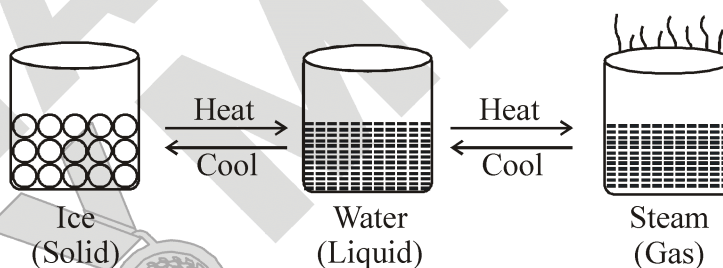
The phenomenon of change of matter from one state to another state and back to original state, by altering the conditions of temperature and pressure, is called interconversion of states of matter.

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

(a) Temperature

(b) Pressure

### 6.1 ALTERING THE TEMPERATURE OF MATTER



#### Solid to Liquid Change : Melting

- The process in which a solid changes into a liquid on heating is called melting or fusion.
  - The temperature at which a solid changes into liquid at atmospheric pressure is called melting point of the substance
  - Higher the melting point, stronger are the forces of attraction between the particles.
- e.g. : Ice at  $0^{\circ}\text{C}$  changes into water at  $0^{\circ}\text{C}$ , when heat energy is supplied to it.

#### Liquid to solid Change : Freezing

- The process of changing a liquid into solid by cooling is called freezing.
  - Freezing is also called solidification and is reverse of melting.
  - The temperature at which a liquid freezes to become a solid at atmospheric pressure is called the freezing point.
- e.g. : Water at  $0^{\circ}\text{C}$  changes into Ice at  $0^{\circ}\text{C}$ , when cooling it.



## Focus Point

The numerical value of melting point and boiling point is same.

Melting point of ice = Freezing point of water =  $0^{\circ}\text{C}$

### Liquid to Gas Change : Boiling or Vaporisation

- The process in which a liquid substance changes into a gas on heating is called boiling or vaporisation.
  - The temperature at which a liquid boils and changes into gas at atmospheric pressure is called boiling point of the liquid.
  - Impurities increase the boiling point of liquids.
  - Boiling point of water is taken as 373 K at 1 atm pressure.
  - Higher the boiling point, stronger are the forces of attraction between the particles.
- e.g. : Water at  $100^{\circ}\text{C}$  changes into water vapour at  $100^{\circ}\text{C}$ , when heat is supplied to it.



## Focus Point

Differences between Gas and Vapour

- A substance is said to be a gas if its boiling point is below room temperature. For example, oxygen, nitrogen, carbon dioxide, etc. If the normal physical state of a substance is either a solid or a liquid but gets converted into the gaseous state either on its own or by absorbing energy, the gaseous state is called the vapour state. For example, vapours of water in air.
- In pressure cooker, water is subjected to heating in a closed vessel in confined space. The steam generated in fixed volume increases the pressure beyond the normal atmospheric pressure so the boiling point of water rises above  $100^{\circ}\text{C}$ . Because the temperature of cooking medium is greater than the normal boiling point, the food gets cooked at a faster rate.

### Gas to Liquid Change : Condensation

- The process of changing a gas to a liquid on cooling is called condensation.
- Condensation is the reverse of vaporisation.
- The constant temperature at which a gas changes into liquid state by giving out heat energy at atmospheric pressure is called condensation point.



## Focus Point

The numerical value of condensation point and boiling point is same.

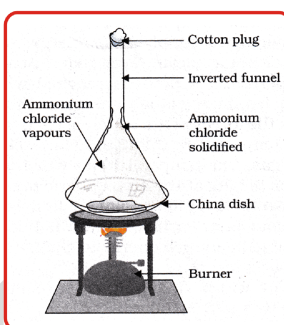
Condensation point of water vapour = Boiling point of water =  $100^{\circ}\text{C}$

**Solid to Gas or Gas to solid Change : Sublimation**

- The process of change of a solid state directly to gaseous state on heating and vice-versa on cooling without passing through the liquid state is called sublimation.



- A gaseous state directly formed from a solid on heating is known as sublime. A solid state of matter formed directly from its gaseous state on cooling is known as sublimate.
- Few examples of the substances which sublime are camphor, ammonium chloride, naphthalene, iodine, solid carbon dioxide, etc.



**Focus Point**

- SCALE OF MEASURING TEMPERATURE**  
There are three scales of temperature  
Celsius scale ( $^{\circ}\text{C}$ ), Fahrenheit scale ( $^{\circ}\text{F}$ ) and Kelvin scale (K)  
 $\text{K} = 273 + ^{\circ}\text{C}$   
 $^{\circ}\text{F} = \frac{9}{5} (^{\circ}\text{C}) + 32$

**6.2 ALTERING THE PRESSURE OF MATTER**

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 ( $\text{CO}_2$ ) is a gas under normal conditions of temperature and pressure. It can be liquefied by compressing it to a pressure 70 times more than atmospheric pressure. Solid  $\text{CO}_2$  is known as 'Dry ice'. Solid  $\text{CO}_2$  is extremely cold and used to 'deep freeze' food and to keep ice-cream cold.

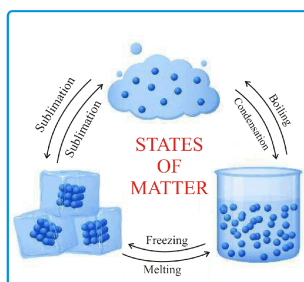
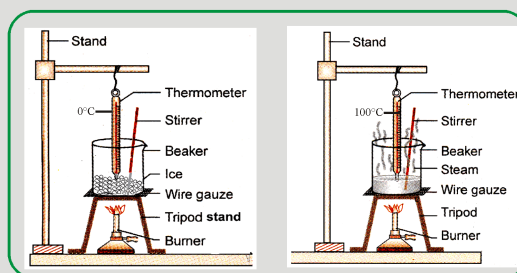


Figure : Inter Conversion of States of Matter

## LAB TIME

Let's Do & Learn

- **Objective :** To demonstrate that the temperature remains constant during the change of state.
- **Preparation Materials Required :** Ice, thermometer and beaker
- **Procedure :**
  - (i) Take about 100 g of ice in a beaker. Hang a laboratory thermometer, in it such that its bulb is in contact with ice.
  - (ii) Note down the initial temperature and start heating the beaker.
  - (iii) Note the temperature when ice starts changing to water.
  - (iv) Note the temperature when the complete ice has been converted to water.
  - (v) Continue heating and note the temperature when water starts changing to vapours.
  - (vi) Note the temperature when most of the water has vaporised.



**Figure : Conversion of Ice into Water and Water into Water Vapour**

- **Observations :** There is no change in temperature till all the ice melts though heating continues.  
Temperature remains constant at 0°C.  
Once the ice is converted to water, the temperature starts rising till the water begins to boil. Once the water starts boiling, the temperature remains constant at 100°C till all the water has changed into vapours.
- **Conclusion :** During the change of state from solid to liquid or from liquid to gas, the temperature remains constant till all the solid has melted or all the liquid has vaporised. The heat energy supplied is used up in overcoming the forces of attraction and hence the thermometer does not show any rise in temperature.

## 7. LATENT HEAT(HIDDEN HEAT)

It is observed that the temperature of the system does not change after melting point is achieved till all the ice melts, though we continue to heat the beaker. This happens because the heat supplied is used up in changing the state by breaking the intermolecular forces of attraction which hold them in solid state. As a result, there is no change in temperature till all the ice melts. This energy required to change solid into liquid is called “latent heat”

The word “latent” means “hidden” because this energy is hidden into the contents of the beaker. Latent heat is of two types

- (a) Latent heat of fusion
- (b) Latent heat of vaporization

### 7.1 LATENT HEAT OF FUSION

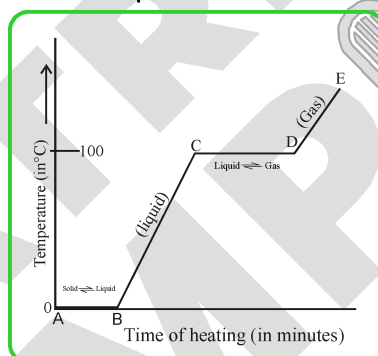
- It is defined as the amount of heat energy required to change 1 kg of a solid into liquid at atmospheric pressure without any change in temperature at its melting point.
- It is observed that latent heat of fusion of ice is  $3.34 \times 10^5$  J/kg or 80 kcal/kg.
- Ice at 273 K is more effective in cooling than water at 273 K. This is due to the reason that for melting, each kilogram of ice absorbs latent heat of  $3.347 \times 10^5$  joules from the substance and hence cools the substance more effectively.

### 7.2 LATENT HEAT OF VAPORISATION

- It is defined as the amount of heat energy required to change 1 kg of the liquid into vapour at its boiling point without any change in temperature.
- Latent heat of vaporisation of water is  $22.5 \times 10^5$  J/kg or 540 kcal/kg.
- Steam contains more heat in the form of latent heat than boiling water.

## 8. TEMPERATURE TIME GRAPH

We can show the change of temperature with time in the form of a temperature-time graph drawn by using the readings obtained in the above experiment. Such a temperature-time graph is shown in figure.



**Figure : Temperature Time Graph**

We can understand the above graph by taking an example of water. In this graph at point A, we have all ice. As we heat it, the ice starts melting to form water but the temperature of ice and water mixture does not rise. It remains constant at  $0^\circ\text{C}$  during the melting of ice. At point B, all the ice has melted to form water. Thus, we have only water at point B. Now, on heating beyond point B, the temperature of water (formed from ice) starts rising as shown by the sloping line BC in the graph. When the temperature of water reaches its boiling point i.e;  $100^\circ\text{C}$ , water starts converting into steam. But during the process of boiling, temperature does not rise and thus constant temperature is observed (line CD). At point D all the water has boiled to form steam. Thus, we have only steam at point D. Now on heating beyond point D, the temperature of steam rises as shown by the sloping line DE.

## 9. EVAPORATION

- The process of conversion of a liquid into vapours at any temperature below its boiling point is called evaporation.
- At any given temperature, the kinetic energy of some particles on the surface of a liquid is high enough to overcome the forces of attraction by other particles, hence they leave the liquid and are converted into vapours.
- During evaporation, a liquid absorbs heat energy from any other body in contact with it or from the surroundings.

### 9.1 FACTORS AFFECTING EVAPORATION

There are various factors which effect process of evaporation.

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

Rate of evaporation  $\propto T$

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

**(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 decreases in the surroundings.

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

### 9.2 DIFFERENCES BETWEEN EVAPORATION AND BOILING

Evaporation	Boiling
It is a surface phenomenon.	It is bulk phenomenon.
It occurs at all temperatures below B.P.	It occurs at B.P. only.
The rate of evaporation depends upon the surface area of the liquid, humidity temperature & wind speed.	The rate of boiling does not depend upon the surface area, wind speed, and humidity.

### 9.3 COOLING CAUSED 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 :

**(i) 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.

**(ii) Pouring the acetone on our palm :**

If we pour some acetone or ether or nail polish remover on our palm then we feel cool because the energy needed for evaporation is taken from our palm. Hence, our palm feels cooling.

**(iii) Sprinkling of water on the open ground after a hot sunny day :**

The sprinkling of water on the open ground or roof after a hot sunny day causes the cooling of the surface of roof because the water evaporates by absorbing heat from the ground and the surrounding air. In this way the ground or roof become cool and we feel comfort.

**(iv) We see water droplets on the outer surface of a glass containing ice cold water :**

Take some ice cold water in a glass. Soon we will see water droplets on the outer surface of the glass. The water vapour present in air on coming in contact with the cold glass of water loses energy and gets converted to liquid state which we see as water droplets.

**(v) Water keeps cool in the earthen pot(matki) during summer :**

When the water oozes out of the pores of an earthen pot, during hot summer, it evaporates rapidly. As the cooling is caused by evaporation, therefore, the temperature of water within the pot falls and hence it becomes cool.

**(vi) Rapid cooling of hot tea :**

If tea is too hot to sip, we pour it in the saucer. In doing so, we increase the surface area and the rate of evaporation increases. This in turn causes cooling and the tea attains a desired temperature for sipping.

**(vii) A wet handkerchief is placed on the forehead of a person suffering from high fever :**

The logic behind placing wet cloth is that as the water from the wet cloth evaporates, it takes heat from the skull and the brain within it. This, in turn, lowers the temperature of brain and protects it from any damage due to high temperature.

## SOLVED EXAMPLES

**SE. 1**

What celsius and kelvin temperature correspond to 68°F?

**Ans.** To convert °F to °C

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32^{\circ}) \times 5/9 = (68 - 32) \times 5/9 = 20^{\circ}\text{C}$$

$$\text{K} = ^{\circ}\text{C} + 273 = 20 + 273 = 293 \text{ K.}$$

**SE. 2**

Few iodine crystals are kept in a conical flask, it is stoppered and kept undisturbed for a long time. A few crystals are seen near the mouth and sides of the flask. Explain.

**Ans.** Over a period of time iodine molecules sublime and are converted into gas. Some of these gas molecules condense back on the surface of the flask and near the mouth of the flask to form iodine crystals.

**SE. 3**

Ordinary water boils at 100°C. Can it be made to boil at 95°C or 105°C?

**Ans.** Yes. The boiling point of a liquid depends upon the pressure acting on it. Water boils at 100°C at 1 atm pressure. If the pressure is reduced, it can be made to boil at lower temperature and if the pressure is increased it can be made to boil at higher temperature.

**SE. 4**

What happens to the heat energy supplied when the solid starts melting?

**Ans.** The temperature of the molten liquid remains constant till the complete solid melts. The heat energy supplied is converted into latent heat of fusion. The temperature starts rising only after the complete solid is converted to liquid.

**SE. 5**

The melting points of two solids X and Y are 300 K and 400 K respectively. Which has more interparticle forces?

**Ans.** Y has more inter particle force because higher melting point shows more energy is required to break interparticle forces.

**SE. 6**

How do aquatic plants survive?

**Ans.** The air contains gases like oxygen, nitrogen, carbon dioxide, etc. These gases dissolve in water by the process of diffusion. The oxygen and carbon dioxide are taken up by aquatic animals and plants respectively for their survival.

**SE. 7**

What are the factors which are responsible for bringing a change in the physical state of a substance?

**Ans.** Temperature and pressure are two factors which can bring about the change in physical state. But they have opposing effect. Increase in temperature separate the particles of a substance apart while increase in pressure brings them closer.

**SE. 8**

How can the evaporation of a liquid be made faster?

**Ans.** (i) By increasing the surface area  
(ii) By increasing the temperature  
(iii) By blowing wind  
(iv) By decreasing the humidity

**SE. 9**

Why is solid carbon dioxide known as dry ice? Why is it stored under high pressure?

**Ans.** Solid carbon dioxide directly changes into carbon dioxide gas without passing through the liquid state. It is an extremely cold substance and does not wet the surface. Hence, it is called dry ice. It is stored under high pressure because on decreasing the pressure, solid carbon dioxide is directly converted to gas.

**NS. 1**

Which of the following are matter?  
Chair, air, love, smell, hate, almonds, thought, cold, cold drink, smell of perfume

**Ans.** Chair, air, smell, almonds, cold drink and smell of perfume

**NS. 2**

Give reasons for the following observation: The smell of hot sizzling food reaches you several metres away, but to get smell from cold food, you have to go close.

**Ans.** This happens because rate of diffusion of gas increase with increase in temperature. In case of hot food diffusion of smell is faster whereas in case of cold food diffusion is slower.

**NS. 3**

A diver is able to cut through water in a swimming pool. Which property of matter does this observation show?

**Ans.** The particles of water are held together by weak forces of attraction, as a result space between molecules is large. It is the reason that the diver is able to cut through water in a swimming pool.

**NS. 4**

(a) Tabulate the differences in the characteristics of states of matter.  
(b) Comment upon the following: rigidity, compressibility, fluidity, filling a gas container, shape, kinetic energy and density

**Ans.** (a) Refer to the theory.  
(b) (i) Rigidity: It is the property which helps a substance to retain its shape when force is applied to it. Solids are rigid while gases and liquids are not.  
(ii) Compressibility: The property due to which the particles of matter can be compressed or reduced in volume by applying force or pressure. Gases are highly compressible.  
(iii) Fluidity: It is the tendency of a substance to flow. Liquids and gases possess fluidity while solids are rigid.

(iv) Filling a gas container: The molecules of a gas move in all directions and due to negligible interparticle force of attraction can fill the entire container.

(v) Shape: Solids have definite shape whereas liquids take the shape of the container in which they are placed and gases do not have any shape.

(vi) Kinetic energy: It is the energy possessed by the particles due to their motion. The particles of a gas have maximum kinetic energy due to free motion of gas particles in all directions. Solids have minimum kinetic energy due to least movement of particles.

(vii) Density: Density is the mass of a substance per unit volume. Solids have highest density since their molecules are closely packed.

**NS. 5**

What are the characteristics of the particles of matter?

**Ans.** The characteristics of the particles of matter are as follows:

- (a) Matter consists of tiny particles.
- (b) The particles of matter have spaces between them.
- (c) The particles of matter attract each other.
- (d) The particles of matter are continuously moving

**NS. 6**

The mass per unit volume of a substance is called density.

(density = mass/volume)

Arrange the following in order of increasing density - air, exhaust from chimneys, honey, water, chalk, cotton and iron

**Ans.** The increasing order of density is air < exhaust from chimney < cotton < water < honey < chalk < iron.

**NS. 7**

Give reasons.

- (a) A gas fills completely the vessel in which it is kept.
- (b) A gas exerts pressure on the walls of the container.

(c) A wooden table should be called a solid.  
 (d) We can easily move our hand in air but to do the same through a solid block of wood we need a karate expert.

**Ans.** (a) The particles of a gas are constantly moving in all the directions with different speeds. Therefore they do not have a fixed volume and hence completely fill the vessel in which they are kept.  
 (b) The molecules of a gas are free to move randomly in all directions. During their motion, they collide with one another and also with the walls of the container. The constant bombardment of the molecules on the walls of the container exerts a steady force. The force acting per unit area on the walls of the container is called pressure. Thus, gases exert pressure.  
 (c) A wooden table is called solid because it has a definite mass, volume and shape.  
 (d) In air, there is lot of empty space between the molecules and the forces between the particles are almost negligible. Hence, we can move our hand in air. However, we cannot move our hand in a solid block because there are strong forces of attractions between particles in a solid and there is no empty space between them.

**NS. 8**

Liquids generally have lower density as compared to solids. But you must have observed that ice floats on water. Find out why?

**Ans.** When water freezes to form ice, some empty spaces are created. As a result, volume increases for the same mass of water. In other words, mass per unit volume or density of ice is lower than that of water and hence ice floats over water.

**NS. 9**

Convert the following temperatures to celsius scale

(a) 300 K (b) 573 K.

**Ans.** (a) Temperature in °C  
 = Temperature in kelvin - 273  
 = 300 - 273  
 = 27°C  
 (b) Temperature in °C = 573 - 273 = 300°C

**NS. 10**

What is the physical state of water at:

(a) 250°C  
 (b) 100°C?

**Ans.** (a) Physical state of water at 250°C is gaseous state because the boiling point of water is 100°C. Therefore at a temperature higher than its boiling point, it exists as gas.  
 (b) At 100°C both liquid and gaseous states are present. These are in a state of equilibrium. So at 100°C both liquid water and vapours are present.

**NS. 11**

For any substance, why does the temperature remain constant during the change of state?

**Ans.** The temperature remains constant during the change of state because the heat supplied during the change is used up in overcoming the intermolecular forces between the particles of the state.

**NS. 12**

Suggest a method to liquefy atmospheric gases.

**Ans.** In order to liquefy a gas, the constituent particles or molecules have to be brought closer. The atmospheric gases can be liquefied either by increasing pressure or by decreasing temperature.

**NS. 13**

Why does a desert cooler cool better on a hot dry day?

**Ans.** The cooling in a desert cooler is caused by the evaporation of water. A desert cooler cools better on a hot and dry day because the higher temperature on a hot day and the dryness of air (low humidity of air) increases the rate of evaporation of water. Hence, due to increased rate of evaporation of water, a desert cooler cools better on a hot and dry day.

**NS. 14**

How does the water kept in an earthen pot (matka) become cool during summer?

**Ans.** An earthen pot (matka) has many small pores. Water seeps out through them and evaporates from the surface of the pot. The energy needed for evaporation is taken from the water kept in the earthen pot. As a result, water kept in earthen pot becomes cool.

**NS. 15**

Why does our palm feel cold when we put some acetone or petrol or perfume on it?

**Ans.** Both acetone and perfume are low boiling liquids. When they are poured on the palm, they evaporate readily and for this change of state they take the energy from the palm and we get a cooling sensation.

**NS. 16**

Why are we able to sip hot tea or milk faster from a saucer rather than a cup?

**Ans.** We are able to sip hot tea faster from a saucer rather than a cup because a saucer has a greater surface area. As a result, rate of evaporation increases.

**NS. 17**

What type of clothes should we wear in summer?

**Ans.** We should wear cotton clothes in summer. During summer, we perspire more because of the mechanism of our body which keeps us cool. Cotton, being a good absorber of water helps in absorbing the sweat and exposing it to the atmosphere for easy evaporation.

**NS. 18**

Convert the following temperatures to Celsius scale :

- (a) 293 K
- (b) 470 K

**Ans.** (a) We know that, temperature in  $^{\circ}\text{C} = \text{K} - 273 = 293 - 273 = 20^{\circ}\text{C}$   
(b)  $^{\circ}\text{C} = \text{K} - 273 = 470 - 273 = 197^{\circ}\text{C}$

**NS. 19**

Convert the following temperatures to the Kelvin scale :

- (a)  $25^{\circ}\text{C}$
- (b)  $373^{\circ}\text{C}$

**Ans.** (a) We know that temperature in  $\text{K} = ^{\circ}\text{C} + 273$   
 $\text{K} = 25 + 273 = 298 \text{ K}$   
(b)  $\text{K} = ^{\circ}\text{C} + 273 = 373 + 273 = 646 \text{ K}$

**NS. 20**

Give reasons for the following observations :

- (a) Naphthalene balls disappear with time without leaving any solid.
- (b) We can get the smell of perfume sitting several metres away.

**Ans.** (a) Naphthalene balls disappear with time without leaving any solid because they undergo sublimation i.e., they directly change into vapours without passing through the liquid state.  
(b) We can get the smell of perfume sitting several metres away due to diffusion. The perfumes contain solvent which carries pleasant smelling vapours. They diffuse quite fast and can reach a person sitting several metres away.

**NS. 21**

Arrange the following substances in increasing order of forces of attraction between the particles: water, sugar, oxygen.

**Ans.** The forces of attraction are the strongest in solids, followed by liquids and the weakest in gases. Oxygen is a gas, water is a liquid and sugar is a crystalline solid. So the increasing order of forces of attraction is oxygen < water < sugar.

**NS. 22**

What is the physical state of water at

- (a)  $25^{\circ}\text{C}$
- (b)  $0^{\circ}\text{C}$
- (c)  $100^{\circ}\text{C}$ ?

**Ans.** (a) At  $25^{\circ}\text{C}$ , the physical state of water is a liquid.  
(b) At  $0^{\circ}\text{C}$ , the physical state of water can be either a solid or a liquid.  
(c) At  $100^{\circ}\text{C}$ , the physical state of water can be either a liquid or a gas (steam).

NS. 23

Give two reasons to justify that:

- (a) Water at room temperature is a liquid.
- (b) An iron almirah is a solid at room temperature.

**Ans.** (a) Water is a liquid at room temperature due to following reasons :

- (i) Water has fixed volume, but not fixed shape, it takes the shape of the container.
- (ii) Water can flow easily, hence it is not rigid but a fluid.

(b) An iron almirah is a solid at room temperature due to following reasons :

- (i) An almirah has a fixed shape and a fixed volume.
- (ii) It cannot flow, hence it is rigid.

NS. 24

Why is ice at 273 K more effective in cooling than water at the same temperature?

**Ans.** Ice at 273 K melts to form water by absorbing heat energy equal to latent heat from the surroundings. Hence, ice is more effective in cooling.

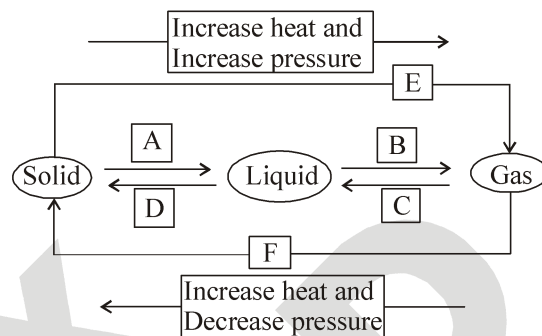
NS. 25

Which produces more severe burns, boiling water or steam?

**Ans.** Steam contains more heat, in the form of latent heat, than boiling water. So, when steam comes in contact with skin it gives out  $22.5 \times 10^5$  joules per kilogram more heat than boiling water, so steam causes more severe burns.

NS. 26

Name A, B, C, D, E and F in the following diagram showing change in its state.



**Ans.** A → Fusion or melting, B → Vaporisation, C → Condensation, D → Solidification, E → Sublimation, F → Sublimation

## EXERCISE – I

### ONLY ONE CORRECT TYPE

- Which of following is not matter ?  
(A) Joy (B) Pen  
(C) Pencil (D) Air
- Name the process by which a drop of ink spreads in a beaker of water.  
(A) Diffusion (B) Vaporization  
(C) Condensation (D) Sublimation
- Which of the following has the strongest interparticle force at the room temperature?  
(A) Nitrogen (B) Mercury  
(C) Iron (D) Chalk
- Fluids are  
(A) liquids and gases  
(B) solids and gases  
(C) liquids and solids  
(D) only solids
- Volume of gases can be defined as  
(A) definite (B) almost nil  
(C) large  
(D) take the volume of container
- The physical state of matter which can be easily compressed is  
(A) liquid (B) Gas  
(C) solid (D) None of these
- The change of state from solid to liquid is known as  
(A) freezing (B) boiling  
(C) melting (D) None of these
- The temperature at which a solid changes into liquid at atmospheric pressure is called  
(A) melting point (B) boiling point  
(C) diffusion (D) evaporation
- Convert the temperature of  $373^{\circ}\text{C}$  to the kelvin scale?  
(A) 646 K (B) 546 K  
(C) 300 K (D) 500 K
- Addition of impurities to water  
(A) decreases the freezing point of water  
(B) increases the boiling point of water  
(C) does not affect the freezing or boiling point of water  
(D) both (A) and (B)
- Which of the following indicates the relative randomness of particles in the three states of matter?  
(A) Solid > liquid > gas  
(B) Liquid < solid < gas  
(C) Liquid > gas > solid  
(D) Gas > liquid > solid
- The process of evaporation causes  
(A) heating  
(B) cooling  
(C) increase in temperature  
(D) none of these
- Ice floats on the surface of water because  
(A) it is heavier than water  
(B) the density of both water and ice is the same  
(C) ice is lighter than water  
(D) none of these
- Evaporation of a liquid can take place  
(A) at its boiling point  
(B) below its boiling point  
(C) above its boiling point  
(D) at a fixed temperature
- A liquid is kept in a China dish. The evaporation of the liquid can be accelerated  
(A) by keeping the dish in the open  
(B) by blowing air into the liquid  
(C) by keeping the dish under a running fan  
(D) all of these
- Which one of the following statements is wrong for gases?  
(A) Gases do not have a definite shape and volume  
(B) Volume of the gas is equal to the volume of the container confining the gas  
(C) Confined gas exerts uniform pressure on the walls of container in all directions  
(D) Mass of the gas cannot be determined by weighing a container in which it is enclosed
- The quantity of matter present in an object is called its  
(A) weight (B) gram  
(C) mass (D) density

18. Which of the following states has the least energetic molecules?  
 (A) Solid (B) Liquid  
 (C) Gas (D) Plasma
19. Which of the following represent the densest (high density) state of matter?  
 (A) Solids (B) Liquids  
 (C) Gases (D) Vapours
20. 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
21. Which of the following statements does not go with the liquid state?  
 (A) Particles are loosely packed in the liquid state  
 (B) Fluidity is maximum in the liquid state  
 (C) Liquids cannot be compressed much  
 (D) Liquids take up the shape of any container in which they are placed
22. The value of latent heat of vaporisation of water in kcal/kg is  
 (A) 80 (B) 540  
 (C) 334 (D) 225
23. The electric bulb on long use forms a black coating on its inner surface. The process associated with this is  
 (A) melting of tungsten  
 (B) sublimation of tungsten  
 (C) oxidation of tungsten  
 (D) reduction of tungsten
24. If a few spoons of salt are dissolved in pure water then  
 (A) its b.pt. becomes less than 100°C  
 (B) its b.pt. becomes more than 100°C  
 (C) its freezing point becomes more than 0°C  
 (D) none of these
25. Latent heat of vaporisation is used to  
 (A) overcome the forces of attraction between molecules in solid state  
 (B) increase the kinetic energy of molecules in liquid state  
 (C) overcome the forces of attraction between molecules in liquid state  
 (D) increase the kinetic energy of molecules in vapour state

**PARAGRAPH TYPE**

**PARAGRAPH # 1**

The molecules of a gas are free to move about in any direction. Because of large intermolecular spaces, the gases are easily compressible. The kinetic energy of the molecules of gases is maximum and they move about randomly at a high speed. The randomly moving high speed molecules hit against the sides of containing vessel. The pressure exerted by any gas is due to the force exerted by molecules on the sides of containing vessel.

26. A gas fills all the space in a container in which it is kept because  
 (A) the gases have large intermolecular spaces  
 (B) the molecules are not free to move  
 (C) the randomly moving molecules hit against the walls of container  
 (D) the molecules have large intermolecular forces of attraction
27. When pressure is applied on a gas, it is converted to a liquid due to  
 (A) increase in intermolecular forces of attraction between the particles  
 (B) increase in intermolecular distances between the particles  
 (C) decrease in intermolecular forces of attraction between the particles  
 (D) increase in kinetic energy of particles
28. The force per unit area exerted by the particles of the gas on the walls of container is called  
 (A) atmospheric pressure  
 (B) pressure of the gas  
 (C) kinetic energy of the gas  
 (D) density of the gas

**PARAGRAPH # 2**

The phenomenon of change of liquid into vapours at any temperature below its boiling point is called evaporation. The rate of evaporation increases with increase in surface area, temperature, speed of wind and decrease in humidity. Evaporation causes cooling due to decrease in average kinetic energy of the remaining liquid after the surface molecules leave. Lower the boiling point of the liquid, higher is its rate of evaporation.



## EXERCISE – II

### VERY SHORT ANSWER TYPE

1. Is the melting point temperature of solid and the freezing point temperature of liquid same or different ?
2. What is the heat absorbed during the change of state of substance called ?
3. Name a common substance which can undergo a change in the state upon heating or cooling without any change in its composition?
4. Predict the physical state of a substance which has melting point below room temperature.
5. What is the space occupied by matter called?
6. Name the temperature at which a liquid solidifies.
7. Why do solids generally lack the property of diffusion?
8. Define gaseous state of a substance.
9. Is dry ice the same thing as ordinary ice?
10. Which property of gas can explain the characteristic that there is large space between the molecules of a gas?

### SHORT ANSWER TYPE

1. Define (i) Latent heat of fusion of a solid.  
(ii) Condensation
2. What is the difference between gas and vapour?
3. What is humidity? What is its effect on evaporation?
4. Explain what happens to the molecular motion and energy of 1 kg of water at 273 K when it is changed into ice at same temperature. How is the latent heat of fusion related to the energy exchange that takes place during this change of state.
5. The water taken from sea, freezes at about  $-2^{\circ}\text{C}$  and boils at about  $101^{\circ}\text{C}$ . Explain the reason.

### LONG ANSWER TYPE

1. State the various factors which affect evaporation.
2. What is meant by interconvertibility of the states of matter?
3. What are the main differences between evaporation and vaporisation or boiling?

4. Calculate the temperature at which Fahrenheit and Celsius scales have the same reading.
5. Why do solids, liquids and gases have different properties?

### TRUE AND FALSE

1. Evaporation decreases with increase in humidity.
2. Process of converting liquid to solid called fusion process.
3. Happiness is example of matter.
4. Alcohol have definite volume and definite shape.
5. Diffusion of gas particles maximum.

### FILL IN THE BLANKS

1. The force of attraction between same type of particles called \_\_\_\_\_.
2. Process of converting gas into liquid called \_\_\_\_\_.
3. Full form of LPG \_\_\_\_\_.
4. With increase in temperature the rate of evaporation \_\_\_\_\_.
5. Iron is example of \_\_\_\_\_ state of matter.

**Answer Key**

**EXERCISE-I**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	A	C	A	D	B	C	A	A	D	D	B	C	B	D
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
D	C	A	A	C	B	B	B	B	C	A	A	B	B	C
31	32	33												
A	B	A												

**EXERCISE – II**

**TRUE / FALSE**

1. T      2. F      3. F      4. F      5. T

**FILL IN THE BLANKS**

1. Cohesive force      2. Condensation      3. Liquefied petroleum gas  
 4. Increases      5. Solid

## SELF PROGRESS ASSESSMENT FRAMEWORK

(CHAPTER : MATTER IN OUR SURROUNDINGS)

CONTENT	STATUS	DATE OF COMPLETION	SELF SIGNATURE
Theory			
In-Text Examples			
Solved Examples			
NCERT Exercises			
Exercise I			
Exercise II			
Short Note-1			
Revision - 1			
Revision - 2			
Revision - 3			
Remark			

### NOTES :

1. In the status, put “completed” only when you have thoroughly worked through this particular section.
2. Always remember to put down the date of completion correctly. It will help you in future at the time of revision.



*Space for Notes :*

A large rectangular area containing 25 horizontal dotted lines, intended for writing notes.



# IS MATTER AROUND US PURE

# 2

## Concepts

### Introduction

1. Classification of Matter
2. Pure Substance
  - 2.1 Elements
  - 2.2 Compounds
3. Mixture (impure substance)
  - 3.1 Types of mixtures
4. True solution or solution
  - 4.1 Type of solutions
5. Solubility
  - 5.1 Effect of temperature and pressure on solubility
6. Concentration of solution
  - 6.1 Mass by mass percentage of solution (w/w%)
  - 6.2 Mass by volume percentage of solution (w/v%)
  - 6.3 Volume by volume percentage of solution (v/v%)
7. Suspension
8. Colloidal Solution
  - 8.1 Properties of colloidal solution
  - 8.2 Classification of Colloids
9. Separation Techniques
  - 9.1 Separation of solid-solid mixtures
  - 9.2 Separation of mixture of solid and liquid
  - 9.3 Separation of mixture of two liquids
10. Separation of gases from air
11. Citywater supply
12. Physical and chemical changes
  - 12.1 Physical changes
  - 12.2 Chemical changes

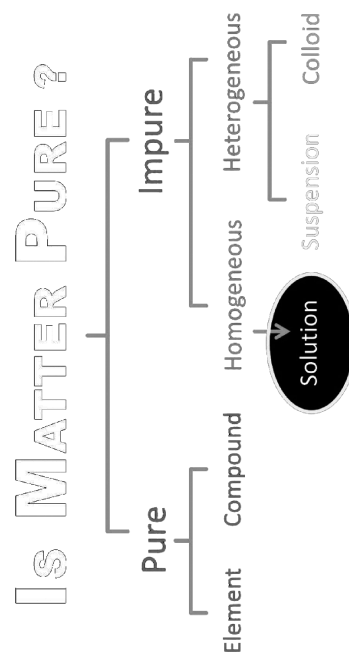
## Solved Examples

### NCERT Solutions

Exercise – I (Competitive Exam Pattern)

Exercise – II (Board Pattern Type)

Answer Key



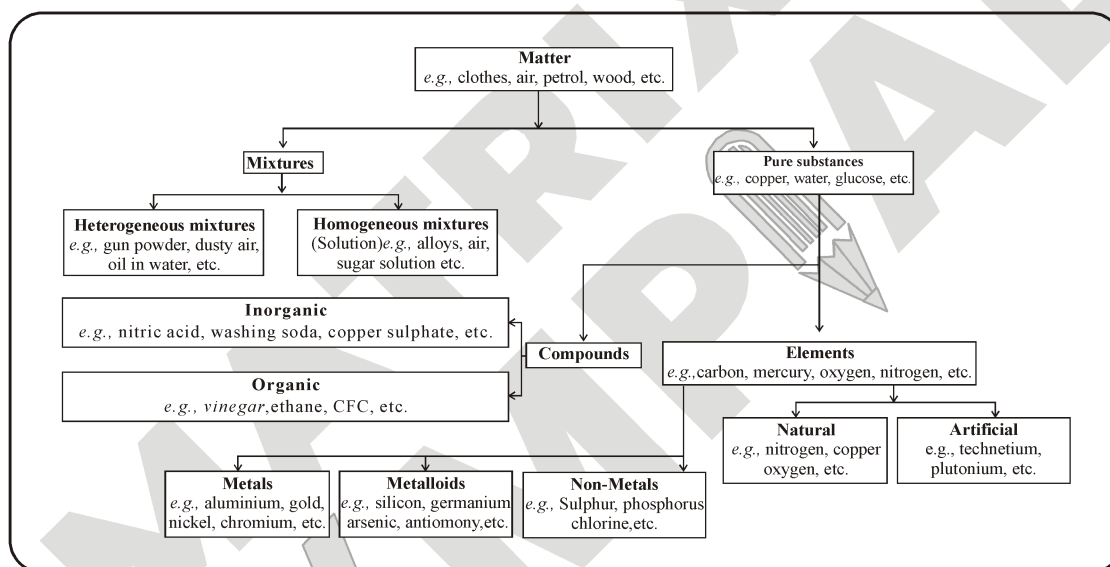


## INTRODUCTION

In previous chapter, we have discussed the three physical states of matter i.e. solid, liquid and gas. We have also studied their characteristics and the effect of temperature and pressure on these physical states. In the present chapter, we shall consider the chemical nature of matter.

We know that all the matter around us is not pure. If we observe some soil and some sugar placed on two different sheets of paper with a magnifying glass, we find that soil contains clay particles, some grass particles and even some dead insects, etc. That is, soil contains particles of different kinds, thus it is called an impure substance (or mixture). Now observe sugar which contains only one kind of particles, is called a pure substance. In terms of science, a substance is a kind of matter which cannot be separated into any other types of matter by some physical means. Such a substance which has only one component and nothing else in it is called a pure substance. But it is quite difficult to get a pure substances as such. Substances are mostly mixed with one another and their combination is known as mixture.

## 1. CLASSIFICATION OF MATTER



## 2. PURE SUBSTANCE

- A substance consists of a single type of particles.
- Substances are always homogeneous.
- All the elements and compounds are pure substances because they contain only one kind of particles.
- A pure substance cannot be separated into other kinds of matter by any physical process.
- A pure substance has a fixed composition as well as a fixed boiling point and melting point.
- Pure Substances can be divided into two types:
  - (i) Elements
  - (ii) Compounds

### 2.1 ELEMENTS

An element is a substance which cannot be split up into two or more simpler substances by the usual chemical methods of applying heat, light or electric energy or by any physical methods.

An element cannot be split up into two (or more) simpler substances because it is made of only one kind of atoms.

### Some facts about elements

- (i) The earth's crust is made mainly of two elements i.e. oxygen 46.6 % and silicon 27.7 %.
- (ii) First three elements namely oxygen 65%, Carbon 18 % and Hydrogen 10 % account for more than 90 % mass of human body.
- (iii) As many as 118 elements are known.
- (iv) 92 elements occur in nature and the rest are artificially made. These man-made elements are called synthetic elements.
- (v) Majority of the elements are solids.
- (vi) Eleven elements are in gaseous state at room temperature.
- (vii) Two elements are liquid at room temperature i.e. mercury and bromine.
- (viii) Elements gallium and caesium become liquid at temperature slightly above room temperature (at 30°C).

### Classification of elements

**(a) Metals :** Metals are the electropositive elements which possess tendency of losing one or more of their valence electrons attaining octet and thereby forming cations.

For example, Sodium, Magnesium, Iron etc.

**(b) Non metals :** Non-metals are the electronegative elements which possess tendency to form anion (negative ions) by gaining one or more electrons.

For example, Carbon, Oxygen, Chlorine etc.

**(c) Metalloids :** 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.

For example, Boron (B), Silicon (Si), and Germanium (Ge) etc.

### Some difference between Metals and Non-metals

Physical Properties	Metals	Non-Metals
State	Metals are solids at room temperature <b>Exception:</b> Mercury (Hg) is a liquid at room temperature.	The non-metals are either solids or gases at room temperature. <b>Exception :</b> Bromine is a liquid at room temperature.
Lustre	Metals are generally lustrous, i.e, they have a shining surface and can be polished, e.g., gold silver, copper, etc.	Non-metals generally do not have any lustre, dull in appearance e.g., sulphur and phosphorus etc. <b>Exception :</b> Iodine has a lustrous appearance.
Melting and Boiling Points	Metals have generally high melting points and boiling points, e.g., the melting point of iron is 1535°C. <b>Exception:</b> Sodium, potassium and gallium have low melting points. The melting point of gallium is so low that it occurs in liquid state at temperature slightly above room temperature.	Non-metals have low melting points and boiling points. <b>Exception:</b> Carbon and silicon, which have high melting points.

Density	<p>Metals have high densities, i.e., they are heavy, e.g., the density of mercury is <math>13.6 \text{ gm/cm}^3</math> which is quite high.</p> <p><b>Exception:</b> Sodium, potassium, calcium and magnesium which are light-weight metals. Sodium and potassium are so light that they can float on water.</p>	<p>Non-metals have low densities. i.e., they are light substances. For example, the density of sulphur is <math>2 \text{ gm/cm}^3</math>, which is quite low.</p> <p><b>Exception:</b> The density of diamond (an allotropic form or of carbon) is high.</p>
Ductility	<p>Metals are ductile, i.e., they can be drawn into thin wires. Gold and silver are the best ductile metals. Other examples are copper and aluminium which can be drawn into wires and are used in electrical wiring.</p>	<p>Non-metals are non-ductile, i.e., they cannot be drawn into thin wires, e.g., sulphur and phosphorus when stretched do not form wires but break into pieces.</p>
Malleability	<p>Metals are generally malleable, i.e., they can be beaten into thin sheets with a hammer, e.g., silver foils are used for decorative purpose on sweets.</p>	<p>Non-metals are not malleable but brittle, i.e., when beaten with a hammer, they break into pieces.</p>
Conduction of heat and electricity	<p>Metals are good conductors of heat and electricity. Silver is the best conductor of heat and electricity whereas lead is the poorest conductivity of heat. Metals are good conductors of electricity because they contain free electrons to conduct electricity.</p>	<p>Non-metals are generally bad conductors of heat and electricity, e.g., the non-metals like sulphur, phosphorus, etc., do not conduct heat and electricity.</p> <p><b>Exception :</b> Graphite (an allotropic form of carbon) is a good conductor of electricity.</p>
Hardness	<p>Metals are hard (except sodium and potassium which are soft metals) but not brittle. Sodium and potassium are so soft that they can be cut with a knife.</p>	<p>Non-metals are generally soft except, diamond (an allotropic form of carbon) which is the hardest substance known.</p>
Sonority	<p>Metals are said to be sonorous, i.e., they make a noise when they are hit with an object.</p>	<p>Non-metals are not sonorous.</p>

## 2.2 COMPOUNDS

A compound is a substance made up of two or more elements chemically combined in a fixed proportion by mass. A compound is formed as a result of chemical reaction, between the constituent elements. The properties of compound are different from the properties of the elements from which it is formed.

For example, Water ( $H_2O$ ) is a compound made up of two elements hydrogen, and oxygen chemically combined in a fixed proportion of 1 : 8 by mass.

### ◆ Characteristics of a compound :

- In a compound constituent are present in definite proportion by mass.
- The properties of compound are different from the properties of its constituents.
- The constituents of a compound cannot be separated by simple physical process.
- Formation of a compound is generally accompanied by change in energy, in the form of heat or light.
- A compound has a fixed melting point and boiling point.
- Compound is always homogeneous in nature.



### Focus Point

- Number of compounds is not limited like number of elements.

### ◆ Classification of compound:

#### (A) On the basis of sources :

##### (i) Inorganic compounds

These compounds have been mostly obtained from non-living sources such as rocks and minerals.

A few examples of inorganic compounds are : common salt, marble, washing soda, baking soda, carbon dioxide, ammonia, sulphuric acid etc.

##### (ii) Organic compounds

The word 'organ' relates to different organs of living beings. Therefore, organic compounds are the compounds which are obtained from living beings i.e., plants and animals.

A few common examples of organic compounds are : methane, ethane, propane (all constituents of cooking gas), alcohol, acetic acid, sugar, proteins, oils, fats etc.

#### (B) On the basis of their properties :

**(i) Acids :** Compounds which give hydrogen ion in aqueous solution.

For example, hydrochloric acid, sulphuric acid, nitric acid, formic acid etc.

**(ii) Bases :** Compounds which give hydroxide ion in aqueous solution.

For example, Sodium hydroxide, Potassium hydroxide etc.

**(iii) Salts :** It is formed by the chemical reaction between acids and bases.

For example, ammonium chloride, zinc sulphate etc.

### Difference between Elements and Compounds

	Element	Compound
1.	An element consists of the same kind of atoms.	A compound is composed of different kind of atoms.
2.	An element cannot be split up by physical and chemical methods.	A compound can be split up into new substances only by chemical methods.
3.	The property of an element is the property of its constituent atoms.	The property of a compound is quite different from that of its constituents atom.



## Focus Point

- Purity of compounds can be tested by determining their melting or boiling points. Pure compounds have fixed melting point and boiling point.

### 3. MIXTURE (IMPURE SUBSTANCE)

A mixture is a substance which consists of two or more elements or compounds not chemically combined together.

All the solutions are mixtures. The various substances present in a mixture are known as "constituents of the mixture" or "components of the mixture".

For example, Lemonade (nimbu pani) is a mixture of water, lemon juice, sugar and salt.

A mixture consists of two or more different type of particles having different chemical nature. Mixture may be homogeneous or heterogeneous. A mixture does not have a fixed composition or a fixed melting point and boiling point.

#### ◆ Properties of mixture:

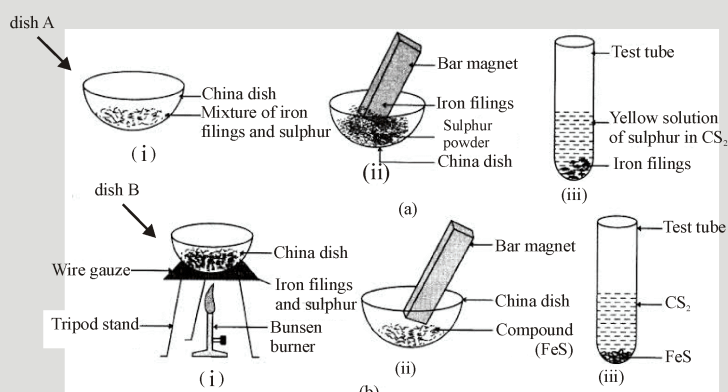
- A mixture can be separated into its constituents by physical or chemical processes.
- A mixture shows the properties of all the constituents present in it.
- Formation of mixture may or may not be accompanied with energy change.
- The composition of a mixture is variable, the constituents can be present in any proportion by mass.
- A mixture does not have a definite melting point, boiling point.
- A mixture may be homogeneous or heterogeneous.

### LAB TIME

Let's Do & Learn



- Objective :** To distinguish between mixtures and compounds.
- Materials required :** Two separate China dishes marked (A) and (B), mixture of nearly 50 g of iron filings and 3 g of powdered sulphur.
- Procedure :** Keep the dish (A) as such while heating the dish (B) to red hot for sometime and then cool it.



(a) Mixture of iron and sulphur  
(b) Compound FeS, where iron and sulphur do not retain their properties

- **Observations :**
  - (i) In the China dish (A) both iron filings and sulphur powder retain their colour. In the dish (B) a black mass will be formed.
  - (ii) Bring a magnet near the mass present in both the dishes. Iron filings will readily cling to the magnet in dish (A) while this will not happen in dish (B).
  - (iii) Transfer a small amount of the mass from dish (A) into a glass tube. Add carbon disulphide (liquid) to it and shake for sometime. The yellow powder will dissolve leaving behind the iron filings in the tube. Repeat the same experiment with the mass present in dish (B) also. Nothing will happen.
- **Conclusion :**
  - (i) In the China dish (A), both iron filings and powdered sulphur are in the form of a mixture. In the dish (B), a chemical reaction has resulted upon heating and the black mass of iron sulphide is formed.
  - (ii) Iron filings present in dish (A) are attracted towards the magnet. Since iron sulphide is a compound, it is not attracted towards the magnet.

#### Difference between compounds and mixtures

S.N.	Characteristics	Compounds	Mixtures
1.	Nature	In a compound, two or more elements combine chemically.	In a mixture, two or more elements or compounds are mixed, such that they do not combine chemically.
2.	Structure	Compounds have a definite structure.	Mixtures do not have a definite structure.
3.	Composition	In case of a compound the constituents are present in a fixed ratio by weight.	In case of mixtures, their constituents can be present in any ratio, i.e., they have variable composition.
4.	Properties	The properties of a compound are entirely different from the properties of its constituents.	The constituents of a mixture retain their individual physical and chemical properties.
5.	Separation of constituents	The constituents of a compound cannot be separated by physical means.	The constituents of a mixture can be separated by physical means.
6.	Energy changes	During the formation of a compound energy is either absorbed or released, i.e., a compound is the result of a chemical change.	During the formation of a mixture energy changes may or may not take place.



## Focus Point

- For a common man, pure actually mean having no adulteration. But for a scientist pure means that is contains only one type of matter or particles, all of which are same in their chemical nature.

### 3.1 TYPES OF MIXTURES

#### ◆ Based on the composition, mixture are of two types

**(1) Homogeneous mixtures:** Those mixtures in which the substances are uniformly mixed together and are indistinguishable from one another, are called homogeneous mixtures.

All the homogeneous mixtures are called solutions.

For example,

A mixture of sugar in water (called sugar solution) is a homogeneous mixture because all the parts of sugar solution have the same sugar-water composition and appear to be equally sweet. There is no visible boundary of separation between sugar and water particles in a sugar solution.

**(2) Heterogeneous mixtures:** Those mixtures in which the components are not mixed uniformly and there is a boundary of separation between them, called heterogeneous mixtures.

For example, The mixture of sugar and sand is a heterogeneous mixture because different parts of this mixture will have different sugar-sand composition. Some parts of this mixture will have more of sugar particles whereas other parts will have more of sand particles. There is a visible boundary of separation between sugar and sand particles. A mixture containing two (or more) immiscible liquids is also a heterogeneous mixture. Let's discuss more about homogeneous and heterogeneous mixture by an activity.

### LAB TIME

Let's Do & Learn



- **Objective :**To illustrate the concept of homogeneous and heterogeneous mixtures.

- **Materials required:**

Beakers, water, spatula, copper sulphate powder, potassium permanganate or common salt.

- **Procedure :**

(i) Let us divide the class into groups A, B, C and D.

(ii) Group A takes a beaker containing 50 mL of water and one spatula full of copper sulphate powder.

Group B takes 50 mL of water and two spatula full of copper sulphate powder in a beaker.

(iii) Group C and D can take different amounts of copper sulphate and potassium permanganate or common salt (sodium chloride) and mix the given components to form a mixture.

(iv) Report the observations on the uniformity in colour and texture.

- **Observation and discussion :**

(i) Both groups A and B have obtained homogeneous mixtures since the composition of these mixtures or solutions is uniform throughout.

(ii) Although both the groups have obtained copper sulphate solutions but the intensity of colour of the two solutions is different. The intensity of blue colour in the solution obtained by group B which contains two spatula full of copper sulphate is much higher than the solution obtained by group A which contains one spatula full of copper sulphate.

(iii) Both groups C and D have obtained heterogeneous mixtures since they not only have physically distinct boundaries but also their composition is not uniform.

**• Conclusion:**

(i) Soluble substances such as copper sulphate, common salt or sugar when dissolved in water form homogeneous mixtures, whose composition depend upon the amount of the substance dissolved.

(ii) When two or more solids which do not react chemically are mixed, they always form heterogeneous mixtures.

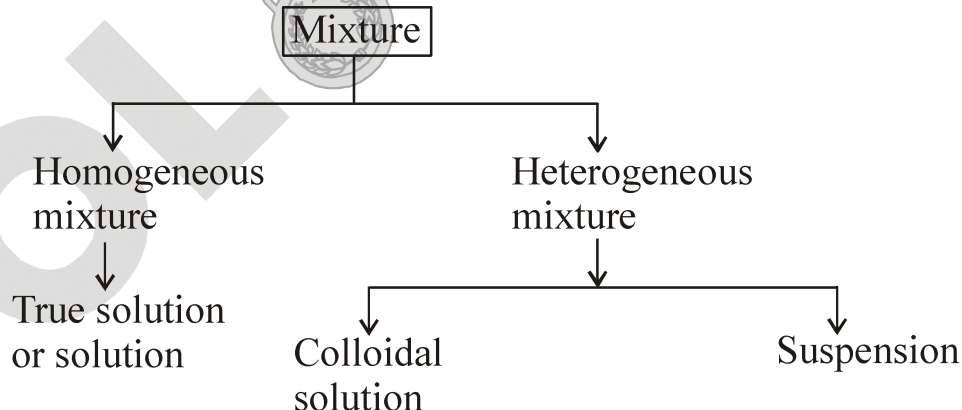
**Difference between homogeneous and heterogeneous mixture**

Homogeneous mixture	Heterogeneous mixture
It has a uniform composition throughout the mass.	It does not have a uniform composition throughout the mass.
No visible boundaries of separation between the various constituents.	Visible boundaries of separation between the various constituents.
e.g. : salt in water, alcohol in water etc.	e.g. : sand and sugar, oil in water etc.



**Focus Point**

- Alloys are mixtures of two or more metals or a metal and a non-metal and cannot be separated into their components by physical methods. But still, an alloy is considered as a mixture because it shows the properties of its constituents and can have variable composition. For example brass is a mixture of approximately 30% zinc and 70% copper.



**Flow chart for type of mixture**

#### 4. TRUE SOLUTION OR SOLUTION

You come across various soda water etc. are all examples of solutions. Usually we think of a solution as a liquid or a gas dissolved in it. But we can also have solid solutions (alloys) and gaseous solutions (air).

**A solution is a homogeneous mixture of two or more substances.**

◆ **Components of a solution:**

The substances which homogeneously mix up together to form a solution are called the components of the solution. When two substances form a solution, one substance is said to dissolve into the other.

The substance which gets dissolved is commonly known as **solute** and the medium in which it gets dissolved is termed as **solvent** or the component of a solution present in excess is referred to as the **solvent** while the other component present in the smaller amount is called the **solute**.

For example,

(a) A solution of sugar in water is a solid in liquid solution. In this solution sugar is the solute and water is the solvent.

(b) A solution of iodine in alcohol known as 'tincture of iodine' has iodine (solid) as the solute and alcohol (liquid) as the solvent.

(c) Aerated drinks like soda water etc., are gas in liquid solutions. These contain carbon dioxide (gas) as solute and water (liquid) as the solvent.

(d) Air is a homogeneous mixture of a number of gases. Its two main constituents are. Oxygen (21%) and nitrogen (78%). The other gases are present in very small quantities.

◆ **Properties of Solution:**

(i) The solute particles in a solution cannot be seen by naked eyes or even with microscope. This is because the solute particles present in a solution are very small, smaller, than 1 nm [ $1\text{nm} = 10^{-9}\text{ metre} = 10^{-7}\text{ cm}$ ].

(ii) A solution is a homogeneous transparent mixture, i.e., the solution has the same composition and the same properties throughout its bulk.

(iii) The particles of a solution being very small do not scatter light beam passing through the solution. When a beam of light is passed through a solution, light beam is not visible during its passage through a solution.

(iv) A solution is stable, i.e., the solute particles do not settle down due to gravity on keeping the solution undisturbed even for a long time.

(v) The solute particles present in a solution cannot be separated from the solvent by filtration.



### Focus Point

- Most of the substances are soluble in water, that's why water is some time called a universal solvent.
- A solution in which water acts as the solvent is called an aqueous solution while the one in which any other liquid act as solvent is called a non-aqueous solution.

#### 4.1 TYPE OF SOLUTION

◆ **On the basis of physical states of solute and solvent:**

Any state of matter (solid, liquid or gas) can act both as a solvent and as a solute during the formation of a solution.

Therefore, depending upon the physical states of solute and solvent, true solutions are classified as -

Name of solution		Solute	Solvent	Examples
<b>Solid solution</b>				
1.	Solid in solid	Solid	Solid	Alloys like steel, brass, bronze, German silver, solder(lead,tin) etc.
2.	Liquid in solid	Liquid	Solid	Hydrated crystal such as blue vitriol (hydrated copper sulphate), dental amalgam (mercury liquid and silver solid).
3.	Gas in solid	Gas	Solid	Gases adsorbed over the surface of the metals (such as nickel, palladium, platinum etc.) under pressure.
<b>Liquid solution</b>				
4.	Solid in liquid	Solid	Liquid	Sugar, common salt or other salts dissolved in water, tincture of iodine.
5.	Liquid in liquid	Liquid	Liquid	Mixture of two miscible liquids such as acetone and water, alcohol and water, vinegar (acetic acid and water), etc.
6.	Gas in liquid	Gas	Liquid	Aerated drinks (carbon dioxide dissolved in water under pressure).
<b>Gaseous solution</b>				
7.	Solid in gas	Solid	Gas	Camphor in air or iodine in air.
8.	Liquid in gas	Liquid	Gas	Clouds and fog (water drops (liquid) dispersed in air).
9.	Gas in gas	Gas	Gas	Air (mixture of gases like nitrogen, oxygen, carbon dioxide, inert gases etc.)

◆ **On the basis of amount of solute:**

Different amount of a given substance may be dissolved in a given quantity of the solvent. Thus solutions of different concentration of a given substance in a given solvent may be prepared. A particular solution may have less.

amount of the dissolved solute while the other solution may have more amount of dissolved solute in the solution. So depending upon the quantity of solute present in a given mass of the solvent, solutions are classified into three types :

**(a) Unsaturated solution:** A solution in which more quantity of the solute can be dissolved without changing the temperature is called **unsaturated solution**.

An unsaturated solution contains lesser amount of the dissolved solute, and more solute can be dissolved in it without changing the temperature. An unsaturated solution does not contain the maximum quantity of the solute which can be dissolved in it at a given temperature.

**(b) Saturated solution:** A solution in which no more solute can be dissolved at a particular temperature is called **saturated solution**.

**(c) Super saturated solution:** A solution that contains more solute than would be necessary to saturate it at a given temperature.

◆ **On the basis of nature of solvent:**

**(a) Aqueous Solutions:** The solutions obtained by dissolving various substances in water are called aqueous solutions.

The common examples are:

- (i) Common salt dissolved in water. (ii) Sugar dissolved in water.  
 (iii) Acetic acid dissolved in water etc.

**(b) Non-Aqueous Solutions:** The solutions obtained by dissolving the substances in liquids other than water are called non-aqueous solutions. The common non-aqueous solvents are alcohol, carbon disulphide, carbon tetrachloride, acetone, benzene etc.

Examples of non-aqueous solutions are:

- (i) Iodine dissolved in carbon tetrachloride. (ii) Sulphur dissolved in carbon disulphide.  
 (iii) Sugar dissolved in alcohol etc.



### Focus Point

- A super saturated solution is meta stable. This means that the solute will go to the bottom of the container and a super saturated solution becomes saturated again by heating up the solutions
- Amalgam is an alloy of a metal with mercury.

## 5. SOLUBILITY

The maximum amount of the solute (in grams) which can be dissolved in 100 grams of the solvent to form the saturated solution is called solubility of the solute in that solvent at that temperature.

Solubility of any solute can be determined as :

$$\text{Solubility} = \frac{\text{Maximum amount of solute dissolved (gm)}}{\text{Amount of solvent (gm)}} \times 100$$

To understand more about solubility, let's discuss an activity.

## LAB TIME

Let's Do &amp; Learn



• **Objective:** To demonstrate that different substances have different solubilities in the same solvent.

• **Materials required**

Beakers, water, sugar, glass rod, barium chloride, common salt.

• **Procedure :**

(i) Take approximately 50 mL of water each in two separate beakers.

(ii) Add common salt in one beaker and sugar or barium chloride in the second beaker with continuous stirring.

(iii) When no more solute can be dissolved, heat the contents of the beaker.

(iv) Start adding the solute again.

• **Discussion and observation :**

(i) The amounts of common salt, sugar and barium chloride that can be dissolved in water (50 mL) at room temperature are different.

(ii) When a saturated solution at a certain temperature is cooled, the solubility decreases and the amount

of the solute which exceeds the solubility at the lower temperature crystallizes out of the solution.

• **Conclusion :**

Different substances have different solubilities in a given solvent at the same temperature and in general the solubility decreases as the solution is cooled and the extra amount of the solute crystallizes out.



## Focus Point

- While expressing the solubility the solution must be saturated but for expressing concentration, the solution need not be saturated in nature.
- While expressing the solubility mass of solvent is considered but for expressing concentration the mass or volume of solution is considered.

## Example 1

A maximum of 24g of potassium nitrate can be dissolved in 75g of water at 20°C. Calculate the solubility of potassium nitrate in water at this temperature.

**Solution :**

75g of water dissolves = 24g of potassium nitrate

100 g of water dissolves =  $\frac{24 \times 100}{75} = 32$  g of potassium nitrate.



## Focus Point

- Solubility of sodium chloride (common salt) in water at 20°C is 36 g / 100 g. This shows that at the maximum 36 grams of sodium chloride can be dissolved in 100 gram of water at 20°C.
- Solubility of potassium nitrate in water at 20°C is 32 g / 100 g. A maximum of 32 grams of potassium nitrate can be dissolved in 100 grams of water at 20°C.

### 5.1 EFFECT OF TEMPERATURE AND PRESSURE ON SOLUBILITY

#### ◆ Effect of Temperature on the solubility of a solid in a liquid

Generally solubility of solid solute increase on increase in temperature.

For example,

Solubility of sugar, glucose, sodium chloride, potassium nitrate etc. in water increases with the increase in temperature. When such solutes are dissolved in water, the solution gets cooled. It is because heat energy is absorbed during the formation of such solutions. Heat is taken away from the solution. Therefore, solution gets cooled.

#### ◆ Effect of Pressure on the Solubility of Solid in a Liquid

Since solids are not compressible so the solubility of a solid (solute) in a liquid does not change with the change in pressure.

#### ◆ Effect of Temperature on the Solubility of a Gas in a Liquid

The solubility of a gas in a liquid decreases with the increase in temperature. It is because when a solution of the gas in a liquid is heated, some of the gas escapes out. When water is heated, the dissolved gases (O<sub>2</sub>, CO<sub>2</sub> etc.)

escape out and their solubility decreases.

#### ◆ Effect of Pressure on the Solubility of a Gas in a Liquid

The solubility of a gas in a liquid increases with the increase in pressure, and decreases with the decrease in pressure.

## 6. CONCENTRATION OF SOLUTION

When one tea spoon sugar is added in a beaker (containing water) while two tea spoon sugar is added in another beaker then we observe that sugar solution present in second beaker is more sweet because in this beaker more amount of sugar is present.

We can say that concentration of solution in beaker two is more than the concentration of solution in beaker one.

The concentration of a solution may be defined as the amount of solute present in a given amount (mass or volume) of solution and can be expressed in various ways given below :

### 6.1 MASS BY MASS PERCENTAGE OF SOLUTION (W/W%)

Mass by mass percentage is defined as the mass of the solute in grams present in 100 g of the solution.

$$w/w\% = \frac{\text{mass of solute (gm)}}{\text{mass of solution (gm)}} \times 100$$

$$w/w\% = \frac{\text{mass of solute}}{(\text{mass of solute} + \text{mass of solvent})} \times 100$$

**Example 2**

A solution is prepared by dissolving 12g of sodium chloride in 150g of solution. Calculate the mass percentage of solution.

**Solution :**

$$\begin{aligned}w/w\% &= \frac{\text{mass of solute(gm)}}{\text{mass of solution (gm)}} \times 100 \\ &= \frac{12}{150} \times 100 = 8\%\end{aligned}$$

**Example 3**

A solution contains 40 grams of common salt in 320 grams of water. Calculate the concentration in terms of mass by mass percentage of the solutions.

**Solution :**

Mass of solute (salt) = 40g

Mass of solvent (water) = 320 gm

Mass of solution = 40 + 320 = 360 g

$$\begin{aligned}w/w\% &= \frac{\text{mass of solute(gm)}}{\text{mass of solution (gm)}} \times 100 \\ &= \frac{40 \times 100}{360} = 11.1\%\end{aligned}$$

**6.2 MASS BY VOLUME PERCENTAGE OF SOLUTION (W/V%)**

It is defined as the mass of solute in gram present in 100 mL of solution.

$$\text{Mass by volume percentage (w/v\%)} = \frac{\text{mass of solute(gm)}}{\text{volume of solution(mL)}} \times 100$$

**Example 4**

Calculate the w/v % of a solution containing 5g of glucose in 200 mL of the solution.

**Solution :**

Mass of solute (glucose) = 5g

volume of solution = 200 mL

$$\begin{aligned}\text{Mass by volume percentage (w/v\%)} &= \frac{\text{mass of solute(gm)}}{\text{volume of solution(mL)}} \times 100 \\ &= \frac{5}{200} \times 100 = 2.5\% \text{ w/v}\end{aligned}$$

**6.3 VOLUME BY VOLUME PERCENTAGE OF SOLUTION (V/V%)**

It is defined as the volume of solute in mL present in 100 mL of solution

$$\text{Volume by volume percentage (v/v\%)} = \frac{\text{volume of solute(mL)}}{\text{volume of solution (mL)}} \times 100$$

**Example 5**

10 mL of ethanol is mixed with 90 mL of water. What is the volume percentage of ethanol in the solution ?

**Solution :**

Volume of ethanol (solute) = 10 mL

Volume of water (solvent) = 90 mL

Total volume of solution = 10 + 90 = 100 mL

$$\text{Volume by volume percentage (v/v\%)} = \frac{\text{volume of solute (mL)}}{\text{volume of solution (mL)}} \times 100$$

$$= \frac{10}{100} \times 100 = 10\% \text{ v/v}$$

**Focus Point**

- Parts per Million (ppm) and parts per Billion (ppb) unit are used for expressing concentration of trace amounts of substance present in the total amount of solution.

$$\text{ppm} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$$

$$\text{ppb} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^9$$

**7. SUSPENSION**

A suspension is a heterogeneous mixture in which the solute particles do not dissolve but remain suspended throughout the bulk of the medium and tend to settle down with time. Those substances which are insoluble in a liquid form suspension.

**For example :**

If we dissolve powdered chalk or sand in water, they do not dissolve in water, but settle down after sometime.

These are the examples of suspensions. Muddy water is a suspension of soil in water. Milk of magnesia is a suspension of magnesium hydroxide in water.

◆ **Properties of Suspension:** Important properties of suspension are given below

(i) **Size of the particles:** Size of the particles of suspension is quite large (greater than 100 nm).

(ii) **Heterogeneous character:** Suspension is a heterogeneous mixture which is not transparent.

(iii) **Visibility:** The particles of suspension can be seen by the naked eyes.

(iv) **Scattering of light:** The particles of a suspension scatter a beam of light passing through it and make its path visible.

(v) **Stability:** When the suspension is left undisturbed, the solute particles settle down showing that a suspension is unstable.

(vi) **Filtration:** The suspension can be separated by filtration, a residue is left on the filter paper.

## 8. COLLOIDAL SOLUTION

A colloidal solution is a heterogeneous mixture in which the size of the solute particles is intermediate between those in true solutions and those in suspensions.

### For Example,

Smoke, shoe polish, shaving cream, face cream, milk, cheese, butter, jelly, blood, starch solution, solutions of synthetic detergents etc. are the important examples of colloidal solutions. The physical state of the colloidal solutions may be solid, liquid or gas.

- ◆ **Components of colloidal solution** : A colloidal solution contains dispersion medium and dispersed phase.
- **Dispersion Medium**: The medium in which colloidal particles are dispersed is called dispersion medium. Dispersion medium is always present in larger amount.
- **Dispersed phase**: The solute-like component or the colloidal particles which are dispersed in a solvent are called dispersed phase. Dispersed phase is always present in smaller amount.

For Example,

- In smoke, air is present in larger amount whereas colloidal particles of carbon are present in smaller amount. Therefore, air is the dispersion medium whereas carbon particles are dispersed phase.
- Milk is a colloidal solution in which liquid fat is dispersed in water. Water is present in larger amount whereas liquid fat is present in smaller amount. Water is the dispersion medium and liquid fat is the dispersed phase.

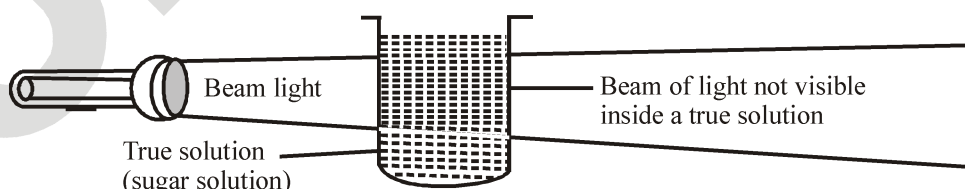
### 8.1 PROPERTIES OF COLLOIDAL SOLUTION

**(i) Heterogeneous character**: The particles of colloids are uniformly spread throughout the solution, the mixture appears to be homogeneous. It is due to the relatively smaller size of colloidal particles. But actually, a colloidal solution is a heterogeneous mixture.

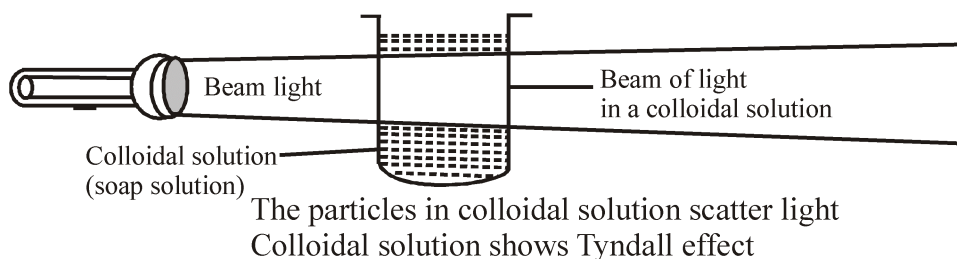
**(ii) Size of the colloidal particles**: The size of the dispersed phase ranges from 1 nm to 100 nm in a colloidal solution.

**(iii) Visibility**: Because of the small size of colloidal particles, we cannot see them by naked eyes. It is difficult to see the colloidal particles even with a microscope.

**(iv) Tyndall effect**: Scattering of light by colloidal solutions is called **Tyndall effect**. When a beam of light is passed in a solution of sodium chloride or sugar, the path of light is not visible inside the true solution. But if a beam of light is passed in a colloidal solution of milk or starch, the path of light becomes visible inside the colloidal solution. It is called Tyndall effect. Tyndall effect is due to the scattering of light.



The particles in true solution do not scatter light.  
True solution does not show Tyndall effect.

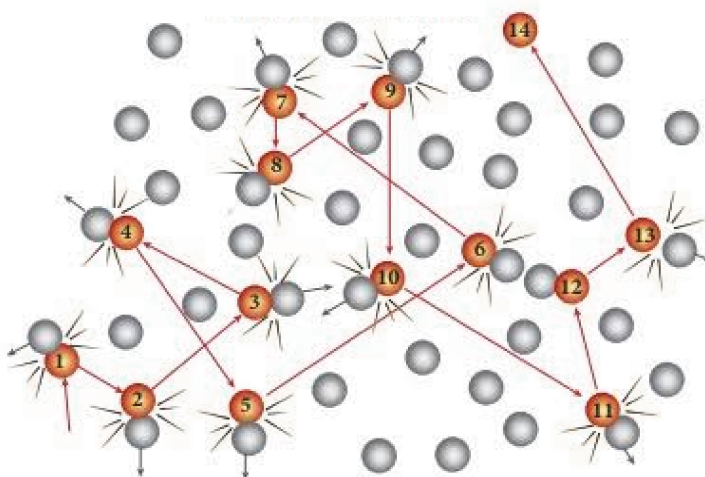


Colloidal particles scatter the beam of light passing through it. Colloidal particles cannot reflect the light due to their small size. But the size of colloidal particles is fairly large to scatter the light and make the path visible.

Tyndall effect can be observed when a beam of light enters a room through a small hole. This happens due to the scattering of light by the particles of dust and smoke present in air. Tyndall effect can also be observed when sunlight passes through the canopy of a dense forest.

**(v) Brownian movement :** Particles of colloidal solution follow zig zag path. It is normally not possible to see the colloidal particle because of their very small size. However, their path can be seen under a microscope.

Brownian movement may be defined as continuous zig-zag movement of colloidal particles in a colloid. This Brownian movement arises due to hitting of the colloidal particles by the particles of the dispersion medium from different directions with different forces.



Particles in Brownian motion

**(vi) Filtration:** If the colloidal solution is left undisturbed for sometime, it does not settle down. This shows that

colloidal solutions are quite stable. But if colloidal solution is left for a long time, the solute particles may settle down. It is important to know that though colloidal solutions cannot be separated by filtration but colloidal particles (dispersed phase) can be separated from the colloidal solution by special methods such as heating, cooling, centrifugation etc.



## Focus Point

- Colloidal particles follow a zig-zag path. Such type of movement was noticed for the first time by Robert Brown, an English scientist, hence is called Brownian movement after his name.

### 8.2 CLASSIFICATION OF COLLOIDS

Colloids are classified on the basis of the physical state of the dispersion medium and dispersed phase. Dispersion medium and dispersed phase may be solid, liquid or gas.

Both dispersion medium and dispersed phase cannot be gas because all non-reacting gases mix together and form homogeneous solution whereas colloidal solutions are heterogeneous mixtures. There are 8 types of colloidal systems.

Type	Dispersed Phase	Dispersion Medium	Examples
Aerosol	Liquid	Gas	Fog, clouds, mist
Aerosol	Solid	Gas	Smoke, automobile exhaust, dust storm, volcanic dust
Foam	Gas	Liquid	Froth, air bubble, soap lather, lemonade
Emulsion	Liquid	Liquid	Milk, face cream, nail polish, shampoo, oil in water, water in oil.
Sol	Solid	Liquid	Milk of magnesia, muddy water, aqueous solution of starch, proteins albumin etc.
Solid foam	Gas	Solid	Foam, rubber, sponge, pumice stone
Gel	Liquid	Solid	Jelly, cheese, butter
Solid Sol	Solid	Solid	Coloured gemstone, milky glass, rock salts, marble.



## Focus Point

- Depending upon the dispersion medium, the sols are given special names as follow:

**Dispersion medium**

Water  
Alcohol  
Benzene  
Gases

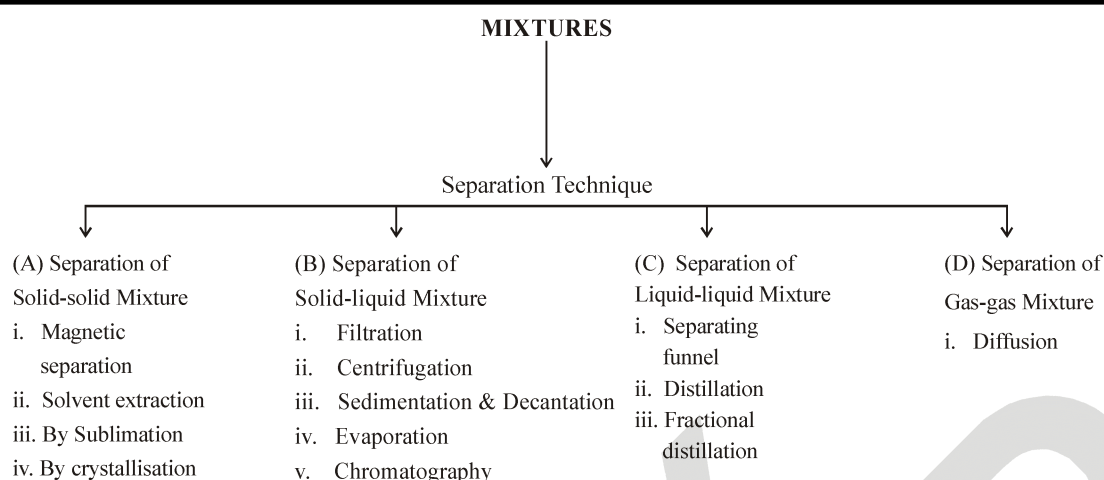
**Name of the sol**

Aquasol or Hydrosol  
Alcosol  
Benzosol  
Aerosol

### 9. SEPARATION TECHNIQUES

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

- Densities of the constituents of the mixture.
- Melting points and boiling points of the constituents of the mixture.
- Property of volatility of one or more constituents of the mixture.
- Solubility of the constituents of the mixture in different solvents.
- Ability of the constituents of the mixture to sublime.
- Ability of the constituents of the mixture to diffuse.



### Focus Point

- Heterogeneous mixture can be separated into their respective components by simple physical methods such as handpicking, sieving, filtration etc, in every day life. However, for separating homogeneous mixtures special techniques are employed depending upon the difference in one or more properties.

### 9.1 SEPARATION OF SOLID-SOLID MIXTURES

#### (i) Magnetic separation method:

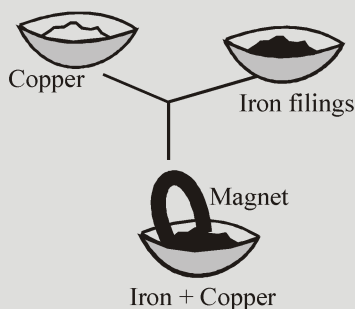
**Principle:** This method is based on the fact that one of the components of a solid-solid mixture is magnetic while the other is non-magnetic in nature.

Let's discuss an activity to understand this method.

### LAB TIME

Let's Do & Learn

- **Objective:** To Separate the mixture of iron filings and copper turnings.
- **Material required :** Iron filings, copper turnings, horse-shoe magnet, china dish.
- **Procedure :**
  - (i) A solid-solid mixture of iron filings and copper turnings can be separated by this technique because iron is magnetic in nature, whereas copper is non-magnetic in nature.
  - (ii) The given mixture is spreaded in a dish. Now run one end of a strong bar magnet or horse shoe magnet through it.



- **Obervation :**

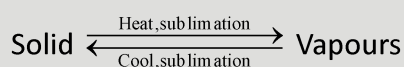
On lifting the magnet, some iron filings get attracted towards magnet. Remove them by hand and collect them in a dish. On repeating the process several times, all the iron filings are picked up and collected in the dish. Copper turnings are left behind in the dish.

- **Conclusion :**

Non- magnetic component can be separated from magnetic component by using magnet.

**(ii) By Sublimation :** We have learnt in previous chapter that ammonium chloride changes directly from solid to gaseous state on heating. So, to separate such mixtures that contain a sublimable volatile component from a non-sublimable impurity (salt in this case), the sublimation process is used.

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



Let's discuss an activity to understand sublimation method.

## LAB TIME

Let's Do & Learn



- **Objective:** To separate a mixture of ammonium chloride and common salt.

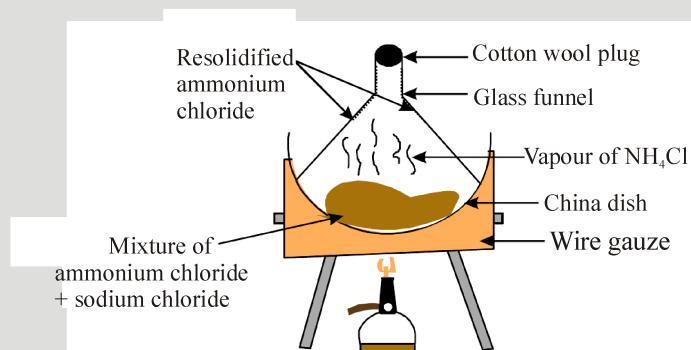
- **Materials required:** Ammonium chloride, common salt, China dish, cotton and inverted funnel.

- **Procedure :** (i) Place the mixture of common salt and ammonium chloride in a china dish and heat it over a low Bunsen flame.

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

(iii) 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.

(iv) 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

- **Observations :** The vapours of pure ammonium chloride undergo sublimation and are deposited near the neck of the funnel while common salt, the non-sublimable substance remains in the China dish as residue.

- **Conclusion :**

A sublimable volatile component can be separated from a non-volatile component of the mixture. Some more examples of mixtures which can be separated by sublimation method.

Solid-Solid Mixutre	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 filings and naphthalene	Naphthalene

### (iii) By Using a Suitable Solvent :

In some cases, one constituent of a mixture is soluble in a particular liquid solvent whereas the other constituent is insoluble in it. This difference in the solubilities of the constituents of a mixture can be used to separate them.

For example, sugar is soluble in water whereas sand is insoluble in it, so a mixture of sugar and sand can be separated by using water as solvent.

This will become more clear from the following activity.

## LAB TIME

Let's Do & Learn

- **Objective:** To Separate a Mixture of Sugar and Sand.

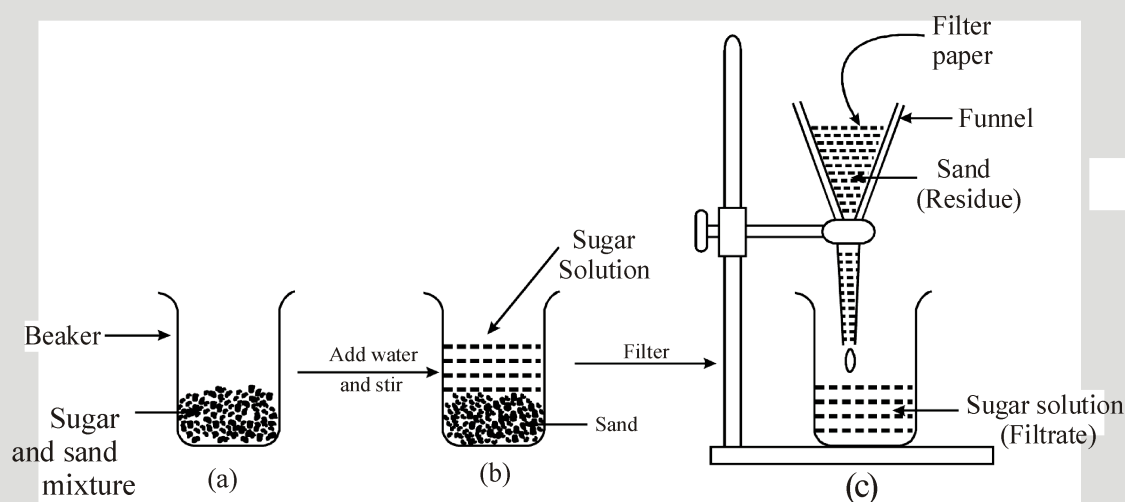
- **Materials required:** Sugar, sand, water, beakers, filter papers, funnel etc.

- **Procedure :**

(i) The mixture of sugar and sand is taken in a beaker and water is added to it.

(ii) The mixture is stirred to dissolve the sugar.

(iii) The sugar solution containing sand is filtered by pouring over a filter paper kept in a funnel.



- **Observation and discussion :**

Sand remains as a residue on the filter paper and sugar solution is obtained as a filtrate in the beaker kept below the funnel. The sugar solution is evaporated carefully to get the crystals of sugar.

- **Conclusion :**

In this way, a mixture of sugar and sand has been separated by using water as the solvent.

#### (iv) Crystallisation

The crystallisation method is used to purify solids. For example, the salt we get from sea water can have impurities in it. To remove these impurities, the process of crystallisation is used.

The process by which a pure soluble substance is separated in the form of crystals from its hot and saturated solution on cooling is called crystallisation.

Crystallisation is better than simple evaporation as a method to get pure solids from liquid as :

- (i) some solids may decompose or get charred when heated to dryness.
- (ii) on evaporation some dissolved impurities also get deposited with the solid while in crystallisation, crystals of pure solid are crystallised leaving the impurities in the solution.



• **Objective :** To obtain pure copper sulphate from impure sample using crystallisation.

• **Materials required :**

China dish, water, impure sample of copper sulphate, filter paper.

• **Procedure :**

- (i) Take some (approximately 5g) impure sample of copper sulphate in a china dish.
- (ii) Dissolve it in minimum amount of water.
- (iii) Filter the impurities out.
- (iv) Evaporate water from the copper sulphate solution so as to get a saturated solution.
- (v) Cover the solution with a filter paper and leave it undisturbed at room temperature to cool slowly for a day.
- (vi) You will obtain the crystals of copper sulphate in the china dish. This process is called **crystallisation**.

• **Discussion and observation :**

When a hot saturated solution of copper sulphate is allowed to cool, crystals of copper sulphate separate out.

All these crystals have a definite geometrical shape and hence look alike. We can separate these crystals from the liquid (called mother liquor) by the process of filtration.

• **Conclusion :**

When a hot saturated solution of a substance is allowed to cool, crystals of the substance having definite geometrical shapes separate out.

◆ **Applications of Crystallisation:**

- (i) Purification of salt that we get from sea water.
- (ii) Separation of crystals of alum (phitkari) from impure samples.

## 9.2 SEPARATION OF MIXTURE OF SOLID AND LIQUID

**(i) By Evaporation :** This method is used for separating a solid dissolved in a liquid. The solution is heated on a water bath or sand bath. This evaporates leaving the solid behind.

Let's understand this process by following activity.

**LAB TIME**

Let's Do & Learn



• **Objective :** To separate the coloured components (dye) from blue or black ink by evaporation.

• **Materials required:**

Beakers, watch glass, ink, burner, wire gauze, tripod stand, water.

• **Procedure :**

(i) Fill half a beaker with water.

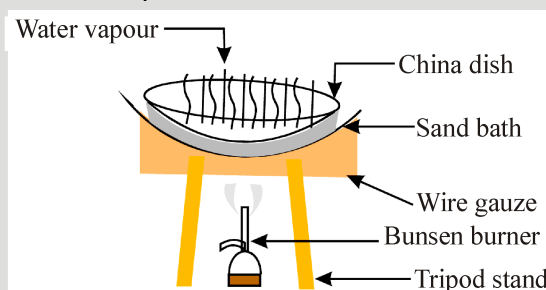
(ii) Put a watch glass on the mouth of the beaker.

(iii) Put few drops of ink on the watch glass.

(iv) Now start heating the beaker. You will see that evaporation is taking place from the watch glass.

(v) Continue heating as the evaporation goes on and stop heating when you do not see any further change on the watch glass.

(vi) Observe carefully and record your observations.



• **Observation and discussion :**

Ink (blue or black) is a mixture of dyes in water. When the ink is heated, the volatile component of the mixture i.e. water gets evaporated while the non volatile components of the mixture i.e. dyes remain as the residue.

• **Conclusion :**

The method of evaporation can be used to separate the volatile component (solvent) of the mixture from its non-volatile solute.

Some more examples of mixture are given below in table which can be separated by using evaporation.

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

**(ii) By Centrifugation :** Sometimes the solid particles in a liquid are very small and pass through a filter paper. For such particles the filtration technique cannot be used for separation. Such mixtures are separated by centrifugation.

The method of separating finely suspended or colloidal particles in a liquid, by whirling the liquid at a very high speed is called **centrifugation**.

◆ **Principle :** 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. Let's understand this process by following activity.

## LAB TIME

Let's Do &amp; Learn



• **Objective :** To separate cream from milk by centrifugation or by churning.

• **Materials required :**

Milk, test tube, centrifuge machine or churner.

• **Procedure :**

(i) Take some full-cream milk in a test tube.

(ii) Centrifuge it by using a centrifuging machine for two minutes.

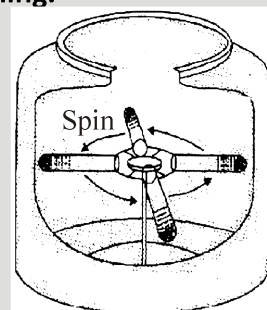
If a centrifuging machine is not available in the school, you can do this activity at home by using a milk churner, used in the kitchen.

• **Discussion and Observation :**

When the milk is churned, the lighter fat particles collide with each other to form cream. The cream thus separated starts floating on the surface of milk and is continuously collected from the outlet provided near the top of the centrifuging machine.

• **Conclusion:**

Liquid mixtures which contain solute particles which can easily pass through a filter paper (i.e. colloids) can be separated by using a centrifuging machine.



◆ **Applications of centrifugation :**

- (1) It is employed in milk dairies to separate cream from the milk.
- (2) It is employed in diagnostic laboratories in testing urine samples.
- (3) It is employed in blood banks to separate different constituents of blood.
- (4) It is used in drying machines to squeeze out water from the wet clothes.

**(iii) By Chromatography :**

The process of separation of different dissolved constituents of a mixture by adsorbing them over an appropriate adsorbent 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 adsorbed differently on the same adsorbent material, because they have different rates of movement.

The rate of movement of each adsorbed material depends upon :

- (1) The relative solubility of the constituents of mixture in a given solvent.
- (2) 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.



## Focus Point

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

Let's discuss an activity to understand chromatography method.

## LAB TIME

Let's Do &amp; Learn



• **Objective :** To separate the different coloured components of ink using chromatography.

• **Materials required :**

Filter paper, pencil, ink, jar / glass beaker / test tube, water.

• **Procedure :**

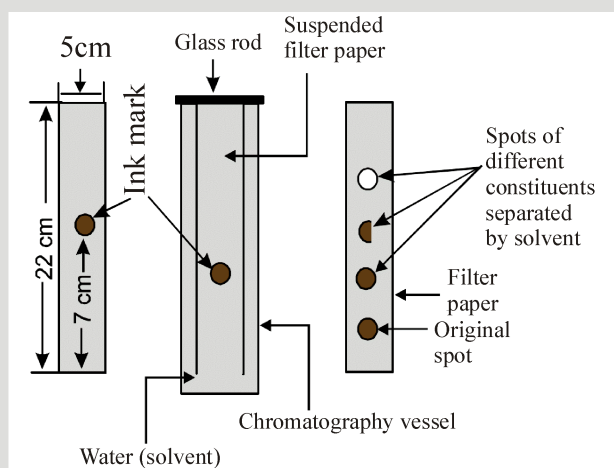
(i) Take a thin strip of filter paper.

(ii) Draw a line on it using a pencil, approximately 7 cm above the lower edge.

(iii) Put a small drop of ink (water soluble, that is, from a sketch pen or fountain pen) at the centre of the line. Let it dry.

(iv) Lower the filter paper into a jar / glass beaker / test tube containing water so that the drop of ink on the paper is just above the water level, as shown in figure below and leave it undisturbed.

(v) Watch carefully, as the water rises up on the filter paper. Record your observations.



• **Discussion and observation :**

(i) As water rises on the filter paper, it takes along with it different components of the ink.

(ii) Since a dye usually consists of two or more coloured substance, therefore, different colours are obtained on the filter paper strip. The dye which is more soluble in water dissolves first rises faster and produces a coloured spot on the paper at a higher position. The less soluble dyes dissolve a little later, rise slower and form coloured spots at lower heights. In this way, all the dyes present in black ink get separated.

• **Conclusion :**

Separation of different coloured components present in ink occurs on a chromatographic paper due to their different solubilities in water.

◆ **Applications of chromatography :**

(1) It is used to separate colours from dye.

(2) It is used in the separation of amino acids.

(3) It is used in the separation of sugar from urine.

(4) It is used in the separation of drugs from the samples of blood.



## Focus Point

- Kromo is Greek word means colour. There are many types of chromatography like gas chromatography, liquid chromatography, etc, but the simplest form is the paper chromatography.
- **Adsorption** : The process by which molecules of a substances, such as a gas or a liquid, collect on the surface of another substance such as a solid. The molecules are attracted to the surface but do not enter the solid's minutes spaces as in absorption.
- Paper chromatography is very useful in separating various constituents of coloured solutes present in a mixture like, ink dyes, etc.

### 9.3 SEPARATION OF MIXTURE OF TWO LIQUIDS

**(i) By Distillation** :Distillation method is used for the separation of components of a mixture containing two miscible liquids that boil without decomposition and have sufficient difference in their boiling points (more than 25°C).

Distillation is the process of heating a liquid to form vapour and then cooling the vapour to get back liquid. Distillation can be represented as :

Liquid  Vapour (or gas)

Let's understand this method by following activity.

### LAB TIME

Let's Do & Learn



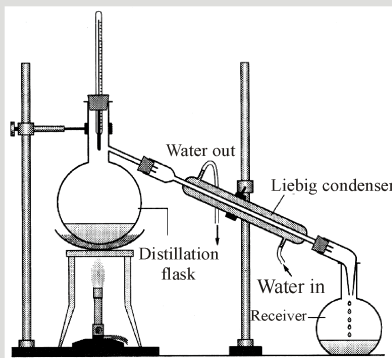
- **Objective** : To separate a mixture of two miscible liquids using distillation.

- **Materials required** :

Distillation flask, thermometer, stand, burner, water condenser, conical flask, mixture of water & acetone.

- **Procedure** :

- Let us try to separate acetone and water from their solution.
- Take the mixture in a distillation flask. Fit it with a thermometer.
- Arrange the apparatus.
- Heat the mixture slowly keeping a close watch at the thermometer.
- The acetone vaporises, condenses in the condenser and can be collected from the condenser outlet.
- Water is left behind in the distillation flask.



- **Discussion and observation :**

(i) When the mixture is heated, the vapours of the low boiling liquid, i.e., acetone are first formed. These travel upwards. On passing through the condenser, they get condensed to form liquid acetone which is collected in the beaker.

(ii) The boiling point of acetone is 329 K (56°C), therefore, the thermometer reading becomes constant at 329 K when acetone is distilling.

- **Conclusion :**

Separation of the components of a mixture containing two miscible liquids which boil without decomposition and have difference in their boiling points (more than 25°C) can be carried out by simple distillation.



## Focus Point

- Those liquids which mix together in all proportions and form a single layer, are called miscible liquids.
- The liquid obtained by condensing the vapour in the process of distillation is called Distillate.

◆ **Fractional distillation :** In case of two liquids which have very close boiling points, both the liquids tend to distil over in different proportions.

To separate a mixture of two or more miscible liquids for which the difference in boiling points is less than 25 K, fractional distillation process is used.

The apparatus is similar to that for simple distillation, except that a fractionating column is fitted in between the distillation flask and the condenser.

Let's understand fractional distillation method by following activity.

## LAB TIME

Let's Do & Learn



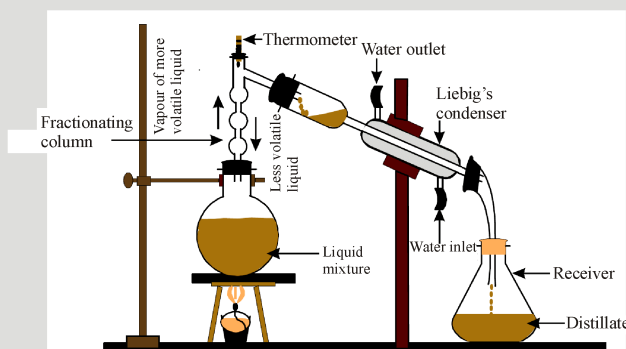
- **Objective :** To separate a mixture of alcohol and water.

- **Materials required:** Mixture of ethyl alcohol and water, distillation flask, fractionating column.

- **Procedure :**

(i) Take a mixture of ethyl alcohol (boiling point 351 K) and water (boiling point 373 K) in a distillation flask provided with a fractionating column.

(ii) Start heating the liquid mixture till the mixture starts boiling.



• **Observations :**

- (i) More volatile liquid is condensed first and collected in the flask.
- (ii) Less volatile liquid with high boiling point is collected next in another flask.

• **Conclusion :**

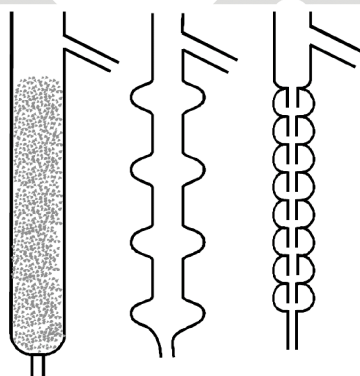
On heating, vapours of alcohol (low boiling point) escape from the flask and get condensed more readily. At the same time the vapours of water (high boiling point) fall back in the flask after getting condensed through fractionating column. When whole of the alcohol has distilled, the temperature starts rising on further heating. When the vapour pressure of water becomes equal to atmospheric pressure, it starts boiling. The vapours are condensed and collected.



### Focus Point

- The process of fractional distillation is useful only, if the difference in the boiling points of the two miscible liquids is less than 25°C.

◆ **Fractionating column :** The design of a fractionating column is such that the vapours of one liquid (with a higher boiling point) are preferentially condensed as compared to the vapours of the other liquid (with lower boiling point).



**Different types of fractionating columns**

Some miscible liquid-liquid mixtures are given below which can be separated by using distillation method.

Miscible liquid - liquid mixture	Component which distils over
Ethyl alcohol (b.p. 78°C) + Water (b.p. 100°C)	Ethyl alcohol
Methyl alcohol (b.p. 64.5°C) + Ethyl alcohol (b.p. 78°C)	Methyl alcohol
Acetone (b.p. 56.5°C) + Water (b.p. 100°C)	Acetone
Acetone (b.p. 56.5°C) + Ethyl alcohol (b.p. 78°C)	Acetone
Methyl alcohol (b.p. 64.5°C) + Acetone (b.p. 56.5°C)	Acetone



## Focus Point

- Petroleum products are also separated by fractional distillation.

### (ii) By Separating Funnel :

A mixture of two immiscible liquids can be separated by using a separating funnel. Two liquids which do not mix with each other are called immiscible liquids. These liquids form heterogeneous mixture. On standing they separate out into two separate layers depending upon their densities.

◆ **Principle** : The separation of two immiscible liquids 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 its bottom. The table below 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

Let's understand this process by following activity.

## LAB TIME

Let's Do & Learn



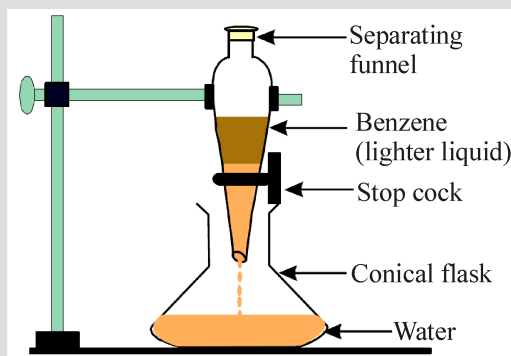
- Objective** : To illustrate separation of two immiscible liquids using a separating funnel.

- Materials required:**

Beakers, separating funnel, kerosene oil, water.

- Procedure :**

- Let us try to separate kerosene oil from water using a separating funnel.
- Pour the mixture of kerosene oil and water in a separating funnel.
- Let it stand undisturbed for sometime so that separate layers of oil and water are formed.
- Open the stopcock of the separating funnel and pour out the lower layer of water carefully.
- Close the stopcock of the separating funnel as the oil reaches the stopcock.



**• Discussion and Observation :**

Kerosene oil and water being insoluble form two separate layers. Kerosene oil being lighter than water forms the upper layer while water forms the lower layer. On opening the stopcock of separating funnel, the lower layer of water comes out first and is collected in a beaker. When the water layer has completely run off, then the stopcock is closed.

The kerosene is left behind in the separating funnel. It can be removed in a separate beaker by opening the stopcock again.

**• Conclusion :**

Immiscible liquid separate out in different layers depending upon their densities and hence can be separated using a separating funnel.

**◆ Applications of separating funnel method :**

(1) This method is used for separating any two immiscible liquids.

(2) This method is used in separation of slag (a waste material) from 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 drained out from two different outlets.

**10. 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 -

**◆ 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  $-20^{\circ}\text{C}$ , where water vapour present in it freezes and hence, air becomes dry.

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

**◆ 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.

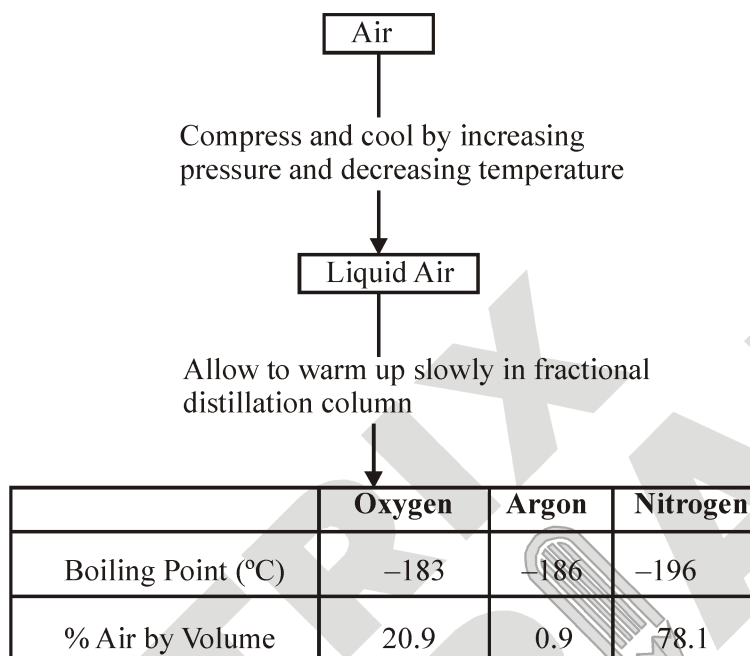
(iii) The compressed and cooled air is passed through a spiral pipe, placed in a vacuum flask. The end of spiral pipe is provided with a fine jet.

(iv) 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.

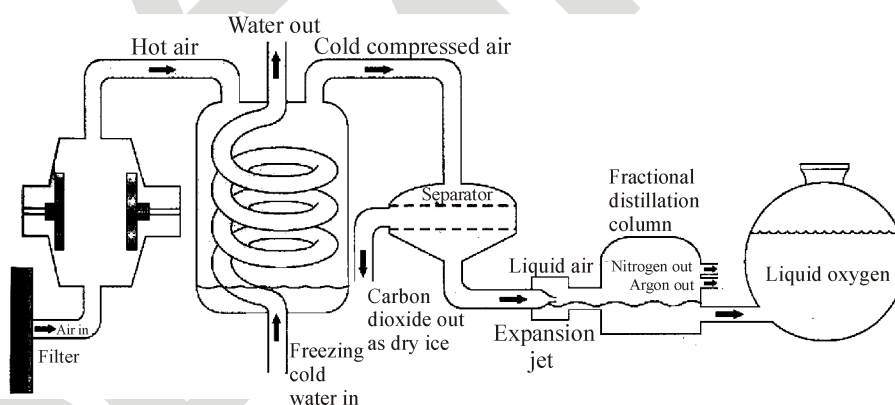
(v) The air so cooled, is now at a pressure equal to that of atmosphere. This cooled air rises up and in the process further cools the incoming compressed air in spiral tube. The air is then sucked again by the compression pump and the cycle is repeated. With every cycle, the temperature of air drops,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

◆ **Fractional Distillation of Air :**

Air is a homogeneous mixture and can be separated into its components by fractional distillation. The flow diagram shows the steps of the process.



- (i) The liquid air mainly consists of nitrogen and oxygen, and is at a temperature of  $-200^{\circ}\text{C}$ .
- (ii) The boiling point of liquid nitrogen is  $-195^{\circ}\text{C}$  and that of liquid oxygen is  $-183^{\circ}\text{C}$ .



- (iii) The liquid is gradually warmed to  $-195^{\circ}\text{C}$ , when nitrogen starts boiling off from the liquid air. The nitrogen gas so formed, is compressed and filled in steel cylinders.
- (iv) The liquefied oxygen left behind, is also changed to gas and then filled in compressed state in steel cylinders.

**11. CITYWATER SUPPLY**

River water is normally used to supply drinking water to big cities. This water is unfit for drinking purpose 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 -

**(i) 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.

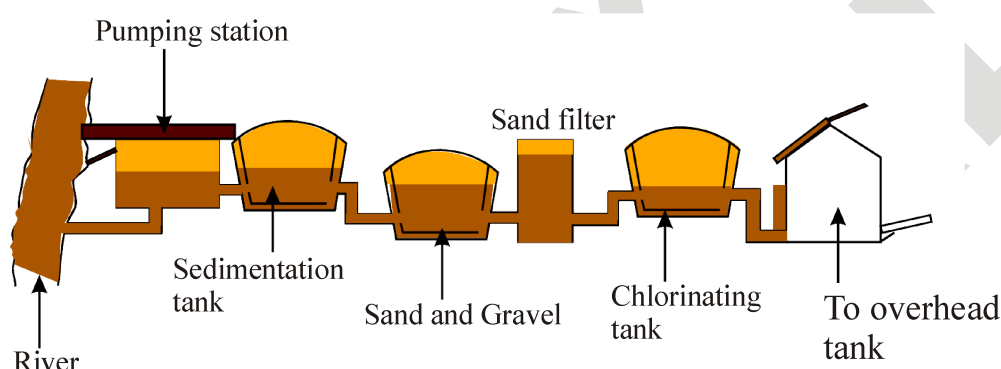
**(ii) Filtration :**

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.

**(iii) Removal of Harmful Micro-Organism or Sterilization :**

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.

**12. PHYSICAL AND CHEMICAL CHANGES**

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

**12.1 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 gets reversed, if the cause producing the change is removed.

**Following points need special consideration :**

**(i) No new or different product is formed :** The composition of molecules of the substance remains unaltered.

For 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.

For 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).



## Focus Point

- 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 no net energy change involved. For example,

If 1 g of water at 100° C on changing into steam at 100°C needs 2260 J of heat energy, then 1 g of steam at 100° C on changing into water at 100° C, gives out 2260 J of heat 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 magnetised. If it is brought near iron nails, they get attracted.	The steel rod acquires the the property of attracting pieces of iron.
3. Action of heat of iodine	The brownish grey crystals of iodine change to form violet vapours. On cooling the vapours condense on cooler parts of the test tube to form crystals.	Change in state and colour.
4. Dissolving common salt in water.	The white crystalline salt disappear in water. However the water tastes exactly like common salt and it can be recovered by evaporation.	Change in state.

**◆ Some Common Examples of Physical Changes :**

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

**12.2 CHEMICAL CHANGES**

**Definition :** A change which alters the specific 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 need 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.

For example,

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), 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.



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

For 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.

For 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 heated in flame of Bunsen burner, it catches fire and burns with dazzling white flame to form white ash.	Magnesium + Oxygen →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 + Water → Rust
3. Burning of LPG	LPG (Liquefied Petroleum Gas) is burnt, with pale blue flame and liberates colourless gas carbon dioxide along with steam.	Butane (LPG) + Oxygen →Carbon dioxide+Water

◆ Some common examples of chemical changes

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



**Focus Point**

- A chemical change is also called a chemical reaction.

**Difference between physical and chemical changes**

Physical Change	Chemical Change
1. The change take place only in state, texture, colour, electrical or magnetic properties or solubility, etc. However, molecular properties (composition) do not change.	1. The change takes place in 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. No new substances are produced.	3. Always new substances are produced.
4. There is no change of weight, if a substance is undergoing a physical change.	4. There is always a change in apparent weight of substance, when it undergoes a chemical changes.
5. Energy change may or may not occur 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 permanent change and cannot be reversed by removing the cause of the change.

## SOLVED EXAMPLES

### SE. 1

How will you separate a mixture of common salt, sulphur powder and sand?

**Ans.** First shake the mixture with carbon disulphide, sulphur powder dissolves leaving behind common salt and sand. The mixture is filtered. Evaporation of carbon disulphide from the filtrate gives sulphur powder. The residue left on the filter paper consists of common salt and sand. Shake this mixture well with water when common salt dissolves leaving behind sand. The mixture is filtered. Evaporation of water from the filtrate gives common salt.

### SE. 2

Comment upon the following :

- (i) Smoke and fog are aerosols.
- (ii) An emulsifying agent stabilizes a colloidal sol of a solid in a liquid.
- (iii) Amalgamated zinc is a compound.

**Ans.** (i) A colloidal solution in which gas is the dispersion medium is called the aerosol. Since smoke is a colloidal sol of solid carbon particles in air and fog is a colloidal sol of moisture (water droplets) in air, therefore, both are aerosols.  
(ii) Colloidal sols of solid in liquid or liquid in solid are quite stable. Therefore, they do not need any emulsifying agent. However, liquid in liquid type colloidal sols called emulsions are usually unstable. Therefore, to stabilize them usually emulsifying agents are added. For example, milk in which liquid fat is dispersed in water is stabilized by the protein lactalbumin present in it.  
(iii) Amalgamated zinc is obtained by vigorously shaking zinc granules with a solution of mercuric chloride. As a result, the surface of zinc granules is coated with mercury. In other words, amalgamated zinc is not a compound but is a heterogeneous mixture of zinc and mercury.

### SE. 3

Classify the following as pure substances or mixtures. Separate the pure substances into elements, compounds and divide the mixtures into homogeneous and heterogeneous :

- (i) Air
- (ii) Milk
- (iii) Graphite
- (iv) Gasoline
- (v) Diamond
- (vi) Tap water
- (vii) Distilled water
- (viii) Oxygen
- (ix) Brass
- (x) 22Carat gold
- (xi) Steel
- (xii) Iron
- (xiii) Sodium chloride
- (xiv) Gun powder

**Ans.** (i) Air : Mixture (Homogeneous)  
(ii) Milk : Mixture (Homogeneous)  
(iii) Graphite : Pure substance (Element)  
(iv) Gasoline : Mixture (Homogeneous)  
(v) Diamond : Pure substance (Element)  
(vi) Tap water : Mixture (Homogeneous)  
(vii) Distilled water : Pure substance (Compound)  
(viii) Oxygen : Pure substance (Element)  
(ix) Brass : Mixture (Homogeneous)  
(x) 22 Carat gold : Mixture (Homogeneous)  
(xi) Steel : Mixture (Homogeneous)  
(xii) Iron : Pure substance (Element)  
(xiii) Sodium chloride : Pure substance (Compound)  
(xiv) Gun powder : Mixture (Heterogeneous)

### SE. 4

How will you separate the components of gun powder?

**Ans.** Gun powder is a mixture of nitre (potassium nitrate), sulphur and powdered charcoal. The mixture is thoroughly shaken with water when nitre goes into solution leaving behind sulphur and charcoal undissolved. The solution is filtered out. The filtrate contains aqueous solution of nitre.  
On slow evaporation, the filtrate gives crystals of nitre.  
Undissolved residue containing sulphur and charcoal is treated with carbon disulphide solution. Sulphur dissolves in the solution but charcoal does not. On filtration, charcoal is obtained as a residue. The filtrate, which contains sulphur, on evaporation gives sulphur as the residue.

**SE. 5**

How will you separate the components of a mixture of common salt and sand?

**Ans.** The mixture is treated with water. Common salt dissolves in water, but sand remains undissolved. The solution is filtered. The filtrate is an aqueous solution of common salt. The solution on evaporation gives common salt as the residue.

**SE. 6**

Calculate the concentration of a solution in volume percent made when 56g of water is mixed with 0.17 L of ethanol.

**Ans.** Volume of water =  $\frac{\text{mass}}{\text{density}}$

$$= \frac{56\text{g}}{1.0\text{gcm}^{-3}} = 56\text{cm}^3 = 56\text{mL}$$

volume of ethanol = 0.17 L =  $0.17 \times 1000$  mL = 170 mL

volume of solution = (56+170) mL = 226 mL

concentration percent by volume

$$= \frac{56}{226} \times 100 = 24.78\%$$

**SE. 7**

How will you separate iron filings, ammonium chloride and sand from their mixture?

**Ans.** The mixture containing iron filings, ammonium chloride and sand is separated as follows:

(i) Iron filings are attracted by a magnet so they are removed by the method of magnetic separation. When a magnet is moved in this mixture, iron filings cling to the magnet and get separated. We are then left with ammonium chloride and sand.

(ii) Ammonium chloride sublimes on heating whereas sand does not sublime. So, ammonium chloride is separated from sand by the process of sublimation. When the mixture containing ammonium chloride and sand is heated, then ammonium chloride forms vapours easily. These vapours on cooling give pure ammonium chloride.

**SE. 8**

You are given a mixture of sand, water and mustard oil. How will you separate the components of this mixture?

**Ans.** This mixture contains three components : sand, water and mustard oil. Now, sand is a solid which is insoluble in water as well as mustard oil. Water and mustard oil are immiscible liquids. (i) The mixture of sand, water and mustard oil is filtered. Sand is left on the filter paper as residue. Water and mustard oil collects as filtrate. (ii) The filtrate containing water and mustard oil is put in a separating funnel. Water forms the lower layer and mustard oil forms the upper layer in separating funnel. The lower layer of water is run out first by opening the stop-cock of the separating funnel. Mustard oil remains behind in the separating funnel and can be removed separately.

**SE. 9**

If 110 g of salt is present in 550 g of solution, calculate the concentration of solution.

**Ans.** Here, mass of solute (salt) = 110 g

And, mass of solution = 550 g

Now, we know that :

Concentration of solution (w/w%)

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

$$= \frac{110}{550} \times 100 = \frac{100}{5} = 20 \text{ percent (or 20\%)}$$

Thus, the concentration of this salt solution is 20 per cent (w/w) (or it is a 20% salt solution).

**SE. 10**

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

**Ans.** Volume of solute (alcohol) = 50 mL  
Volume of solvent (water) = 150 mL  
So, Volume of solution  
= Volume of solute + Volume of solvent  
= 50 + 150 = 200 mL  
Concentration of solution (v/v%)

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

$$= \frac{50}{200} \times 100 = 25\%(\text{v/v})$$

**SE. 11**

Can physical and chemical changes occur together? Illustrate your answer.

**Ans.** In some cases, physical and chemical changes occur together. One such example is burning of candle. The solid wax present in the candle first changes into liquid state and then into the vapour state. Both these changes are physical changes. The wax vapours then combine with oxygen of the air to form a mixture of carbon dioxide and water. This involves a chemical change. The unburnt wax vapours again change first to the liquid state and finally to the solid state. This interconversion of states is a physical change. Thus, burning of candle involves both physical and chemical changes.

**SE. 12**

How can a saturated solution be made unsaturated?

**Ans.** A saturated solution can be made unsaturated in the following two ways :

(i) By increasing the temperature of the solution. When a saturated solution is heated, solubility of the solute increases and hence the solution becomes unsaturated.

(ii) By adding more of the solvent or by diluting.

**SE. 13**

Mercuric oxide is a red powder (HgO). When heated in a dry test tube, it gives out liquid mercury and colourless oxygen gas as :  
Mercuric oxide  $\rightarrow$  Mercury + Oxygen  
What conclusion will you draw regarding these three substances : mercuric oxide, mercury and oxygen?

**Ans. Mercuric oxide :** It is a compound because it splits up into simpler substances mercury and oxygen.

**Mercury :** It is an element because it cannot be further decomposed into simpler substances.

**Oxygen :** It is also an element because it cannot be further decomposed into simpler substances.

**NS. 1**

What is meant by a pure substance?

**Ans.** A pure substance is one which is made up of only one kind of atoms or molecules, e.g., water is made up of only one kind of particles. So water is a pure substance.

**NS. 2**

Differentiate between homogeneous and heterogeneous mixtures with examples.

**Ans.** Refer to the theory.

**NS. 3**

To make a saturated solution 36 g of sodium chloride is dissolved in 100 g of water at 293 K. Find its concentration at this temperature.

**Ans.** Mass of sodium chloride (solute) = 36 g

Mass of water (solvent) = 100 g

Mass of solution = 36 + 100 = 136 g

Concentration of solution

$$= \frac{\text{mass of solute}}{\text{mass of solution}} \times 100 = \frac{36}{136} \times 100 = 26.47\%$$

(w/w)

**NS. 4**

How will you separate a mixture containing kerosene and petrol, (difference in their boiling points is more than 25°C), which are miscible with each other?

**Ans.** The mixture of two miscible liquids such as kerosene and petrol whose boiling points differ by more than 25°C can be easily separated by the technique of simple distillation. At the boiling point of more volatile (low boiling) liquid of the mixture, the vapours almost exclusively consist of the more volatile liquid. Likewise at the boiling point of the less volatile (high boiling) liquid, vapours almost entirely consist of the less volatile liquid since the more volatile liquid has already distilled over.

**NS. 5**

Name the technique to separate

(i) butter from curd

(ii) salt from sea water

(iii) camphor from salt.

**Ans.** (i) Butter from curd can be separated by the technique of centrifugation.

(ii) Salt from sea water can be separated by the technique of crystallisation or by the evaporation.

(iii) Camphor is sublimable but salt is not. So, camphor can be separated from salt by sublimation technique.

**NS. 6**

What type of mixtures are separated by the technique of crystallisation?

**Ans.** Homogeneous mixtures such as common salt solution and copper sulphate solution are separated by technique of crystallisation.

**NS. 7**

Classify the following as chemical or physical changes.

(i) cutting of trees

(ii) melting of butter in a pan

(iii) rusting of almirah

(iv) boiling of water to form steam

(v) passing of electric current through water and the water breaking down into hydrogen and oxygen

(vi) dissolving common salt in water

(vii) making a fruit salad with raw fruits

(viii) burning of paper and wood

**Ans.** (i) Cutting of trees is a chemical change since all chemical reactions stop and we cannot get back the original tree from the wooden pieces.  
 (ii) Melting of butter in a pan is a physical change since there is no change in the chemical composition of butter, only the physical state changes from solid to liquid.  
 (iii) Rusting of almirah is a chemical change since during rusting, a new chemical compound called hydrated iron oxide (rust) is formed.

(iv) Boiling of water to form steam is a physical change because during this change only change of state occurs from liquid water to steam (gaseous) without any change in its chemical composition.

(v) Passing of electrical energy through water to form hydrogen and oxygen is a chemical change since the properties of hydrogen (combustible gas) and oxygen (supporter of combustion) are altogether different from those of water which is neither combustible nor a supporter of combustion but it actually extinguishes fire.

(vi) Dissolution of common salt in water is a physical change since salt can be easily recovered by evaporating water.

(vii) Making a fruit salad with raw fruits is a physical change since there is no change in the chemical properties of the fruits but only the physical appearance has changed.

(viii) Burning of paper and wood is a chemical change since carbon dioxide, water vapours, smoke and ash which are the products of combustion cannot be converted back into paper or wood by any physical method.

**NS. 8**

Try segregating the things around you as pure substances or mixtures.

- |                     |                       |
|---------------------|-----------------------|
| (a) distilled water | (b) curd              |
| (c) diamond         | (d) ice cream         |
| (e) kerosene oil    | (f) cooking oil       |
| (g) steel           | (h) graphite          |
| (i) raw rubber      | (j) vulcanized rubber |
| (k) solder wire.    |                       |

**Ans.** Pure substances : Distilled water, diamond, graphite, raw rubber

Mixtures : Curd, ice cream, kerosene oil, cooking oil, steel, vulcanised rubber, solder wire (alloy of lead and tin).

**NS. 9**

Which separation techniques will you apply for the separation of the following?

- (a) Sodium chloride from its solution in water.
- (b) Ammonium chloride from a mixture containing sodium chloride and ammonium chloride.
- (c) Small pieces of metal in the engine oil of a car.
- (d) Different pigments from an extract of flower petals.
- (e) Butter from curd.
- (f) Oil from water.
- (g) Tea leaves from tea.
- (h) Iron pins from sand.
- (i) Wheat grains from husk.
- (j) Find mud particles suspended in water.

**Ans.**

- (a) Evaporation: Water will evaporate leaving behind sodium chloride.
- (b) Sublimation : Ammonium chloride will be collected as sublimate.
- (c) Filtration : Pieces of metal can be separated by filtration.
- (d) Chromatography: Pigments (coloured components) from the extract of flower plants can be separated by chromatography.
- (e) Centrifugation : Butter will get separated upon centrifugation.
- (f) Separating funnel : Oil and water can be separated by the use of separating funnel.
- (g) Filtration : Upon filtration through a sieve, tea leaves will be collected on the sieve.
- (h) Magnetic separation : A magnet will attract iron pins and not sand particles.
- (i) Sieving: Wheat grains from husk can be separated with the help of sieves.
- (j) Sedimentation : As a result of sedimentation, mud particles will settle as precipitate. It can be separated later on by filtration.

**NS. 10**

Write the steps you would use for making tea. Use the words solution, solvent, solute, dissolve, soluble, insoluble, filtrate and residue.

**Ans.** Take 100 mL of water which acts as solvent. Boil water on a gas stove. Add one teaspoon of sugar which acts as solute. Sugar is soluble in water, so gets dissolved in water and forms a solution. Now add about half a teaspoon of tea leaves which are insoluble in water. Boil the contents for 4 to 5 minutes and add a half cup of milk and allow to boil again for 2-3 minutes. Filter the tea with the help of a sieve. Tea leaves will be left as residue while tea will be obtained as filtrate.

**NS. 11**

Pragya tested the solubility of three different substances at different temperatures and collected the data as given below (results are given in the following table, as grams of substance dissolved in 100 grams of water to form a saturated solution).

Substance	Temperature in K				
	283	293	313	333	353
Dissolved					
Potassium nitrate	21	32	62	106	167
Sodium chloride	36	36	36	37	37
Potassium chloride	35	35	40	46	54
Ammonium chloride	24	37	41	55	66

- (a) What mass of potassium nitrate would be needed to produce a saturated solution of potassium nitrate in 50 grams of water at 313 K?
- (b) Pragya makes a saturated solution of potassium chloride in water at 353 K and leaves the solution to cool at room temperature. What would she observe as the solution cools? Explain.
- (c) Find the solubility of each salt at 293 K. Which salt has the highest solubility at this temperature?
- (d) What is the effect of change of temperature on the solubility of a salt?

**Ans.** (a) Solubility of potassium nitrate at 313 K  

$$= \frac{62}{100}$$

100 g of water contains potassium nitrate = 62 g  
 50 g of water contains potassium nitrate

$$= \frac{62}{100} \times 50 = 31\text{g}$$

Thus, 31 g potassium nitrate would be needed to produce a saturated solution of potassium nitrate in 50 g of water at 313 K.

(b) When a saturated solution of potassium chloride at 353 K is cooled, the solubility of potassium chloride in water decreases. As a result the amount of potassium chloride which exceeds its solubility at lower temperature separates out as crystals.

(c) The maximum amount of the salt which is dissolved in 100 g of water to form a saturated solution at the given temperature, is known as solubility.

$$\text{Solubility of potassium nitrate at 293 K} = \frac{32}{100}$$

$$\text{Solubility of sodium chloride at 293 K} = \frac{36}{100}$$

$$\text{Solubility of potassium chloride at 293 K} = \frac{35}{100}$$

$$\text{Solubility of ammonium chloride at 293 K} = \frac{37}{100}$$

From the above data it is clear that ammonium chloride has the highest solubility at 293 K

(d) In general, the solubility of a salt increases with increasing temperature. The increase is, however, different for different salts. For example, the solubility of potassium nitrate increases appreciably, that of ammonium chloride increases slightly, that of potassium chloride increases marginally while that of sodium chloride almost remains constant.

**NS. 12**

Explain the following by giving examples.

- (a) saturated solution
- (b) pure substance
- (c) colloid
- (d) suspension

**Ans.** (a) **Saturated solution** : A solution in which no more solute can be dissolved in a given amount of solvent at a particular temperature is called saturated solution. For example, if we dissolve 40 g sodium chloride in 100 g of water at 293 K, it will form a saturated solution because the solubility of sodium chloride at 293 K is 36 g per 100 g of water.

(b) **Pure substance** : A substance made up of only one kind of atoms or molecules is called a pure substance. A pure substance has the same colour, taste and texture at a given temperature and pressure. A pure substance also has a fixed melting and boiling point at a constant pressure. For example, hydrogen gas, sodium chloride, water, etc.

(c) **Colloid** : A substance is said to be a colloid if the particle size lies between 1 to 100 nm. A colloidal solution is heterogeneous and consists of two phases, i.e., dispersed phase (colloidal particles) and dispersion medium in which colloidal particles are suspended. For example, colloidal solution of sulphur or starch, milk, etc.

(d) **Suspension** : It is a heterogeneous mixture in which the particles of the solute do not dissolve but remain suspended throughout the bulk of the solvent. The size of the suspension particles is more than  $10^{-7}$  m. For example, chalk powder in water is a suspension.

**NS. 13**

Classify each of the following as a homogeneous or heterogeneous mixtures. Soda water, wood, air, soil, vinegar, filtered tea

**Ans.** Homogeneous mixtures : Soda water, vinegar and filtered tea.

Heterogeneous mixtures : Wood and soil.

Air is a homogeneous mixture of different gases.

However, if some dust or other particles are also present, then air becomes heterogeneous mixture.

**NS. 14**

How would you confirm that a colourless liquid given to you is pure water?

**Ans.** If the boiling point and freezing point of the given liquid comes out to be  $100^{\circ}\text{C}$  or 373 K and  $0^{\circ}\text{C}$  or 273 K respectively under one atmospheric pressure, it confirms that the given liquid is pure water.

**NS. 15**

Which of the following materials fall in the category of a "pure substance"?

(a) ice, (b) milk, (c) iron, (d) hydrochloric acid, (e) calcium oxide, (f) mercury, (g) brick, (h) wood, (i) air

**Ans.** Ice, iron, calcium oxide and mercury are pure substances since they contain particles of only one kind of matter. In contrast, milk, hydrochloric acid (hydrogen chloride gas dissolved in water), brick and air cannot be called pure substances because they consist of particles of more than one kind of matter.

**NS. 16**

Identify the solutions among the following mixtures.

(a) Soil, (b) sea water,  
(c) air, (d) coal,  
(e) soda water

**Ans.** A solution is a homogeneous mixture of two or more substances. In the light of this, the solutions among the given mixtures are (b) sea water, (c) air and (e) soda water.

**NS. 17**

Which of the following will show Tyndall effect?

(a) Salt solution  
(b) Milk  
(c) Copper sulphate solution  
(d) Starch solution

**Ans.** (b) Milk and (d) starch solution show Tyndall effect because they are colloidal solutions, whereas (a) salt solution and (c) copper sulphate solution are true solutions. Their particle size is too small to scatter light, so they do not show Tyndall effect.

**NS. 18**

- (a) Salt solution
- (b) Milk
- (c) Copper sulphate solution
- (d) Starch solution

**Ans.** (b) milk and (d) starch solution show Tyndall effect because they are colloidal solutions, whereas (a) salt solution and (c) copper sulphate solution are true solutions. Their particle size is too small to scatter light, so they do not show Tyndall effect.

**NS. 19**

Classify the following into elements, compounds and mixtures.

- (a) Sodium, (b) soil, (c) sugar solution, (d) silver, (e) calcium carbonate, (f) tin, (g) silicon, (h) coal, (i) air, (j) soap, (k) methane, (l) carbon dioxide, (m) blood

**Ans.** Elements : The elements are regarded as the building blocks of the universe. So (a) sodium, (d) silver, (f) tin and (g) silicon are elements.  
Compounds : It is a pure substance made up of two or more elements chemically combined in a fixed proportion by mass. So, (e) calcium carbonate, (k) methane and (l) carbon dioxide are compounds.  
Mixtures : It is a substance containing two or more substances (elements or compound) in any proportion. So (b) soil, (c) sugar solution, (h) coal, (i) air, (j) soap and (m) blood are mixtures.

**NS. 20**

Which of the following are chemical changes?

- (a) Growth of a plant
- (b) Rusting of iron
- (c) Mixing of iron filings and sand
- (d) Cooking of food
- (e) Digestion of food
- (f) Freezing of water
- (g) Burning of a candle

**Ans.** (a) Growth of a plant (b) rusting of iron, (d) cooking of food (e) digestion of food and (g) burning of a candle, are chemical changes.

## EXERCISE – I

### ONLY ONE CORRECT TYPE

- The components of the substance can be separated by a chemical means only then it is a/ an  
(A) element  
(B) compound  
(C) mixture  
(D) none of these
- The zig-zag movement of dispersed phase particles in a colloidal system is known as  
(A) Brownian motion  
(B) translational motion  
(C) circular motion  
(D) linear motion
- Iodized common salt is  
(A) homogeneous mixture  
(B) heterogeneous mixture  
(C) pure substance  
(D) oxidized substance
- Pigments of natural colours can be separated by  
(A) chromatography  
(B) centrifugation  
(C) filtration  
(D) sublimation
- The fine particles of an insoluble substance uniformly dispersed throughout a gas or liquid. This mixture is called  
(A) suspension  
(B) precipitate  
(C) colloidal solution  
(D) impurity
- Which of the following upon shaking with water will not form a true solution?  
(A) Alum  
(B) Common salt  
(C) Albumin  
(D) Sucrose
- Which of the following will show Tyndall effect?  
(A) Starch solution  
(B) Sodium chloride solution  
(C) Copper sulphate solution  
(D) Sugar solution
- An emulsion is a colloidal solution formed by mixing  
(A) two miscible liquids  
(B) any two liquids  
(C) any two gases  
(D) two immiscible liquids
- The size of colloidal particles is in the range of  
(A) 1-100 nm (B) 100-1000 nm  
(C)  $10^{-5}\text{m}$ - $10^{-7}\text{m}$  (D)  $10^{-7}$ - $10^{-9}\text{cm}$
- Brass contains  
(A) gold and copper (B) copper and zinc  
(C) zinc and silver (D) copper and silver
- Which of the following is a homogeneous mixture?  
(A) Solution of sugar in water  
(B) Chalk powder in water  
(C) Kerosene oil in water  
(D) None of these
- Solutions with low concentrations of solutes are  
(A) concentrated solutions  
(B) dilute solutions  
(C) solvents  
(D) none of these
- Which of the following statement is correct?  
(A) A pure substance must contain only one type of atom.  
(B) A mixture containing two compounds must be heterogeneous.  
(C) A heterogeneous mixture must contain at least three components.  
(D) A homogeneous mixture must be uniform.
- Which of the following is not an example of a physical change?  
(A) Dissolving sugar in water  
(B) Casting iron in moulds  
(C) Settling of cement  
(D) Magnetisation of iron
- Separation of petroleum into its components is done by  
(A) chromatography  
(B) sublimation  
(C) distillation  
(D) fractional distillation

16. Identify the false statement.  
 (A) Colloids are homogeneous  
 (B) Colloids show Tyndall effect  
 (C) Colloids show Brownian movement  
 (D) The size of colloidal particles ranges between 1 -100 nm
17. Smoke is an example of  
 (A) gas dispersed in liquid  
 (B) gas dispersed in solid  
 (C) solid dispersed in gas  
 (D) solid dispersed in solid
18. Which one of the following is correctly matched?  
 (A) Emulsion - mud (B) Foam - mist  
 (C) Aerosol - smoke (D) Solid sol - cake
19. Which gas present in air has the highest boiling point?  
 (A) Oxygen (B) Nitrogen  
 (C) Argon (D) Hydrogen
20. Which of the following involves both physical and chemical change?  
 (A) Burning of a candle  
 (B) Rusting of iron  
 (C) Cooking of food  
 (D) Boiling of water
21. We can separate a pure solid from its solution by  
 (A) crystallization (B) simple distillation  
 (C) sedimentation (D) both (A) and (B)
22. Soda water is a solution of carbon dioxide in water. What is this solution composed of?  
 (A) Liquid solute in a gaseous solvent  
 (B) Gaseous solute in a liquid solvent  
 (C) Liquid solute in a liquid solvent  
 (D) Gas in suspended form in liquid
23. Which of the following pairs does not contain both elements?  
 (A) Carbon, silicon (B) Helium, nitrogen  
 (C) Bronze, zinc (D) Copper, silver
24. Principle of chromatography is  
 (A) rate of absorption  
 (B) rate of adsorption  
 (C) rate of diffusion  
 (D) none of these

25. A 15% alcohol solution means  
 (A) 15 mL alcohol and 85 mL water  
 (B) 15 mL alcohol and 100 mL water  
 (C) 15 mL water and 85 mL alcohol  
 (D) 15 mL alcohol and 50 mL water

**PARAGRAPH TYPE**

**PARAGRAPH # 1**

Pure substances can be elements or compounds. An element is a form of matter which cannot be broken down by chemical reactions into simpler substances. A compound is a substance composed of two or more different types of elements, chemically combined in a fixed proportion. Properties of a compound are different from its constituent elements, whereas a mixture shows the properties of its constituting elements or compounds.

26. Which of the following is not a pure substance?  
 (A) Tin (B) Coal  
 (C) Ice (D) Lime stone
27. The substance formed by mixing, crushing and heating iron filings and sulphur powder is  
 (A) an element (B) a compound  
 (C) a mixture (D) a solution
28. Lustre, ductility, malleability, conductivity are properties of  
 (A) metals (B) non-metals  
 (C) metalloids (D) compounds

**PARAGRAPH # 2**

The substances which homogeneously mix up together to form a solution are called the components of the solution. When two substances form a solution, one substance is said to dissolve into the other.

The substance which gets dissolved is commonly known as solute and the medium in which it gets dissolved is termed as solvent or the component of a solution present in excess is referred to as the solvent while the other component present in the smaller amount is called the solute.

A colloidal solution is a heterogeneous mixture in which the size of the solute particles is intermediate between those in true solutions and those in suspensions.

29. Blood is example of–  
 (A) True solution  
 (B) Suspension  
 (C) Colloidal solution  
 (D) None of these
30. The size of colloidal particle  
 (A) <1 nm  
 (B)  $10\text{Å} - 1000\text{Å}$   
 (C)  $10^{-9}\text{ cm} - 10^{-7}\text{ cm}$   
 (D) >10 nm
31. Air is example of  
 (A) Heterogenous mixtue  
 (B) Colloidal  
 (C) Suspension  
 (D) Homogeneous mixture

**MATCH THE COLUMN TYPE**

In this section, each question has two matching lists Choices for the correct combination of elements **Column-I** and **Column-II** are given as options (A), (B), (C) and (D) out of which one is correct.

32. **Column-I**                      **Column-II**  
 (P) Fog                              1. Solid in gas  
 (Q) Smoke                          2. Solid in solid  
 (R) Steel                             3. Solid in liquid  
 (S) Toothpaste                    4. Liquid in gas  
 (A) P-4, Q- 1, R-2, S-3  
 (B) P-2, Q- 3, R-1, S-4  
 (C) P-1, Q- 2, R-3, S-4  
 (D) P-3, Q- 2, R-1, S-4

33. **Column-I**                      **Column-II**  
 (P) Miscible liquids              1. Distillation  
 (Q) Immiscible liquids        2. Crystallisation  
 (R) Impure copper sulphate    3. Sublimation  
 (S) Salt and ammonium chloride 4. Separating funnel  
 (A) P-4, Q- 1, R-2, S-3  
 (B) P-1, Q- 4, R-2, S-3  
 (C) P-1, Q- 2, R-3, S-4  
 (D) P-3, Q- 2, R-1, S-4

## EXERCISE – II

### VERY SHORT ANSWER TYPE

1. In terms of physical properties why is it possible to separate the components of a mixture by physical means?
2. Is ice water homogeneous or heterogeneous substance? Is it pure or impure substance?
3. Explain why filter paper cannot be used to separate colloids?
4. What is meant by the terms composition and structure when referring to matter?
5. Classify the following elements as metal, non-metal or metalloid : aluminium, fluorine, gallium, phosphorus, tellurium, thorium, barium, strontium, calcium, krypton.
6. What type of mixture can be separated by technique of crystallisation?
7. Name the methods used for  
(i) getting pure sugar from impure sample,  
(ii) separating mixtures of components in blue ink.
8. Give an example of a non-aqueous solution.
9. 100 mL of alcohol is dissolved in 400 mL of water. Calculate the volume percentage of the solute.
10. Particle size of a substance in water is 200 nm. What is the nature of the solution?

### SHORT ANSWER TYPE

1. Which type of solution is aerated water?
2. What type of a change is rusting of iron?
3. By using the words solvent, solute, dissolve, solution, soluble, insoluble, filtrate and residue, explain how will you separate common salt from wheat husk.
4. A mixture of ethyl alcohol and water is homogeneous while that of oil and water is heterogeneous. Why?
5. Identify the statements which belong to a mixture and a compound.  
(a) The properties of the constituents are entirely different from the properties of the product formed by their chemical reaction.  
(b) The constituents retain their individual chemical properties in the product formed by mixing them.

### LONG ANSWER TYPE

1. When 100 g of a saturated solution is evaporated at 50°C, 50 g of solid is left over. Find the solubility of the substance at 50°C.
2. Why is the product formed on heating 1 g of sulphur powder and 2 g of copper turnings called a compound while the product formed by mixing 1 g of sulphur powder and 2 g of copper turnings is called a mixture?
3. List few applications of colloids.
4. Difference between solution, colloidal solution and suspension.
5. Identify the following as either a physical or a chemical property,  
(i) Soap is slippery,  
(ii) Gold does not rust,  
(iii) Water freezes at 0°C.  
(iv) Cooking gas burns in air to give a flame,  
(v) Ice melts when kept outside the fridge.

### TRUE AND FALSE TYPE

1. Air is a heterogeneous mixture.
2. Silver is a compound.
3. Compounds are homogeneous in nature.
4. Non-miscible liquids can be separated by distillation.
5. Rusting of iron is a chemical change.

### FILL IN THE BLANKS

1. Liquid in liquid colloidal solution called\_\_\_\_\_.
2. Size of solution particle \_\_\_\_\_.
3. A mixture of two immiscible liquids can be separated by \_\_\_\_\_.
4. Clotting of blood is example of \_\_\_\_\_.
5. The scattering of light by colloidal particle called\_\_\_\_\_.

### NUMERICAL TYPE QUESTIONS

1. If 2ml acetone is present in 45ml of its aqueous solution, what will be concentration of this solution?  
(A) 4.4% (B) 0.44%  
(C) 44% (D) 44.1%





## SELF PROGRESS ASSESSMENT FRAMEWORK

(CHAPTER : IS MATTER AROUND US PURE)

CONTENT	STATUS	DATE OF COMPLETION	SELF SIGNATURE
Theory			
In-Text Examples			
Solved Examples			
NCERT Exercises			
Exercise I			
Exercise II			
Short Note-1			
Revision - 1			
Revision - 2			
Revision - 3			
Remark			

### NOTES :

1. In the status, put “completed” only when you have thoroughly worked through this particular section.
2. Always remember to put down the date of completion correctly. It will help you in future at the time of revision.



*Space for Notes :*

A large rectangular area filled with horizontal dotted lines, intended for writing notes.



# ATOMS & MOLECULES

# 3

## Concepts

### Introduction

1. Laws of chemical combination
  - 1.1 Law of conservation of mass
  - 1.2 Law of definite proportion
2. Dalton's atomic theory
3. What is an atom ?
4. Symbol of atoms of different elements
  - 4.1 Dalton's symbols of elements
  - 4.2 Berzelius's symbols of elements
5. Significance of a symbol
6. Atomic mass, gram atomic mass
  - 6.1 Atomic mass
  - 6.2 Gram atomic mass
7. Molecules
  - 7.1 Molecule of Elements
  - 7.2 Molecule of Compounds
8. Atomicity
9. Molecular mass & gram molecular mass
  - 9.1 Molecular mass
  - 9.2 Gram molecular mass
10. Ions and its classification
  - 10.1 On the basis of charge
  - 10.2 On the basis of number of atoms
11. Formulae of ionic Compounds
12. Mole concept
  - 12.1 Moles in terms of mass
  - 12.2 Moles in terms of number of particles
  - 12.3 Moles in terms of volume of gas at STP
13. Average atomic mass
14. Percentage composition
15. Molecular formula and empirical formula
  - 15.1 Molecular formula
  - 15.2 Empirical formula
16. Relation between empirical and molecular formula
17. Calculation of the empirical and molecular formula

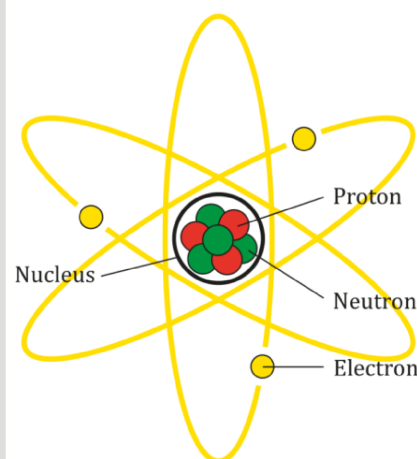
### Solved Examples

#### NCERT Solutions

#### Exercise – I (Competitive Exam Pattern)

#### Exercise – II (Board Pattern Type)

#### Answer Key





## INTRODUCTION

Ancient Indian and Greek philosophers have been thinking about what matter is ultimately made up of. It was around 500 BC that an Indian philosopher, Maharishi Kanad had postulated that matter is divisible, i.e., if we go on breaking matter, we will get smaller and smaller particle and ultimately, the particles obtained may be so small that they cannot be further divided. These indivisible particles were named as 'paramanu'. Almost during the same period, ancient Greek philosophers, Democritus and Leucippus, also put forward the same idea. However, they called the smallest indivisible particles as 'atoms'.

However, all these theories proposed by the Indian and Greek philosophers were based on abstract thinking and not on experiments. For about 2000 years, the atomic theory remained a mere speculation till John Dalton, an English school teacher, gave his theory on atoms. Dalton's theory was based on the chemical laws of combination known at that time. These laws of chemical combination were given by A.L. Lavoisier and Joseph L. Proust and were based upon extensive study of chemical reactions.



### Focus Point

- Atom word is taken from a Greek word 'atomos' means 'indivisible'.

## 1. 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 proportion

### 1.1 LAW OF CONSERVATION OF MASS

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.

OR

The law of conservation of mass means that in a chemical reaction, the total mass of products is equal to the total mass of the reactants. There is no 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,



Suppose a g of 'A' and b g of '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 :

When Calcium Carbonate ( $\text{CaCO}_3$ ) is heated, a chemical reaction takes place to form Calcium Oxide ( $\text{CaO}$ ) and Carbon dioxide ( $\text{CO}_2$ ). 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. Since the total mass of products (100 g) is equal to the total mass of the reactants (100 g), there is no change in the mass during this chemical reaction. The mass remains same or conserved.

## LAB TIME

Let's Do & Learn

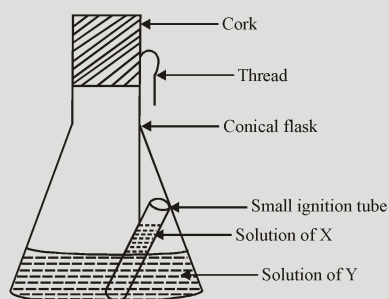


- **Object :** To demonstrate the law of conservation of mass.
- **Preparation Materials required :** Conical flask, thread, cork, ignition tube, solution of copper sulphate, sodium carbonate, barium chloride, sodium sulphate, lead nitrate, sodium chloride.
- **Procedure :**

(i) Take one of the following sets, X and Y of chemicals,

S. No.	X	Y
(I)	Copper sulphate	Sodium carbonate
(II)	Barium chloride	Sodium sulphate
(III)	Lead nitrate	Sodium chloride

- (ii) Prepare separately a 50% solution of any one pair of substance listed under X and Y in water.  
 (iii) Take a little amount of solution of Y in a conical flask and some solution of X in an ignition tube.  
 (iv) Hang the ignition tube in the flask carefully, see flask the solutions do not get mixed. Put a cork on the flask (see fig.)



- (v) Weight the flask with its contents carefully.  
 (vi) Now tilt and swirl the flask, so that the solution X and Y get mixed.  
 (vii) Weight again.

- **Observations :**

It is observed that on mixing two solution chemical reaction takes place which is indicated by the formation of a white precipitate in this case.



- **Conclusion :**

The mass of the flask and its contents remains constant. Thus, during a chemical reaction mass is neither created nor destroyed.

## 1.2 LAW OF DEFINITE PROPORTION

This law deals with the composition of elements present in a given compound. It was put forward by J.L. Proust in 1799. It states as follows:

A chemical compound always contains the same element combined together in fixed proportion by mass. For Example,

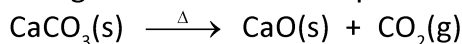
Water obtained from any source like river or tap etc and from any country is always made up of the same elements, i.e. hydrogen and oxygen combined together in the same fixed proportion, i.e., 1 : 8 by mass. This can be checked by taking 9 g of water from any source and then decomposing it by passing electricity and collecting the gases formed. We always get 1g hydrogen and 8 g oxygen.

**Example 1**

10.0 g of  $\text{CaCO}_3$  on heating gave 4.4 g of  $\text{CO}_2$  and 5.6 g of  $\text{CaO}$ . Show that these observations are in agreement with the law of conservation of mass.

**Solution :**

The given reaction takes place according to the following equation:



Mass of reactant ( $\text{CaCO}_3$ ) = 10 g

Mass of products ( $\text{CaO} + \text{CO}_2$ ) = (5.6 + 4.4) g = 10 g

Since, mass of the reactant is equal to the mass of the products, therefore, these observations are in agreement with the law of conservation of mass.

**Example 2**

In an experiment, 5.40 g of copper oxide give 4.32 g of metallic copper on reduction while in another experiment 2.30 g of copper oxide on reduction yielded 1.84 g of copper. Show that these findings are in accordance with the law of constant proportions.

**Solution :****Experiment I**

Mass of copper = 4.32 g

Mass of copper oxide = 5.40 g

$\therefore$  Mass of oxygen = Mass of copper oxide – Mass of copper  
= 5.40 – 4.32 = 1.08 g

Ratio of masses of copper and oxygen,

$$\frac{\text{Mass of copper}}{\text{Mass of oxygen}} = \frac{4.32}{1.08} = \frac{4}{1}$$

$\therefore$  Ratio is 4 : 1.

**Experiment II**

Mass of copper = 1.84 g

Mass of copper oxide = 2.30 g

$\therefore$  Mass of oxygen = Mass of copper oxide – Mass of copper  
= 2.30 – 1.84 = 0.46 g

Ratio of masses of copper and oxygen,  $\frac{\text{Mass of copper}}{\text{Mass of oxygen}} = \frac{1.84}{0.46} = \frac{4}{1}$

$\therefore$  Ratio is 4 : 1

As the ratio of copper and oxygen (by mass) is same in the two experiments, law of constant proportions is verified.

**2. DALTON'S ATOMIC THEORY**

John Dalton provided the basic theory about the nature of matter. He took the name, 'atoms', for the smallest particle of matter as given by the Greek. Based on the laws of chemical combination, he proposed a model of atom known as **Dalton's atomic theory**.

**The main postulates of the Dalton's atomic theory are:**

- (i) All 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 a 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) Atoms of two or more elements join together during chemical combination to form molecule 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.

### Merits of Dalton's Theory

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.** The 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 consists 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.

### Limitations of Dalton's Theory

The main drawbacks of Dalton's atomic theory are :

- (i) It could explain the laws of chemical combination by mass but failed to explain the law of gaseous volumes.
- (ii) It could not explain why atoms of different elements have different masses, sizes, valencies, etc.
- (iii) It could not explain how and why atoms of different elements combine with each other to form compound.
- (iv) It failed to explain the nature of forces that bind together atoms in a molecule.
- (v) It gave no satisfactory explanation of the differences between the ultimate particle of an element and that of a compound.

## 3. WHAT IS AN ATOM ?

All the matter is made up of atoms. An atom is 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 "nanometres"(nm).

1 metre =  $10^9$  nanometres or  $1\text{nm} = 10^{-9}$  m.

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

Species	Atomic radius
Hydrogen atom	$10^{-10}$ m
Molecule of water	$10^{-9}$ m
Molecule of haemoglobin	$10^{-8}$ m
Grain of sand	$10^{-4}$ m
An ant	$10^{-2}$ m
Watermelon	$10^{-1}$ m

#### 4. SYMBOL OF ATOMS OF DIFFERENT ELEMENTS

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

##### 4.1 DALTON'S SYMBOLS OF ELEMENTS

Dalton was the first to use symbols to represent elements in a short way but Dalton's symbols for element were difficult to draw and inconvenient to use, so Dalton's symbols are only of historical importance.

Substances	Symbol	Substances	Symbol	Substances	Symbol	Substances	Symbol
Hydrogen		Carbon		Copper		Water	
Oxygen		Sulphur		Zinc		Carbon dioxide	
Nitrogen		Lead		Mercury		Hydrogen disulphide	

##### 4.2 BERZELIUS'S SYMBOLS OF ELEMENTS

J.J. Berzelius proposed the modern system of representing an 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.

**Symbols of elements derived from English names :**

English name of the element	Symbol	English name of the element	Symbol
1. Argon	Ar	15. Iodine	I
2. Arsenic	As	16. Lithium	Li
3. Aluminium	Al	17. Magnesium	Mg
4. Boron	B	18. Manganese	Mn
5. Barium	Ba	19. Nitrogen	N
6. Bromine	Br	20. Neon	Ne
7. Carbon	C	21. Nickel	Ni
8. Calcium	Ca	22. Oxygen	O
9. Chlorine	Cl	23. Phosphorus	P
10. Chromium	Cr	24. Platinum	Pt
11. Cobalt	Co	25. Sulphur	S
12. Fluorine	F	26. Uranium	U
13. Hydrogen	H	27. Zinc	Zn
14. Helium	He		

**Symbols of elements derived from their Latin names :**

	English name of the element	Latin name of the element	Symbol
1.	Antimony	Stibium	Sb
2.	Copper	Cuprum	Cu
3.	Gold	Aurum	Au
4.	Iron	Ferrum	Fe
5.	Lead	Plumbum	Pb
6.	Mercury	Hydrargyrum	Hg
7.	Potassium	Kalium	K
8.	Silver	Argentum	Ag
9.	Sodium	Natrium	Na
10.	Tin	Stannum	Sn

**5. SIGNIFICANCE OF A SYMBOL**

The symbol of element has both qualitative as well as quantitative significance. These are,

- The symbol stands for the name of the element.
- The symbol stands for one atom of the element.
- The symbol represents quantity of the element equal in mass to its atomic mass, or gram-atomic mass.
- The symbol also represents mass of the element which contains one Avogadro's number of atoms of that element. For example, the symbol O stands for
  - The element oxygen
  - One atom of oxygen
  - The mass of oxygen equal to its gram-atomic mass, i.e., 16 g of oxygen
  - The mass of oxygen which contains one Avogadro's number ( $6.022 \times 10^{23}$ ) of oxygen atoms.

**Focus Point**

- Atoms cannot be divided using chemicals. They do consist of parts, which include protons, neutrons and electrons but an atom is a basic chemical building block of matter.
- Almost all of the mass of an atom is in its nucleus; almost all of the volume of an atom is occupied by electrons.

**6. ATOMIC MASS, GRAM ATOMIC MASS****6.1 ATOMIC MASS**

Atoms are extremely small particles. Hence, the actual masses of the atoms are so small that it is difficult to determine the actual masses of individual atoms.

In 1961, IUPAC recommended the use of an isotope of carbon with mass number 12 as the standard reference for measuring atomic masses. It is called carbon-twelve (C-12) and is represented as  $^{12}\text{C}$ . The atomic mass (or earlier called as "atomic weight") is now defined as follows :

The atomic mass of an element is the relative mass of its atoms as compared with the mass of an atom of carbon-12 isotope taken as 12 units.

Atomic mass unit (amu) may be defined as  $1/12^{\text{th}}$  of the mass of an atom of carbon-12 isotope on the atomic scale, i.e.,  $1 \text{ amu} = \frac{1}{12}$  th of mass of C-12 isotope.

**Atomic masses of some common elements (in amu or u)**

Element	Symbol	Atomic mass	Element	Symbol	Atomic mass
Hydrogen	H	1	Phosphorus	P	31
Helium	He	4	Sulphur	S	32
Lithium	Li	7	Chlorine	Cl	35.5
Beryllium	Be	9	Argon	Ar	40
Boron	B	11	Potassium	K	39
Carbon	C	12	Calcium	Ca	40
Nitrogen	N	14	Iron	Fe	56
Oxygen	O	16	Copper	Cu	63.5
Fluorine	F	19	Zinc	Zn	65
Neon	Ne	20	Silver	Ag	108
Sodium	Na	23	Platinum	Pt	195
Magnesium	Mg	24	Gold	Au	197
Aluminium	Al	27	Lead	Pb	207
Silicon	Si	28	Uranium	U	238

## 6.2 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.

For Example, Atomic mass of nitrogen, (N) = 14 u

So, gram atomic mass of nitrogen = 14 grams

Atomic mass of sodium, (Na) = 23 u

So, gram atomic mass of sodium = 23 grams

Atomic mass of magnesium, (Mg) = 24 u

So, gram atomic mass of magnesium = 24 grams



## Focus Point

### How do Atoms Exist ?

The atoms of only a few elements called noble gases (such as helium, neon, argon, etc.) are chemically unreactive and exist in free state or single atoms. Atoms of most the elements are chemically reactive and do not exist in free state or single atom. Atoms usually exist in two ways.

- (i) In the form of molecules                      (ii) In the form of ions

## 7. 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".

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

### 7.1 MOLECULE 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  $H_2$  representing Hydrogen gas. Similarly, Ozone gas has 3 oxygen atoms combined together, so ozone exists in the form of  $O_3$ . The noble gases like helium, neon, argon and krypton etc., exist as single atoms like He, Ne, Ar and Kr respectively. So, their atoms and molecules are just the same.

### 7.2 MOLECULE OF COMPOUNDS

The molecule of a 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 examples of the molecules of compounds are : sulphur dioxide ( $SO_2$ ), methane ( $CH_4$ ) and ammonia ( $NH_3$ ) etc.

Compound	Combining elements	Ratio by mass
Hydrogen chloride (HCl)	Hydrogen, Chlorine	1 : 35.5
Water ( $H_2O$ )	Hydrogen, Oxygen	1 : 8
Ammonia ( $NH_3$ )	Hydrogen, Nitrogen	3 : 14
Carbon dioxide ( $CO_2$ )	Carbon, Oxygen	3 : 8



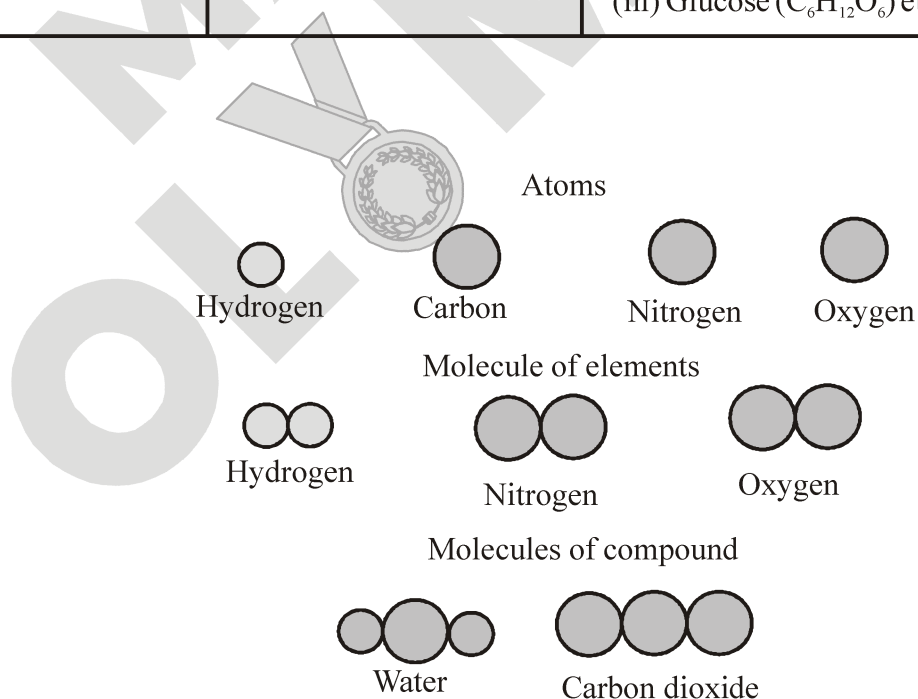
## Focus Point

- Molecules of elements are homoatomic which means that the atoms present in them are same. For example,  $H_2$ ,  $O_2$ , etc.
- Molecules of compounds are heteroatomic which means that the atoms present in them are different. For example,  $H_2O$ ,  $CO_2$  etc.

## 8. ATOMICITY

The number of atoms present in one molecule of an element or compound is called its 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 monoatomic, diatomic, and triatomic molecules.

Atomicity	Name of the class	Examples
1	Mono-atomic	(i) Noble gases: Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr) etc. (ii) Metals (Exist as large clusters): Sodium (Na), Magnesium (Mg) etc.
2	Di-atomic	(i) Hydrogen (H <sub>2</sub> ), (ii) Oxygen (O <sub>2</sub> ), (iii) Chlorine (Cl <sub>2</sub> ), (iv) Fluorine (F <sub>2</sub> ), (v) Nitrogen (N <sub>2</sub> ), (vi) Hydrogen Chloride (HCl) (vii) Carbon monoxide (CO) etc.
3	Tri-atomic	(i) Ozone (O <sub>3</sub> ), (ii) Water (H <sub>2</sub> O), (iii) Carbon di-oxide (CO <sub>2</sub> ) etc.
4	Tetra-atomic	(i) Phosphorus (P <sub>4</sub> ), (ii) Ammonia (NH <sub>3</sub> ) etc.
More than 4	Poly-atomic	(i) Sulphur (S <sub>8</sub> ), (ii) Fullerenes (C <sub>60</sub> ) (iii) Glucose (C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> ) etc.





## Focus Point

- An atom is the smallest portion of an element while molecule is the smallest portion of a compound.
- Actual masses of the atoms and molecules of the elements are very, very small. To avoid the inconvenience in using such small and complicated figures in our calculations, it was necessary to define atomic mass in such a way that we get simple figures for them.
- So a new unit amu (atomic mass unit) is used to represent the mass of a single atoms or molecules.
- One amu is defined as  $1/12^{\text{th}}$  of the mass of an atom of carbon-12 isotope.  
 $1 \text{ amu} = 1/12 \times \text{mass of a carbon-12 atom.}$
- In modern system 1 amu is replaced by 1 u.

## 9. MOLECULAR MASS & GRAM MOLECULAR MASS

### 9.1 MOLECULAR MASS

Molecular mass of a substance (element or compound) is the average relative mass of its molecules as compared with that of an atom of C-12 isotope taken as 12. In other words, molecular mass of a substance represent the number of times the molecule of that substance is heavier than  $1/12^{\text{th}}$  of the mass of an atom of C -12 isotope.

#### Calculation of Molecular Mass

As molecules are made up of two or more atoms of the same or different elements, and each atom has a definite atomic mass, therefore, molecular mass of a molecule of a substance can be calculated by adding atomic masses of all the atoms present in one molecule of the substance.

#### For example,

Molecular mass of  $\text{H}_2 = 2 \times \text{atomic mass of hydrogen}$   
 $= 2 (1) = 2 \text{ a.m.u}$

Molecular mass of  $\text{H}_2\text{O} = 2 (\text{atomic mass of hydrogen}) + \text{atomic mass of oxygen}$   
 $= 2 (1) + 16 = 18 \text{ a.m.u.}$

Molecular mass of  $\text{CO}_2 = \text{atomic mass of C} + 2 (\text{atomic mass of oxygen})$   
 $= 12 + 2 (16) = 12 + 32 = 44 \text{ a.m.u.}$

Molecular mass of  $\text{NH}_3 = \text{atomic mass of nitrogen} + 3 (\text{atomic mass of hydrogen})$   
 $= 14 + 3 (1) = 17 \text{ a.m.u.}$

### 9.2 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.

For example, Molecular mass of di-nitrogen,  $(\text{N}_2) = 28 \text{ u}$

So, gram molecular mass of di- nitrogen = 28 grams

Molecular mass of water  $(\text{H}_2\text{O}) = 18 \text{ u}$

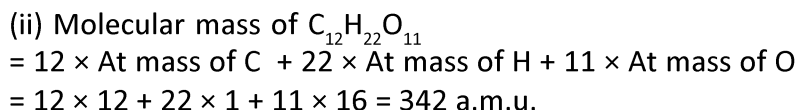
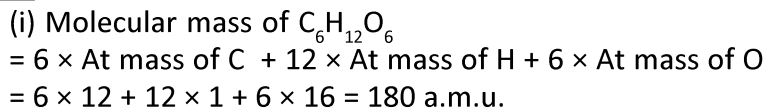
So, gram molecular mass of water = 18 grams

**Example 3**

Calculate the molecular masses of the followings :



**Solution :**



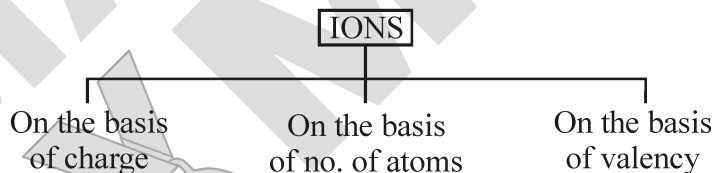
**Focus Point**

- **Formula unit mass :** The formula unit 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 u.

**10. IONS AND ITS CLASSIFICATION**

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

**Classification of Ions**



**10.1 ON THE BASIS OF CHARGE**

**(i) Cation:** A positively charged ion is known as cation. For example : Sodium ion:  $Na^+$ , Magnesium ion:  $Mg^{2+}$   
 A cation is formed by the loss of one or more electrons by an atom.

For example : Sodium atom, loses one electron to form a sodium ion  $Na^+$



**(ii) Anion:** A negatively charged ion is known as anion.

For example :  $Cl^-$  (chloride ion),  $O^{2-}$  (oxide ion) etc.

An anion is formed by the gain of one or more electrons by an atom.

For example : A chlorine atom gains one electron to form a chloride ion  $Cl^-$ .



### 10.2 ON THE BASIS OF NUMBER OF ATOMS

(i) **Monoatomic ions** : The ion consisting of only single atom are called monoatomic ions.

e.g.  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{O}^{2-}$ , etc.

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

e.g. Ammonium ion ( $\text{NH}_4^+$ ), hydroxide ion ( $\text{OH}^-$ ) etc. which are formed by the joining of two or more types of atoms, nitrogen and hydrogen in the first case and oxygen and hydrogen in the second.

(C) **On the basis of valency** :

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

(i) **Monovalent ion**: If an ion contain + 1 or –1 charge then it is known as monovalent ion.

e. g.  $\text{Na}^+$ ,  $\text{Cl}^-$ ,  $\text{K}^+$  etc.

(ii) **Di-valent ion** : If an ion contain + 2 or –2 charge then it is known as Di- valent ion.

e. g.  $\text{Mg}^{2+}$ ,  $\text{O}^{2-}$ ,  $\text{Ca}^{2+}$  etc.

(iii) **Tri-valent ion** : If an ion contain + 3 or –3 charge then it is known as Tri- valent ion.

e. g.  $\text{Al}^{3+}$ ,  $\text{Fe}^{3+}$ , etc.



### Focus Point

- Ions having single atom are also known as simple ions.  
For example,  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ , etc.
- Ions having more than one atom are called compound ions.  
For example,  $\text{NH}_4^+$ ,  $\text{SO}_4^{2-}$ , etc.

### List of Some Common Positive Ions (Cations)

Monovalent		Bivalent		Trivalent		Tetravalent	
Hydrogen	$\text{H}^+$	Barium	$\text{Ba}^{2+}$	Aluminium	$\text{Al}^{3+}$	Manganese (IV)	$\text{Mn}^{4+}$
Potassium	$\text{K}^+$	Calcium	$\text{Ca}^{2+}$	Chromium	$\text{Cr}^{3+}$	Tin (IV)	$\text{Sn}^{4+}$
Sodium	$\text{Na}^+$	Magnesium	$\text{Mg}^{2+}$	Iron (III)	$\text{Fe}^{3+}$	Lead (IV)	$\text{Pb}^{4+}$
Silver	$\text{Ag}^+$	Zinc	$\text{Zn}^{2+}$	Gold (III)	$\text{Au}^{3+}$	Platinum (IV)	$\text{Pt}^{4+}$
Copper (I)	$\text{Cu}^+$	Cobalt	$\text{Co}^{2+}$				
Gold (I)	$\text{Au}^+$	Copper (II)	$\text{Cu}^{2+}$				
Ammonium ( $\text{NH}_4^+$ )		Iron (II)	$\text{Fe}^{2+}$				
		Manganese (II)	$\text{Mn}^{2+}$				
		Tin (II)	$\text{Sn}^{2+}$				
		Lead (II)	$\text{Pb}^{2+}$				
		Platinum (II)	$\text{Pt}^{2+}$				

List of Some Common Negative Ions (Anions)

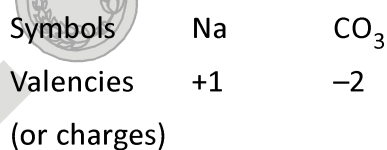
Monovalent		Bivalent		Trivalent		Tetravalent	
Chloride	Cl <sup>-</sup>	Sulphide	S <sup>2-</sup>	Nitride	N <sup>3-</sup>	Carbide	C <sup>4-</sup>
Bromide	Br <sup>-</sup>	Oxide	O <sup>2-</sup>	Phosphide	P <sup>3-</sup>		
Iodide	I <sup>-</sup>	Carbonate	(CO <sub>3</sub> ) <sup>2-</sup>	Phosphate	(PO <sub>4</sub> ) <sup>3-</sup>		
Hydroxide	(OH) <sup>-</sup>	Sulphate	(SO <sub>4</sub> ) <sup>2-</sup>	Borate	(BO <sub>3</sub> ) <sup>3-</sup>		
Nitrate	(NO <sub>3</sub> ) <sup>-</sup>	Sulphite	(SO <sub>3</sub> ) <sup>2-</sup>	Arsenate	(AsO <sub>4</sub> ) <sup>3-</sup>		
Nitrite	(NO <sub>2</sub> ) <sup>-</sup>	Manganate	(MnO <sub>4</sub> ) <sup>2-</sup>				
Bicarbonate	(HCO <sub>3</sub> ) <sup>-</sup>	Oxalate	(C <sub>2</sub> O <sub>4</sub> ) <sup>2-</sup>				
Cyanide	(CN) <sup>-</sup>	Chromate	(CrO <sub>4</sub> ) <sup>2-</sup>				
Permanganate	(MnO <sub>4</sub> ) <sup>-</sup>	Dichromate	(Cr <sub>2</sub> O <sub>7</sub> ) <sup>2-</sup>				
Chlorate	(ClO <sub>3</sub> ) <sup>-</sup>						

11. FORMULAE OF IONIC COMPOUNDS

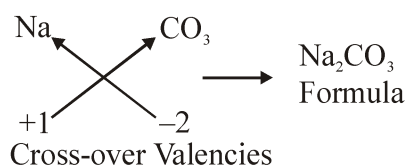
- First, write the symbols of the ions from which the ionic compound is made. As a convention, the cation is written on the left side while the anion is written on the right side.
- Then, the valencies of the respective cation and anion are written below their symbols.
- The valencies of the cation and anion are exchanged. The number of cation and anion 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.
- The final formula of the ionic compound is then written but the charges present on the cation and the anion are not shown.

**Example :** To write the formula for sodium carbonate.

(1) First, write the symbol of sodium ion and carbonate ion and write their valencies below their symbols as shown.



(2) Now, exchange the valencies of sodium ion and carbonate ion.



(3) So -2 gets associated with Na and +1 gets associated with CO<sub>3</sub> in this way we get Na<sub>2</sub> and CO<sub>3</sub> and final formula of sodium carbonate is Na<sub>2</sub>CO<sub>3</sub>.



### Focus Point

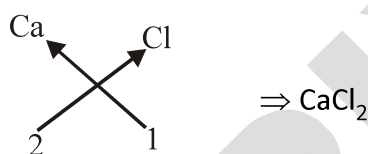
- In the formula of the compound, the valency 1; is normally omitted. For example,  $\text{MgCl}_2$  and not as  $\text{Mg}_1\text{Cl}_2$ .
  - In case there is some common factor in the formula, it has to be taken out. For example,  $\text{CaSO}_4$  in place of  $\text{Ca}_2(\text{SO}_4)_2$  is used.
- Some examples are given below:

#### Example 4

Calcium chloride

Calcium ion  $\rightarrow \text{Ca}^{2+}$

Chloride ion  $\rightarrow \text{Cl}^-$

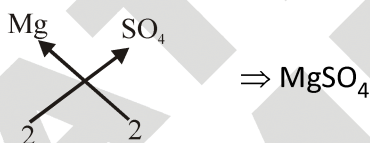


#### Example 5

Magnesium sulphate

Magnesium ion  $\rightarrow \text{Mg}^{2+}$

Sulphate ion  $\rightarrow \text{SO}_4^{2-}$



#### Example 6

Aluminium sulphate

Aluminium ion  $\rightarrow \text{Al}^{3+}$

Sulphate ion  $\rightarrow \text{SO}_4^{2-}$



#### Example 7

Aluminium phosphate

Aluminium ion  $\rightarrow \text{Al}^{3+}$

Phosphate ion  $\rightarrow \text{PO}_4^{3-}$

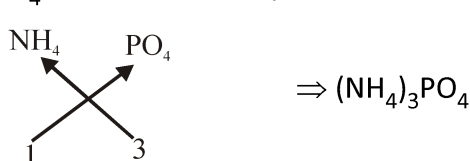


#### Example 8

Ammonium phosphate

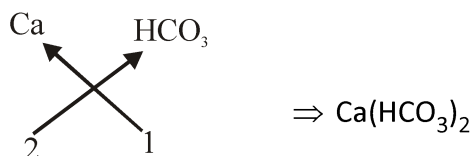
Ammonium ion  $\rightarrow \text{NH}_4^{1+}$

Phosphate ion  $\rightarrow \text{PO}_4^{3-}$



**Example 9**

Calcium bicarbonate

Calcium ion  $\rightarrow \text{Ca}^{2+}$ Bicarbonate ion  $\rightarrow \text{HCO}_3^{1-}$ **12. 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 gram of the carbon  $^{12}_6\text{C}$ .

**Focus Point**

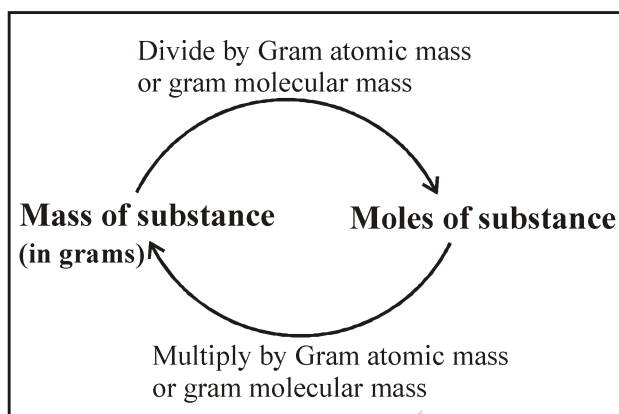
- Mole is the Latin word meaning heap or pile.
- The SI unit of the amount of a substance is Mole.
- Mole is a collection of  $6.022 \times 10^{23}$  particles (may it be atoms, molecules or ions) of a substance.  
e.g. 1 mole of oxygen atoms (O) =  $6.022 \times 10^{23}$  atoms of oxygen.  
1 mole of oxygen molecules ( $\text{O}_2$ ) =  $6.022 \times 10^{23}$  molecules of oxygen.
- The number,  $6.022 \times 10^{23}$ , which represents the number of particles in a mole, is known as Avogadro constant ( $N_A$ ).
- The mass of one mole of atoms is called gram atomic mass and the mass of one mole of molecules is called gram molecular mass.
- Mass of one mole of atoms and one mole of molecules is also known as molar mass.

**12.1 MOLES IN TERMS OF MASS**

- Mass of one mole of atoms is called gram atomic mass.
- Mass of one mole of molecules is called gram molecular mass.
- If mass of any element or compound is given than number of moles of atoms or molecules can be calculated as:

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

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



**Example 10**

Calculate the number of moles in 5.75 g of sodium. (Atomic mass of sodium = 23 u).

**Solution :**

Mass of sodium = 5.75g

Atomic mass of sodium = 23 u

∴ gram atomic mass (GAM) of sodium = 23 g

$$\begin{aligned} \text{Number of moles of sodium atoms} &= \frac{\text{Mass of sodium in grams}}{\text{Gram atomic mass of sodium}} \\ &= \frac{5.75}{23} = 0.25 \text{ moles} \end{aligned}$$

**Example 11**

Calculate the number of moles in 9.0 g of water.

(Atomic mass of hydrogen = 1 u, atomic mass of oxygen = 16 u)

**Solution :**

Mass of water = 9.0 g

$$\begin{aligned} \text{Molecular mass of water (H}_2\text{O)} &= 2 \times \text{atomic mass of hydrogen} + 1 \times \text{atomic mass of oxygen} \\ &= 2 \times 1 + 1 \times 16 = 18 \text{ u.} \end{aligned}$$

∴ gram molecular mass (GMM) of water = 18 g

$$\begin{aligned} \text{Number of moles of water molecules} &= \frac{\text{Mass of water in gram}}{\text{Gram molecular mass of water}} \\ &= \frac{9.0}{18} = 0.5 \text{ moles} \end{aligned}$$

**Example 12**

What mass in grams is represented by (a) 0.40 mol of CO<sub>2</sub>, (b) 3.00 mol of NH<sub>3</sub>

**Solution :**

(a) Moles of CO<sub>2</sub> = 0.40 moles

gram molecular mass of CO<sub>2</sub> = 44 gm.

$$\text{Number of moles of CO}_2 \text{ molecules} = \frac{\text{Mass of CO}_2 \text{ (in gram)}}{\text{Gram molecular mass of CO}_2}$$

$$\begin{aligned} \text{So, mass of CO}_2 \text{ (in gram)} &= \text{moles of CO}_2 \times \text{gm molecular mass of CO}_2 \\ &= 0.40 \times 44 \\ &= 17.60 \text{ gm.} \end{aligned}$$

(b) Moles of  $\text{NH}_3 = 3.00$  moles  
gram molecular mass of  $\text{NH}_3 = 17$  gm.

$$\text{Number of moles of NH}_3 \text{ molecules} = \frac{\text{Mass of NH}_3 \text{ (in gram)}}{\text{Gram molecular mass of NH}_3}$$

$$\begin{aligned} \text{So, mass of NH}_3 \text{ (in gram)} &= \text{moles of NH}_3 \times \text{gm molecular mass of NH}_3 \\ &= 3.00 \times 17 \\ &= 51.0 \text{ gm.} \end{aligned}$$

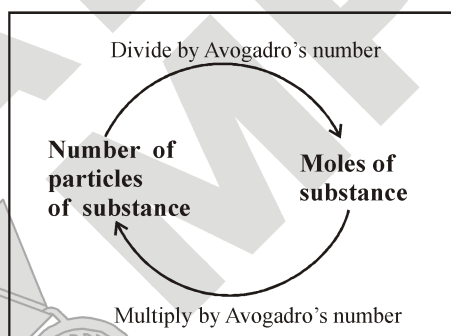
### 12.2 MOLES IN TERMS OF NUMBER OF PARTICLES

Mole is a collection of  $6.022 \times 10^{23}$  particles (may it be atoms, molecules or ions) of a substance.

e.g. 1 mole of oxygen atoms (O) =  $6.022 \times 10^{23}$  atoms of oxygen.  
1 mole of oxygen molecules ( $\text{O}_2$ ) =  $6.022 \times 10^{23}$  molecules of oxygen.

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

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



#### Example 12

In a container  $12.04 \times 10^{22}$  molecules of  $\text{CO}_2$  are present, calculate the moles of  $\text{CO}_2$  present in container.

**Solution :**

No. of molecules of  $\text{CO}_2 = 12.04 \times 10^{22}$   $\text{CO}_2$  molecules

$$\text{No. of moles of CO}_2 = \frac{\text{No. of molecules of CO}_2}{\text{Avogadro's no.}} = \frac{12.04 \times 10^{22}}{6.02 \times 10^{23}} = 0.2 \text{ mole.}$$

#### Example 13

$6.022 \times 10^{23}$  molecules of oxygen ( $\text{O}_2$ ) is equal to how many moles ?

**Solution :**

$$\text{No. of moles} = \frac{\text{No. of molecules of oxygen}}{\text{Avogadro's no. of molecules}} = \frac{6.022 \times 10^{23}}{6.022 \times 10^{23}} = 1 \text{ mole.}$$

**Example 14**

Calculate the mass of  $6.022 \times 10^{23}$  molecules of  $\text{CaCO}_3$ .

**Solution :**

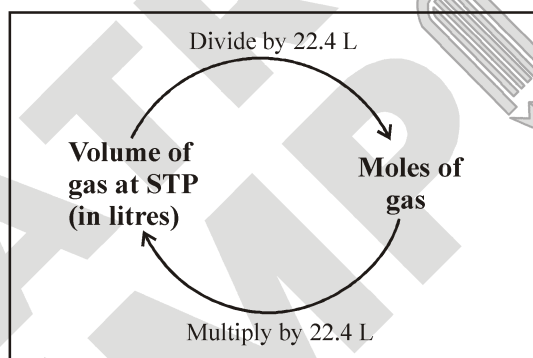
$$\text{No. of moles of CaCO}_3 = \frac{\text{Number of molecules}}{\text{Avogadro's number}} = \frac{6.022 \times 10^{23}}{6.022 \times 10^{23}} = 1 \text{ mole}$$

$$\begin{aligned} \text{Now, mass of CaCO}_3 &= \text{no. of moles} \times \text{gram molecular mass} \\ &= 1 \times 100 = 100 \text{ gm.} \end{aligned}$$

**12.3 MOLES IN TERMS OF VOLUME OF GAS AT STP**

- STP means standard temperature and pressure.
- Standard temperature =  $0^\circ \text{C}$  or  $273 \text{ K}$ .  
Standard pressure = 1 atmospheric pressure.
- The volume of one mole of any gas is equal to 22.4 litre at STP. It is also known as molar volume.
- If volume of any gas is given at STP then moles of gas can be calculated as:

$$\text{Number of mole of gas} = \frac{\text{volume of gas at STP (in litre)}}{22.4}$$

**Example 15**

Calculate the volume of 5 mole of He gas at STP.

**Solution :**

Moles of He = 5 moles.

$$\text{Moles of He} = \frac{\text{Volume of He (at STP)}}{22.4}$$

$$\begin{aligned} \text{So, volume of He (at STP)} &= \text{moles of He} \times 22.4 \\ &= 5 \times 22.4 = 112 \text{ litres.} \end{aligned}$$

**Example 16**

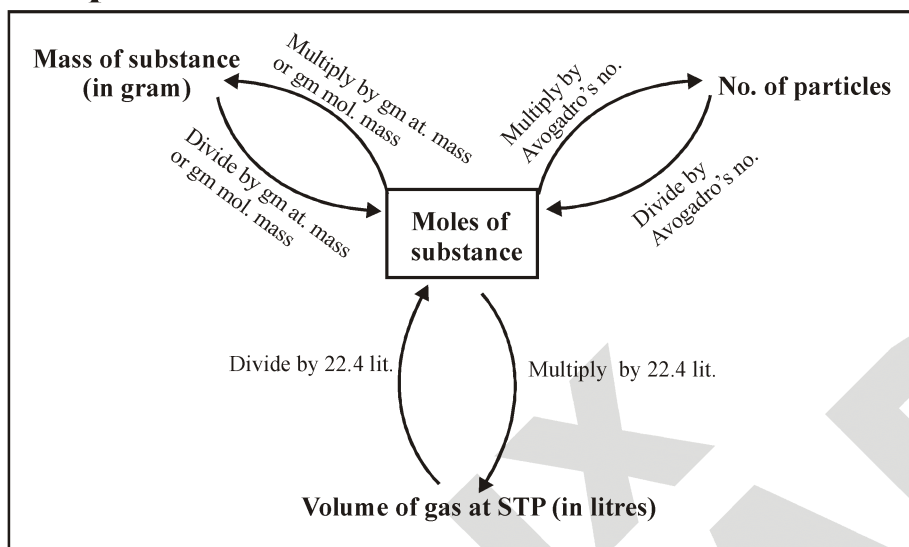
Calculate the volume of 20 g of hydrogen gas at NTP.

**Solution :**

$$\text{Moles of hydrogen gas} = \frac{20}{2} = 10 \text{ moles.}$$

$$\begin{aligned} \text{Volume of the gas at NTP} &= \text{No. of moles} \times 22.4 \\ &= 10 \times 22.4 = 224 \text{ litres.} \end{aligned}$$

### Important flow chart for formulae of moles



### Focus Point

- Gram-atoms  $\equiv$  moles of atoms
- Gram-molecules  $\equiv$  moles of molecules
- If gram-atoms or gram-molecules are given means moles of atoms or moles of molecules are given.
- If gram of atoms or gram of molecules are given means mass of atoms or mass of molecules are given.

### 13. AVERAGE ATOMIC MASS

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 atomic masses.

Average atomic mass can be calculated as :

$$\text{Average atomic mass} = \frac{M_1n_1 + M_2n_2 + \dots}{n_1 + n_2 + \dots}$$

Where

$M_1, M_2, M_3$  ----- are the atomic masses of isotopes

$n_1, n_2, n_3$  ----- are the % abundance of isotopes

e.g. :

Chlorine has two isotopes  $^{35}\text{Cl}$  and  $^{37}\text{Cl}$  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

$$= \frac{35 \times 75 + 37 \times 25}{100} = 35.5 \text{ u}$$

Thus, the average atomic mass of chlorine is 35.5 u.

**14. PERCENTAGE COMPOSITION**

If the formula of a compound is known, its chemical composition can be expressed as the mass percent or percentage composition of each element in the compound.

Percentage composition of a compound indicates the number of parts of an element present in one hundred parts of the compound. The percentage composition of a compound may be calculated if the mass of each element present in a given mass of compound is known.

$$\text{Mass \% of an element in a compound} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

**Example 17**

What are the percentage composition of hydrogen and oxygen in water ( $\text{H}_2\text{O}$ ) ?

(Atomic masses :  $\text{H} = 1 \text{ u}$   $\text{O} = 16 \text{ u}$ )

**Solution :**

Molecular mass of water,  $\text{H}_2\text{O} = 2 + 16 = 18 \text{ amu}$ .

$\text{H}_2\text{O}$  has two atoms of hydrogen.

$$\text{Percentage of H} = \frac{2 \times 100}{18} = 11.11\%$$

Similarly,

$$\text{percentage of oxygen} = \frac{16 \times 100}{18} = 88.88\%$$

**Example 18**

What is the percentage of calcium in calcium carbonate ( $\text{CaCO}_3$ ) ?

**Solution :**

Molecular mass of  $\text{CaCO}_3 = 40 + 12 + 3 \times 16 = 100 \text{ amu}$ .

$\text{CaCO}_3$  has one atom of calcium.

$$\text{So percentage of calcium} = \frac{40}{100} \times 100 = 40\%$$

**15. MOLECULAR FORMULA AND EMPIRICAL FORMULA****15.1 MOLECULAR FORMULA**

It represents the exact number of different type of atoms present in a molecule of a compound.

For example, molecular formula of glucose is  $\text{C}_6\text{H}_{12}\text{O}_6$ , that is its one molecule has 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms.

Molecular formula of benzene is  $\text{C}_6\text{H}_6$  that is its one molecule has 6 carbon atoms and 6 hydrogen atoms.

Molecular formula of hydrogen peroxide is  $\text{H}_2\text{O}_2$  that is its one molecule has 2 hydrogen atoms and 2 oxygen atoms.

**15.2 EMPIRICAL FORMULA**

It represents the simplest whole number ratio of different type of atoms present in a molecule of a compound.

For example, molecular formula of glucose is  $\text{C}_6\text{H}_{12}\text{O}_6$ , that its one molecule has 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms.

$\text{C}_6\text{H}_{12}\text{O}_6$  (molecular formula of glucose)

Ratio of atoms C : H : O

6 : 12 : 6 (Now divide by common factor 6)

Simplest whole number ratio 1 : 2 : 1

Empirical formula of glucose has one carbon atom, 2 hydrogen atoms and one oxygen atom so empirical formula of glucose is  $\text{CH}_2\text{O}$ .

Molecular formulae	Empirical formulae
$\text{C}_2\text{H}_6$ (ethane)	$\text{CH}_3$
$\text{C}_2\text{H}_4$ (ethene)	$\text{CH}_2$
$\text{C}_2\text{H}_2$ (ethyne)	$\text{CH}$
$\text{C}_6\text{H}_6$ (benzene)	$\text{CH}$
$\text{C}_6\text{H}_{12}\text{O}_6$ (glucose)	$\text{CH}_2\text{O}$
$\text{H}_2\text{O}_2$ (Hydrogen peroxide)	$\text{HO}$

### 16. RELATION BETWEEN EMPIRICAL AND MOLECULAR FORMULA

The molecular formula of a compound is a simple whole number multiple of its empirical formula,

$$\text{Molecular formula} = (\text{Empirical formula})_n$$

where n is any integer, e.g., 1, 2, 3, ....., etc.

The value of n is obtained as

$$n = \frac{\text{Gram molecular mass}}{\text{Empirical formula mass}}$$

### 17. CALCULATION OF THE EMPIRICAL AND MOLECULAR FORMULA

If the mass percentage of various elements present in a compound is known, its empirical formula can be determined. Molecular formula can further be obtained if the molar mass is known. The following sequence of steps are involved in the calculation of empirical and molecular formula.

**a. Conversion of mass percent to grams:**

Take 100 g of the substance given. The given mass percentage represents the masses of the elements in grams.

**b. Convert into number of moles of each element:**

Divide the masses obtained by respective atomic masses of various elements.

**c. To calculate the simplest whole number :**

Divide the moles obtained in step (b) by the smallest quotient or least value from amongst the values obtained for each element. This gives the simplest molar ratio.

**d. Writing empirical formula :**

It is written by mentioning the numbers after writing the symbols of respective elements.

**e. Writing molecular formula :**

The molecular formula of a substance may be determined from the empirical formula if the molecular mass of the substance is known. The molecular formula is always a simple multiple of the empirical formula and the value of simple multiple (n) is obtained by dividing gram molecular mass with empirical formula mass.

$$n = \frac{\text{Gram molecular mass}}{\text{Empirical formula mass}}$$

**Example 19**

Hydrocarbon has 75% carbon and 25% Hydrogen, then calculate its empirical formula.

**Solution :**

Let suppose the mass of hydrocarbon = 100 g.

So, mass of carbon = 75 g.

Mass of hydrogen = 25 g.

Element	Mass	Mole	Simple ratio
C	75 g	$\frac{75}{12} = 6.25$	$\frac{6.25}{6.25} = 1$
H	25 g	$\frac{25}{1} = 25$	$\frac{25}{6.25} = 4$

Hence, empirical formula of hydrocarbon is  $\text{CH}_4$ .

**Example 20**

An organic compound on analysis has been found to have following percentage composition:

Percentage of carbon = 40%

Percentage of hydrogen = 6.66%

If the molecular mass of the compound is 60, find out the molecular formula of the compound.

**Solution :**

Let suppose the mass of organic compound = 100 g.

So, mass of carbon = 40 g.

Mass of hydrogen = 6.66 g.

And mass of oxygen =  $100 - (40 + 6.66)$

= 53.34 g

Element	Mass	Mole	Simple ratio
C	40 g	$\frac{40}{12} = 3.33$	$\frac{3.33}{3.33} = 1$
H	6.66 g	$\frac{6.66}{1} = 6.66$	$\frac{6.66}{3.33} = 2$
O	53.34 g	$\frac{53.34}{16} = 3.33$	$\frac{3.33}{3.33} = 1$

Hence, empirical formula of given organic compound is  $\text{CH}_2\text{O}$ .

Empirical formula mass =  $1 \times \text{at. mass of C} + 2 \times \text{at. mass of H} + 1 \times \text{at. mass of O}$

$$= 1 \times 12 + 2 \times 1 + 1 \times 16 = 30$$

Given, molecular mass of organic compound = 60.

$$\text{So, } n = \frac{60}{30} = 2$$

Since we know that

$$\begin{aligned} \text{molecular formula} &= (\text{Empirical formula})_n \\ &= (\text{CH}_2\text{O})_2 \\ &= \text{C}_2\text{H}_4\text{O}_2 \end{aligned}$$

## SOLVED EXAMPLES

**SE. 1**

Which of the following symbols of elements are incorrect? Give their correct symbols.

- (a) Cobalt CO                      (b) Carbon c  
 (c) Aluminium AL                (d) Helium He  
 (e) Sodium So

**Ans.** (a) Cobalt CO is incorrect symbol. Its correct is Co.  
 (b) Carbon c is incorrect symbol. Its correct symbol is C.  
 (c) Aluminium AL is incorrect symbol. Its correct symbol is Al.  
 (d) Helium, He is the correct symbol.  
 (e) Sodium So is incorrect symbol. Its correct is Na. (It is derived from Latin name 'Natrium').

**SE. 2**

Classify each of the following on the basis of their atomicity as monoatomic, diatomic and polyatomic molecules.

- (a) F<sub>2</sub>    (b) NO<sub>2</sub>                      (c) N<sub>2</sub>O    (d) C<sub>2</sub>H<sub>6</sub>  
 (e) P<sub>4</sub>    (f) H<sub>2</sub>O<sub>2</sub>                      (g) P<sub>4</sub>O<sub>10</sub>    (h) O<sub>3</sub>  
 (i) HCl    (j) CH<sub>4</sub>                      (k) He                      (l) Ag

**Ans.** They are classified as  
 Monoatomic → (k) He, (l) Ag  
 Diatomic → (a) F<sub>2</sub>, (i) HCl  
 Polyatomic → (b) NO<sub>2</sub>, (c) N<sub>2</sub>O, (d) C<sub>2</sub>H<sub>6</sub>, (e) P<sub>4</sub>,  
 (f) H<sub>2</sub>O<sub>2</sub>, (g) P<sub>4</sub>O<sub>10</sub>, (h) O<sub>3</sub>, (j) CH<sub>4</sub>

**SE. 3**

Calculate molecular masses of following molecules.

- (a) Sodium chloride (NaCl)  
 (b) Carbon di-oxide (CO<sub>2</sub>)  
 (c) Ozone (O<sub>3</sub>)  
 (d) Methane (CH<sub>4</sub>)

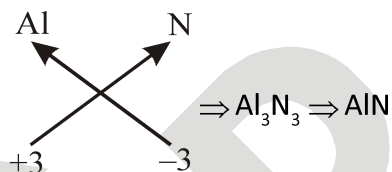
**Ans.** (a) Molecular mass of NaCl  
 = 1 × at mass of Na + 1 × at mass of Cl  
 = 1 × 23 + 1 × 35.5 = 58.5u  
 (b) Molecular mass of CO<sub>2</sub>  
 = 1 × at mass of C + 2 × at mass of O  
 = 1 × 12 + 2 × 16 = 44 u  
 (c) Molecular mass of ozone  
 = 3 × at mass of O  
 = 3 × 16 = 48 u

(d) Molecular mass of CH<sub>4</sub>  
 = 1 × at mass of C + 4 × at mass of H  
 = 1 × 12 + 4 × 1 = 16 u

**SE. 4**

Write down the formula of Aluminium nitride.

**Ans.** The valency of Aluminium ion is + 3 and valency of Nitride ion is -3. Now,



The formula of Aluminium nitride is AlN

**SE. 5**

Calculate the molecular mass of the following compounds

- (i) Sulphuric acid: H<sub>2</sub>SO<sub>4</sub>  
 (ii) Ammonia: NH<sub>3</sub>

**Ans.** (i) Sulphuric acid: H<sub>2</sub>SO<sub>4</sub>  
 Molecular mass = 2 × atomic mass of hydrogen  
 + 1 × atomic mass of sulphur  
 + 4 × atomic mass of oxygen.  
 = 2 × 1 + 1 × 32 + 4 × 16  
 = 2 + 32 + 64 = 98 u

(ii) Ammonia: NH<sub>3</sub>  
 Molecular mass = 1 × atomic mass of nitrogen  
 + 3 × atomic mass of hydrogen  
 = 1 × 14 + 3 × 1 = 17 u

**SE. 6**

15.9 g of copper sulphate and 10.6 g of sodium carbonate were made to react with each other. As a result, 14.2 g of sodium sulphate and 12.3 g of copper carbonate were formed. Show that these results are in a agreement with the law of conservation of mass.

**Ans.** Copper sulphate + sodium carbonate → sodium sulphate + copper carbonate  
 Total mass of copper sulphate and sodium carbonate = 15.9 g + 10.6 g = 26.5 g.  
 Total mass of sodium sulphate and copper carbonate = 14.2 g + 12.3 g = 26.5 g.

The total mass of the reacting substances is equal to the total mass of the substance produced during the reaction. Hence, these results are in agreement with the law of conservation of mass.

**SE. 7**

Carbon and oxygen react in the ratio 3 : 8 by mass. What weight of carbon should be react completely with 40 g of oxygen ?

**Ans.** 8 g of oxygen reacts with 3g of carbon.

40 g of oxygen will react with  $\frac{3 \times 40}{8} = 15$  g of carbon.

**SE. 8**

Calculate the mass of the following :

- (i) 0.5 mole of O<sub>2</sub> gas
  - (ii) 0.5 mole of O atoms
  - (iii) 3.011 × 10<sup>23</sup> atoms of O
  - (iv) 6.022 × 10<sup>23</sup> molecules of O<sub>2</sub>.
- (Given : Gram atomic mass of oxygen = 16 g, gram molecular mass of oxygen (O<sub>2</sub>) = 32 g ).

**Ans.** (i) 0.5 mole of O<sub>2</sub> gas

$$\text{No. of moles} = \frac{\text{Mass of O}_2 \text{ in grams}}{\text{Gram molecular mass}} = \frac{m}{M}$$

$$\text{Mass of O}_2 \text{ in grams (m)} = \text{No. of moles} \times M$$

$$= 0.5 \times (32\text{g}) = 16\text{g}$$

(ii) 0.5 mole of oxygen (O) atoms

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

$$\text{Mass of oxygen atoms (O) in grams (m)} = \text{No. of moles} \times M = 0.5 \times (16\text{g}) = 8\text{g} .$$

(iii) 3.011 × 10<sup>23</sup> atoms of oxygen (O)

$$\text{No. of gram atoms} = \frac{\text{No. of atoms of oxygen}}{\text{Avogadro no.}}$$

$$= \frac{N}{N_A} = \frac{3.011 \times 10^{23}}{6.022 \times 10^{23}}$$

$$= 0.5 \text{ gram atoms}$$

So, Mass of oxygen atoms (O)  
= Gram atomic mass of oxygen × No. of gram atoms of oxygen.  
= 16 × 0.5 = 8g.

(iv) 6.022 × 10<sup>23</sup> molecules of oxygen (O<sub>2</sub>)

$$\text{No. of moles} = \frac{\text{No. of molecules of oxygen}}{\text{Avogadro no.}}$$

$$= \frac{N}{N_A} = \frac{6.022 \times 10^{23}}{6.022 \times 10^{23}} = 1 \text{ mole}$$

So, Mass of oxygen molecules (O<sub>2</sub>) = Gram molecular mass of oxygen × No. of moles of oxygen = 32 × 1 = 32 g

**SE. 9**

Calculate the mass percentage composition of magnesium sulphate [given the atomic masses Mg = 24, S = 32, and O = 16].

**Ans.** Molecular formula: MgSO<sub>4</sub>  
Molecular mass = 1 × 24 + 1 × 32 + 4 × 16 = 120

Gram molecular mass = 120 g

$$\text{Mass percentage of Mg} = \frac{24}{120} \times 100 = 20.00$$

$$\text{Mass percentage of S} = \frac{32}{120} \times 100 = 26.66$$

$$\text{Mass percentage of O} = \frac{64}{120} \times 100 = 53.33$$

**SE. 10**

How many grams of oxygen are liberated on decomposition of 12.25 g of KClO<sub>3</sub>?

**Ans.**  $2\text{KClO}_3 \xrightarrow{\Delta} 2\text{KCl} + 3\text{O}_2 \uparrow$   
2 gram moles of KClO<sub>3</sub> yields, 3 gram moles of oxygen

245 g KClO<sub>3</sub> yields 3 × 32 = 96 g of O<sub>2</sub>

$$12.25 \text{ g of KClO}_3 \text{ will yield } \frac{96}{245} \times 12.25 = 4.8 \text{ g}$$

Mass of O<sub>2</sub> liberated = 4.8 g.

**NS. 1**

A 0.24 g sample of a compound of oxygen and boron was found by analysis to contain 0.096 g of boron and 0.144 g of oxygen. Calculate the percentage composition of the compound by weight.

**Ans.** % of any element in a compound

$$= \frac{\text{Mass of the element present}}{\text{Mass of the compound}} \times 100$$

$$\therefore \% \text{ of boron} = \frac{\text{Mass of boron}}{\text{Mass of compound}} \times 100$$

$$= \frac{0.096 \text{ g}}{0.24 \text{ g}} \times 100 = 40\%$$

$$\% \text{ of oxygen} = \frac{\text{Mass of oxygen}}{\text{Mass of compound}} \times 100$$

$$= \frac{0.144 \text{ g}}{0.24 \text{ g}} \times 100 = 60\%$$

**NS. 2**

When 3.0 g of carbon is burnt in 8.00 g oxygen, 11.00 g of carbon dioxide is produced. What mass of carbon dioxide will be formed when 3.00 g of carbon is burnt in 50.00 g of oxygen? Which law of chemical combination will govern your answer?

**Ans.** Carbon + Oxygen → Carbon dioxide

3.0 g            8.00 g            11.00 g

Total mass of reactants = Mass of carbon + Mass of oxygen

$$= 3.0 \text{ g} + 8.0 \text{ g} = 11.0 \text{ g}$$

Total mass of products = Mass of CO<sub>2</sub> = 11.0 g

Thus, total mass of products = Total mass of reactants

Hence, the law of conservation of mass is proved.

Further, it also shows that carbon dioxide contains carbon and oxygen in a fixed ratio by mass, which is 3 : 8. Thus, it also proves the law of constant proportions.

As 3.0 g of carbon combines with fixed mass of oxygen to form CO<sub>2</sub>, therefore, CO<sub>2</sub> formed will be again same, i.e., **11 g**. (Oxygen combined will be 8 g and oxygen left uncombined will be 50 – 8 = 42 g).

**NS. 3**

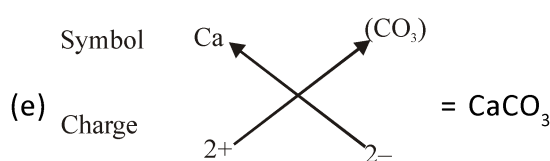
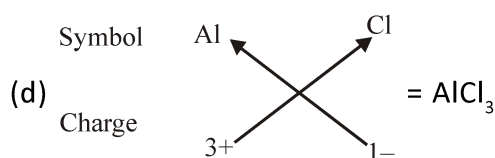
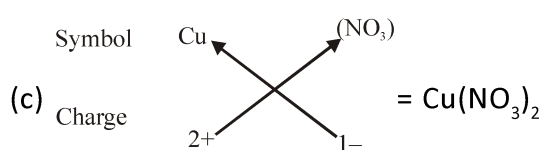
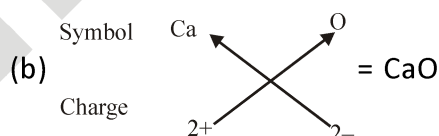
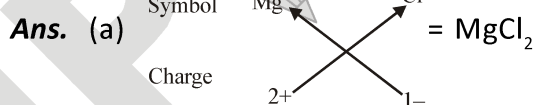
What are polyatomic ions? Give examples.

**Ans.** A polyatomic ion is a group of atoms carrying positive or negative charge. For example, NH<sub>4</sub><sup>+</sup> (ammonium ion), CO<sub>3</sub><sup>2-</sup> (carbonate ion), HCO<sub>3</sub><sup>-</sup> (hydrogen carbonate or bicarbonate ion) etc.

**NS. 4**

Write the chemical formulae of the following:

- Magnesium chloride
- Calcium oxide
- Copper nitrate
- Aluminium chloride
- Calcium carbonate.



**NS. 5**

Give the names of the elements present in the following compounds:

- (a) Quick lime                      (b) Hydrogen bromide  
(c) Baking powder                (d) Potassium sulphate

**Ans.** (a) Quick lime is CaO. Elements present are calcium and oxygen.  
(b) Hydrogen bromide is HBr. Elements present are hydrogen and bromine.  
(c) Baking powder is NaHCO<sub>3</sub>. Elements present are sodium, hydrogen, carbon and oxygen.  
(d) Potassium sulphate is K<sub>2</sub>SO<sub>4</sub>. Elements present are potassium, sulphur and oxygen.

**NS. 6**

Calculate the molar mass of the following substances :

- (a) Ethyne, C<sub>2</sub>H<sub>2</sub>  
(b) Sulphur molecule, S<sub>8</sub>  
(c) Phosphorus molecule, P<sub>4</sub> (Atomic mass of phosphorus = 31)  
(d) Hydrochloric acid, HCl  
(e) Nitric acid, HNO<sub>3</sub>.

**Ans.** (a) Molecular mass of C<sub>2</sub>H<sub>2</sub>  
= 2 × Atomic mass of C + 2 × Atomic mass of H  
= 2 × 12u + 2 × 1u = 26u  
∴ Molar mass of C<sub>2</sub>H<sub>2</sub> = 26 g mol<sup>-1</sup>.  
(b) Molecular mass of S<sub>8</sub>  
= 8 × Atomic mass of sulphur  
= 8 × 32 u = 256 u  
∴ Molar mass of S<sub>8</sub> = 256 g mol<sup>-1</sup>.  
(c) Molecular mass of P<sub>4</sub>  
= 4 × Atomic mass of P = 4 × 31 u = 124 u  
∴ Molar mass of P<sub>4</sub> = 124 g mol<sup>-1</sup>.  
(d) Molecular mass of HCl  
= Atomic mass of H + Atomic mass of Cl  
= 1.0 u + 35.5 u = 36.5 u  
∴ Molar mass of HCl = 36.5 g mol<sup>-1</sup>.  
(e) Molecular mass of HNO<sub>3</sub>  
= Atomic mass of H + Atomic mass of N + 3 × Atomic mass of O  
= 1.0 u + 14.0 u + 3 × 16.0 u = 63 u  
∴ Molar mass of HNO<sub>3</sub> = 63 g mol<sup>-1</sup>.

**NS. 7**

What is the mass of:

- (a) 1 mole of nitrogen atoms (molar mass of N = 14g mol<sup>-1</sup>)  
(b) 4 moles of aluminium atoms (Atomic mass of aluminium = 27) ?

**Ans.** (a) Mass (m) = No. of moles (n) × Molar mass (M)  
= 1 mol × 14 g mol<sup>-1</sup> = 14 g.  
(b) Mass (m) = 4 mol × 27 g mol<sup>-1</sup> = 108 g.  
(Molar mass of Al = 27 g mol<sup>-1</sup>)

**NS. 8**

Convert into mole :

- (a) 12 g of oxygen gas  
(b) 20 g of water  
(c) 22 g of carbon dioxide.

**Ans.** (a) No. of moles (n) =  $\frac{\text{Given mass (m)}}{\text{Molar mass (M)}}$   
Molar mass (M) of O<sub>2</sub> = 2 × 16 g mol<sup>-1</sup> = 32 g mol<sup>-1</sup>  
∴ No. of moles in 12 g O<sub>2</sub> =  $\frac{12\text{g}}{32\text{g mol}^{-1}}$   
= 0.375 mole  
(b) Molar mass of H<sub>2</sub>O = 2 × 1.0 + 16  
= 18 g mol<sup>-1</sup>  
∴ No of moles in 20 g H<sub>2</sub>O =  $\frac{20\text{g}}{18\text{g mol}^{-1}}$   
= 1.11 mole.  
(c) Molar mass of CO<sub>2</sub> = 12 + 2 × 16  
= 44 gmol<sup>-1</sup>  
=  $\frac{22\text{g}}{44\text{g mol}^{-1}}$  = 0.5 mole.

NS. 9

What is the mass of:

(a) 0.2 mole of oxygen atoms ?

(b) 0.5 mole of water molecules ?

**Ans.** (a) Mass (m) = No. of moles (n)  $\times$  Molar mass(M)

$\therefore$  Molar mass of O-atoms =  $16 \text{ g mol}^{-1}$

$\therefore$  Mass of 0.2 mole of O-atoms

$$= 0.2 \text{ mol} \times 16 \text{ g mol}^{-1} = 3.2 \text{ g.}$$

(b) Molar mass of  $\text{H}_2\text{O} = 2 \times 1.0 + 16$

$$= 18 \text{ g mol}^{-1}$$

$\therefore$  Mass of 0.5 mole of water molecules

$$= 0.5 \text{ mol} \times 18 \text{ g mol}^{-1} = 9.0 \text{ g.}$$

*Space for Notes :*

## EXERCISE – I

### ONLY ONE CORRECT TYPE

#### SECTION (A) : INTRODUCTION OF ATOMS AND MOLECULES

- The term 'Paramanu' for the smallest particles of matter (padarth) was given by-  
(A) Dalton (B) Maharishi Kanad  
(C) Proust (D) Lavoisier
- The first scientist to use the symbols of elements was-  
(A) Dalton (B) Berzelius  
(C) Kanad (D) Proust
- Which of the following is symbol of copper ?  
(A) Ca (B) Cu  
(C) Co (D) None of these
- Atoms can exist in the form of -  
(A) Molecules (B) Ions  
(C) Both A & B (D) None of these
- Which of the following represents a polyatomic ion?  
(A) Sulphide (B) Chloride  
(C) Sulphate (D) Nitride
- Which of the following is the formula of nitrate ion  
(A)  $N^{3-}$  (B)  $NO_3^-$   
(C)  $NO^+$  (D)  $NO_2^+$
- Which of the following set of ions is present in potassium sulphate ( $K_2SO_4$ ) ?  
(A)  $K^+$ ,  $SO_4^{2-}$  (B)  $K^{+4}$ ,  $SO^{2-}$   
(C)  $K^{+2}$ ,  $SO^{4-}$  (D)  $K^+$ ,  $SO^{4-}$
- Symbol of ferric ion is -  
(A)  $Fe^{++}$  (B)  $Fe^{+++}$   
(C) Fe (D)  $F^-$
- If the molecular mass of a compound is 74.5 then the compound is -  
(A) KCl (B) HCl  
(C) NaCl (D) LiCl
- 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

- A molecule of hydrogen is represented as -  
(A) H (B) 2H  
(C)  $H_2$  (D) All of these

#### SECTION (B) : CHEMICAL COMBINATION AND LAWS

- The law of conservation of mass was given by  
(A) John Dalton (B) Proust  
(C) Lavoisier (D) None of these
- 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 of the above
- When calcium carbonate is heated, it gives -  
(A) CaO & CO (B) Ca &  $CO_2$   
(C) CaO &  $CO_2$  (D) None of these
- 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
- A chemical equation is always balanced to fulfil the condition of -  
(A) Law of conservation of mass  
(B) Law of multiple proportions  
(C) Law of constant proportions  
(D) All of these
- Which postulate of Dalton's Atomic theory suggests the law of conservation of mass?  
(A) Atoms cannot be divided.  
(B) All the matter is made up of very small particles called atoms.  
(C) Elements consists of atoms combined in a fixed ratio.  
(D) Atoms can neither be created nor be destroyed.

18. 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) Compounds consist of atoms combined in a fixed ratio.  
 (D) Atoms can neither be created nor be destroyed.

**SECTION (C) : MOLE CONCEPT**

19. Which of the following has the smallest mass ?  
 (A) 4 g of He  
 (B)  $6.023 \times 10^{23}$  atoms of He  
 (C) 1 atom of He  
 (D) 1 mole atoms of He
20. 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
21. The number of gram atoms in 8 g of He are -  
 (A) 2 (B)  $1.204 \times 10^{24}$   
 (C)  $3.1 \times 10^{23}$  (D) None of these
22. The percentage of hydrogen in  $H_2O$  is -  
 (A) 8.88 (B) 11.11  
 (C) 20.60 (D) 80.0
23. Which of the following is correctly represents 360 g of water ?  
 (i) 2 moles of  $H_2O$   
 (ii) 20 moles of water  
 (iii)  $N_A$  molecules of water  
 (iv)  $1.2044 \times 10^{25}$  molecules of water  
 (A) i (B) i and iv  
 (C) ii and iii (D) ii and iv
24. If 32 g sulphur has x atoms, then the number of atoms in 32 g of oxygen will be :  
 (A)  $\frac{x}{2}$  (B) 2x  
 (C) x (D) 4x
25. If 12 gram of carbon has x atoms, then the number of atoms in 12 grams of magnesium will be :  
 (A) x (B) 2x  
 (C)  $\frac{x}{2}$  (D) 1.5 x

**PARAGRAPH TYPE QUESTIONS**

**PARAGRAPH # 1**

One day vaibhav was performing experiments in the science laboratory based on the laws of chemical combination. Just then his chemistry teacher, Mr. Rajeev, came into the laboratory. Mr. Rajeev told Vaibhav that in an experiment conducted by a class IX student when 10.6 g of sodium carbonate was reacted with 12.0 g of ethanoic acid in a closed flask, then 16.4 g of sodium ethanoate, 4.4 g of carbon dioxide and an unknown mass of substance Y were produced. Mr. Rajeev asked Vaibhav to make use of this information and answer the following questions :

26. Write a word equation for the reaction which takes place on reacting sodium carbonate and ethanoic acid.  
 (A)  $2CH_3COOH + Na_2CO_3 \rightarrow CH_3COONa + H_2O + CO_2 \uparrow$   
 (B)  $2CH_3COOH + Na_2CO_3 \rightarrow CH_3COONa + H_2O + CO \uparrow$   
 (C)  $2CH_3COOH + Na_2CO_3 \rightarrow CH_3COONa + H_2 + CO_2 \uparrow$   
 (D)  $2CH_3COOH + Na_2CO_3 \rightarrow CH_3COONa + H_2 + CO \uparrow$
27. What is the substance Y which is produced in this reaction ?  
 (A) Carbon dioxide (B) Water  
 (C) Carbon monoxide (D) Dihydrogen
28. What mass of substance Y is produced in this reaction ?  
 (A) 1g (B) 2g  
 (C) 1.8 g (D) 3.1 g

**PARAGRAPH # 2**

Ravi was performing some experiments related to the laws of chemical combination in the science laboratory under the guidance of his chemistry teacher Mr. John. Ravi found that when he burned 1 gram of hydrogen gas in 8 grams of oxygen gas in a closed vessel, he obtained 9 grams of water. He repeated this experiment many times but obtained the same results every time.

29. Write a balanced chemical equation for the reaction between hydrogen and oxygen to form water. Also write the names of all the substances involved below their formulae in the equation.  
 (A)  $2H_2 + O_2 \longrightarrow 2H_2O$  (B)  $2H + 2O \longrightarrow 2H_2O$   
 (C)  $H_2 + O_2 \longrightarrow H_2O$  (D)  $2H_2 + O_2 \longrightarrow 2H_2O_2$



## EXERCISE – II

### VERY SHORT ANSWER TYPE

1. What is atomic mass unit.
2. Write down the latin name of sodium.
3. What is the atomic mass of P atom.
4. What is the formula of nitrogen molecule.
5. What is the molecular mass of hydrogen molecule.
6. Write down the statement of law of conservation of mass.
7. Write the cations and anions present (if any) in the following compounds  
(a) NaCl (b) CaCl<sub>2</sub>
8. What are the symbols of sodium, iron, silver and gold?
9. Calculate the mass of  $10.044 \times 10^{25}$  molecules of oxygen.
10. What weight of oxygen gas will contain the same number of molecules as 56 g of nitrogen gas ? (Atomic mass : O = 16 u ; N = 14u)

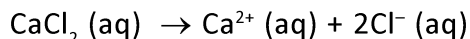
### SHORT ANSWER TYPE

1. A sample of vitamin C is known to contain  $2.58 \times 10^{24}$  oxygen atoms. How many moles of oxygen atoms are present in the sample?
2. Write the molecular formulae for the following compounds  
(a) Copper (II) bromide  
(b) Aluminium (III) nitrate  
(c) Calcium (II) phosphate  
(d) Iron (III) sulphide  
(e) Mercury (II) chloride  
(f) Magnesium (II) acetate
3. Which has more number of atoms? 100g of N<sub>2</sub> or 100 g of NH<sub>3</sub>
4. The molecular formula of glucose is C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>. Calculate its molecular mass.
5. Which postulate of Dalton's atomic theory can explain the law of conservation of mass?

### LONG ANSWER TYPE

1. Give the chemical formulae for the following compounds and compute the ratio by mass of the combining elements in each one of them.  
(a) Ammonia (b) Carbon monoxide  
(c) Hydrogen chloride (d) Aluminium fluoride  
(e) Magnesium sulphide

2. Calcium chloride when dissolved in water dissociates into its ions according to the following equation.



Calculate the number of ions obtained from CaCl<sub>2</sub> when 222 g of it is dissolved in water.

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
  - (ii) Ammonium sulphate
  - (iii) Calcium hydroxide
  - (iv) Lead bromide
4. 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?
  5. What is the mass of  $4.0 \times 10^{-3}$  mol of glucose, (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) ? How many carbon atoms are there in  $4.0 \times 10^{-3}$  mol of glucose ?

### TRUE AND FALSE TYPE

1. Symbol of copper is CU.
2. Chemical formula of sodium sulphate is Na<sub>2</sub>SO<sub>4</sub>.
3. Avogadro's number is  $6.022 \times 10^{22}$ .
4. Moles of water molecules in 36 gram of water are two.
5. Gram atomic mass of phosphorus is 31 g.

### FILL IN THE BLANKS TYPE

1. One mole atoms of oxygen contains \_\_\_\_\_ atoms of oxygen.
2. The number of atoms in a molecule of the elementary substance called is \_\_\_\_\_.



**Answer Key**

**EXERCISE-I**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B	A	B	C	C	B	A	B	A	B	C	C	D	C	B
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A	D	C	C	C	A	B	D	B	C	A	B	C	A	C
31	32	33												
A	A	B												

**EXERCISE – II**

**TRUE / FALSE**

1. F    2. T    3. F    4. T    5. T

**FILL IN THE BLANKS**

1.  $6.022 \times 10^{23}$     2. Atomicity    3. 1 : 8    4. Hydrargyrum  
 5.  $12.044 \times 10^{23}$ ,  $6.022 \times 10^{23}$

**NUMERICAL TYPE**

1. C    2. A    3. C    4. D    5. D

## SELF PROGRESS ASSESSMENT FRAMEWORK

(CHAPTER : ATOMS & MOLECULES)

CONTENT	STATUS	DATE OF COMPLETION	SELF SIGNATURE
Theory			
In-Text Examples			
Solved Examples			
NCERT Exercises			
Exercise I			
Exercise II			
Short Note-1			
Revision - 1			
Revision - 2			
Revision - 3			
Remark			

### NOTES :

1. In the status, put “completed” only when you have thoroughly worked through this particular section.
2. Always remember to put down the date of completion correctly. It will help you in future at the time of revision.



*Space for Notes :*

A large rectangular area filled with horizontal dotted lines, intended for writing notes.

