INDEX

Chapter 1

Matter in Our Surroundings

INTRODUCTION

Chemistry can be defined as the study of matter and the changes it undergoes.

Matter is defined as anything that occupies space and has mass. It is the stuff our universe is made of, and all the chemicals that make up tangible things, from rocks to pizza to people, are examples of matter.

The early scientists thought that there were only four kinds of matter, or elements - Earth, Air, Fire and Water.

All of the different kinds of matter we see around us were believed to come from mixtures of these four. While this was a good start, four elements alone did not seem to provide enough diversity to account for all matter.

The forms of matter that we see on the earth are often changing. Trees grow, die, and decay. Rocks undergoes weathering thus crumble, and form the fertile soil of the plains or deposits in the oceans. The changes that matter undergoes are another concern of chemistry. But there is even more. In addition to matter, the universe is also composed of energy. When a log burns in the fireplace, it is obvious that a change in matter has occurred. The log seems to have disappeared, leaving a small pile of ash. But the burning of the log warms us as it has given off heat. The heat and light that were liberated by the burning process are forms of energy. Energy is a more abstract concept than matter.

GENERAL CHARACTERISTICS OF MATTER

There are various forms of matter in the nature. The various forms of matter have some common characteristics. The general characteristics have been discussed below :

(i) The Matter has Mass

If we take two pieces of bricks of different size, we will find that one is lighter while the other is heavy. The small sized brick is lighter because it contains less matter, while big sized brick is heavier because it contains more matter. Hence, the amount of matter present in anything is called its mass.

The things may be invisible even then they will have some mass e.g., the air. Although air is invisible even then it has some mass.

(ii) The Matter Occupies Space

You must have experienced this phenomenon during your everyday life. If one stool is placed in the corner of your drawing room, you know another stool cannot be placed in the same corner. If the space on your bookshelf is completely filled with the books, you cannot keep more books on it. The two trucks coming from the opposite directions in a narrow lane cannot cross each other as there is space only for one. If they will try to cross each other they will collide. Therefore, it is clear that matter occupies space.

(iii) The Matter has Inertia

If any thing is lying on any place, it will remain there until and unless some external force disturbs its position. Similarly if anything is in motion, it will remain in motion till some external force stops it. This is known as property of inertia. The matter itself cannot change its position. Suppose if a foot ball is placed in the centre of a playground, it will remain there till it is pushed by anybody. Similarly if the football is pushed by a player it will move on till it is stopped by other players or by the friction of the play-ground.

(iv) The Matter is Effected by the Gravity

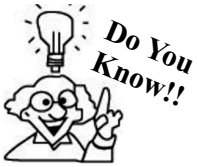
If anything is thrown upward with a certain force it will automatically come to the ground because of force of attraction exerted by the earth. This attraction is called gravity.

When you throw a ball upward with a certain force, it will automatically come down on the earth because of earth's gravity. The fruits always fall downwards from the trees because of this gravity. Similarly water always flows from higher level to lower level.

(v) The Matter cannot be Destroyed

In all physical and chemical changes, total mass of the matter before and after the change remains the same. This can be proved by a simple experiment performed by Lavoisier.

Lavoisier's experiment – Lavoisier took tin metal in an airtight flask. The flask (with tin) was weighed. It was then heated. Tin metal reacted with the oxygen present in the air of the flask and was converted into tin oxide. The flask was cooled and again weighted. It was found that the weight practically remains unchanged.



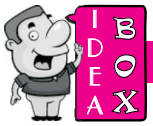
Law of conservation of mass – This law was given by Lavoisier after carrying out experiment. According to this law " In any chemical reaction mass of reactants always remains equal to the mass of products. i.e. during any chemical reaction mass remain conserved.

CHECK Point

☛ **Take one football bladder filled with air and hang it on one side of the beam of a physical balance and put weight on the pan hanging on other side untill balance becomes horizontal. Now remove the air from the bladder. What will you find and what does it indicates?**

SOLUTION

You will find that the end of beam (on which the bladder has been hanged) moves upward. This indicates that air has a mass. Therefore, all the forms of matter have mass.



idea box

Perform this experiment in your school chemistry lab. Take few ml of aqueous solution of NaCl in a test tube (20ml) tied with a thread. Also take few ml of $CuSO_4$ aqueous solution in 250 ml conical flask. Now put test tube containing NaCl solution in conical flask containing $CuSO_4$ solution. One end of the thread is tied with test tube while other end is kept out of conical flask and flask is closed with rubber cork and then weigh the flask. Now pull the free end of thread to tilt the test tube so that content of test tube and flask get mixed (chemical change). Now again weigh the flask and record your observations what you conclude from this activity?

PHYSICAL NATURE OF MATTER

Every substance has a unique set of properties that allow us to recognize it and to distinguish it from other substances. The properties of matter can be categorized as physical or chemical. Physical properties can be measured without changing the identity and composition of the substance. These properties include color, odour, density, melting point, boiling point, and hardness. Chemical properties describe the way a substance may change or react to form other substances. A common chemical property is flammability, the ability of a substance to burn in the presence of oxygen.

PARTICLE NATURE OF THE MATTER

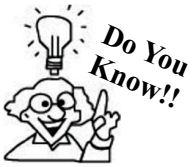
The concept about the nature of matter is very old. According to the ancient Hindu and Greek philosophers the matter is composed of very small particles which cannot be further sub-divided. John Dalton was the first person who gave scientific explanation about the nature and the composition of the matter.

Evidences for Particles in Matter

Most of the evidence for the existence of particles in matter and their motion comes from the experiments on *diffusion* and *Brownian motion*.

(a) Dissolving a solid in a liquid

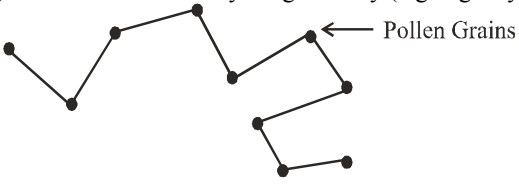
Potassium permanganate is a purple coloured solid substance and water is a liquid.
Take 2-3 crystals of potassium permanganate and dissolve them in 100 ml of water.
Now take out 10 ml of this solution & put into another 90 ml of clear water.
Keep diluting the solution like this 5 to 8 times. Everytime solution will become purple colour.
This experiment shows that just a few crystals of potassium permanganate can colour a large volume of water.
It means a crystal of $KMnO_4$ is made up of millions of tiny particles. They divide themselves into smaller & smaller particles. So we concluded that matter is made up of small (tiny) particles. Particles of $KMnO_4$ and particles of water spread into each other, it means they are moving. This self movement of different particles among each other, so they become mixed uniformly, is called *diffusion*.



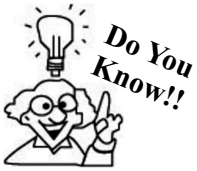
Reason for diffusion of particles of matter is that they are continuously in random motion as they possess kinetic energy. As kinetic energy depends upon temperature. Thus rate of diffusion becomes faster with increase in temperature.

(b) Movement of pollen grains in water

Pollen grains move rapidly throughout the water in a very irregular way (zig-zag way).



The pollen grains move on the surface of water because they are constantly being hit by fast moving particles of water. This type of zig-zag movement of the small particles suspended in a liquid (or gas) is called *Brownian motion*.



Brownian motion increases on increasing the temperature because of increase in kinetic energy of particles of matter.
The existence of Brownian motion gives two conclusions.
(i) *Matter is made up of tiny particles.* **(ii)** *Particles of matter are constantly moving.*

CHECK Point

☛ **What is nature of matter is it continuous or particulate?**

SOLUTION

Particulate

Characteristics of Particles of Matter

(i) The particles of matter are very, very small

The matter is composed of small particles : To understand particle nature of the matter, let us perform one experiment. Take a beaker full of water. Now place a small crystal of blue vitriol (copper sulphate) in the water. You will observe that the water begins to become blue coloured and slowly the size of the crystal becomes smaller and smaller. The crystal has divided itself into number of smaller particles and ultimately it dissolves in water. This experiment suggests that matter is composed of small particles.

(ii) The particles of matter have spaces between them

Is there vacant space between the particles of matter ? Let us perform the following experiments –
Experiment (1) – Take a piece of chalk (used for writing on black board) and dip it into water. Some water is absorbed by the chalk. There are vacant spaces or pores in the chalk which are occupied by the water.
Experiment (2) – Take a wide mouthed test tube, almost half filled with water. Now put a sugar cube in the test tube and mark the water level with a glass marking pencil. The sugar cube will dissolve in water and the level of water will go down to a small extent. Why it so happened ? There are vacant spaces between the particles of water. This vacant space is occupied by the particles of the sugar and water level goes down.

idea box

Perform this experiment in your school chemistry lab. Take a big sized test tube and fill it with water. Add a few drops of Phenolphthalein solution. Now tie a cellophane paper on the mouth of the test tube. Invert the test tube on the open mouth of a bottle containing ammonium hydroxide. Record your observation and discuss your observation with your friends and teacher.

(iii) The particles of matter are constantly moving

This property can be explained by Brownian motion and diffusion.
Diffusion **:** It is the phenomenon in which the movement of molecules or particles occur from their higher concentration towards the lower concentration. *"Intermixing of particles of two different types of matter on their own is called diffusion".*

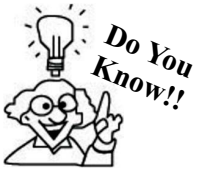
For eg : When a perfume bottle is open in one corner of a room, its fragrance spreads in the whole room quickly. The particles of perfume move rapidly in all directions and mix with the moving particles of air in the room.

CHECK Point

☛ **Why liquids diffuse slowly as compared to gases?**

SOLUTION

In liquids, the molecules are less free than in a gas, i.e., the intermolecular forces (van der Waals forces) in a liquid are greater than in a gas.



We have seen that the particles of matter in liquid and gaseous state are mobile. But it is difficult to visualise that the particles of solid matter are also mobile. We do not find any movement of the particles in case of solid matter like wood, iron, gold, copper etc. even if these substances are placed in water or air. If you dip a zinc rod in mercury, you will find that after sometime the particles of mercury enters into the zinc metal. Similarly if a gold rod is placed in mercury, the mercury particles slowly enters into gold. This process is very slow.

Both heat as well as temperature are responsible for the motion. When the temperature is increased there will be increase in the motion also. We may conclude that particles of matter are mobile, whether the matter is in solid, liquid or gaseous state. The motion of the particles is fast in case of gaseous state, slow in liquid state and very slow in solid state.

idea box

Take two 250 ml beakers. Now fill one beaker with cold water and the other with hot water. Now with the help of dropper add 1-2 drops of ink in both the beakers. Record your observations and draw a conclusion on the basis of your observations.

(iv) Particles of matter attract each other

There are some forces of attraction between the particles of matter which bind them together.
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.*
For eg : If we take a piece of chalk, a cube of ice and an iron nail and beat them with a hammer.
Observation : Chalk will easily break into smaller pieces.
More force is required to break a cube of ice. Iron nail does not break.
Conclusion : Force of attraction is quite weak in between the chalk particles.
Force of attraction in between the particles of ice cube is a bit stronger.
Force of attraction in between the particles of iron is very, very strong.

CONNECTING TOPICS

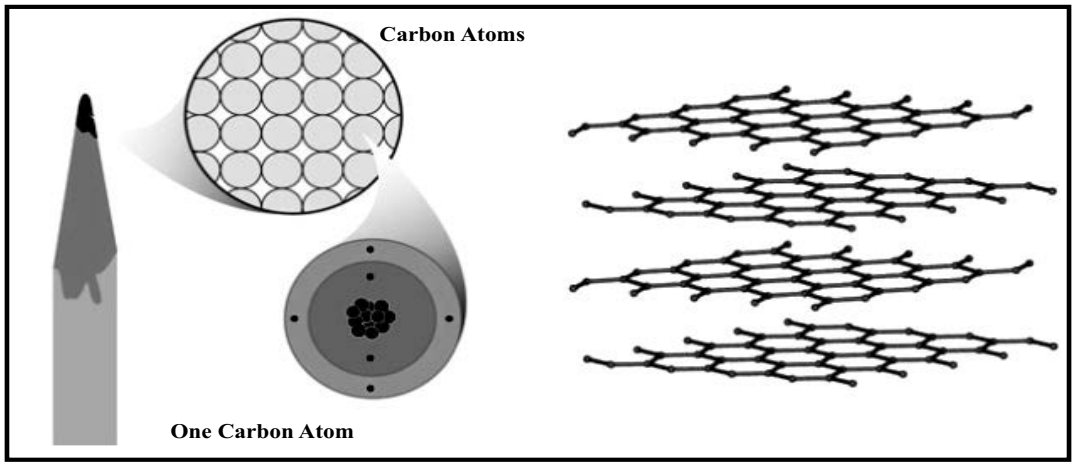
THEORIES RELATED TO MATTER

(1) Atomic Theory of Matter

The earliest ideas about matter and atoms were developed by Greek philosophers between 380 and 450 B.C. At that time, the question under discussion was whether matter had the property of being continuous or discontinuous. These concepts can be visualized if you took the "lead" or graphite of a broken pencil point and divided it in half, then divide that piece in half and again half of that piece. This process could be continued as long as possible. If matter was continuous, the process could be continued indefinitely without ever "running out" of graphite. If matter was discontinuous, then at some point, the dividing process would end when the last particle which could still be called graphite was all that remained. A further division would result in destroying the matter called graphite.

Democritus used the word "*atomos*" meaning "*indivisible*" or "*uncuttable*" to describe the ultimate building blocks of matter. Later word atoms is used for atomos. Atoms result from the repeated division of matter to very very tiny, permanent, indivisible, invisible bits of matter with definite size and shape. This Atom Theory was applied in support of the *Discontinuous Theory of Matter*. The Continuous Theory of Matter received wide spread support until the 1800's when *John Dalton* revived the atom concept to explain certain aspects of chemical reactions.

The final division of matter such as graphite results in atoms of the element carbon.



(2) Kinetic Theory of Matter :

The Kinetic Theory explains the differences between the three states of matter. It states that all matter is made up of moving particles which are molecules or atoms. In solids, the particles are so tightly bound to each other that they can only vibrate but not move to another location.

In liquids, the particles have enough free space to move about, but they still attract one another. In gases, the particles are far apart and can move about freely since there is much free space. Solids change into liquids, and liquids into gases, when the particles gain more kinetic energy, like when being heated and are able to move apart from one another. When the molecules vibrate more quickly upon heating, some of it escapes from the matter.

The main postulates of kinetic Theory of matter are following :

- Matter consists of molecules. These are the smallest particles, which are capable of free existence and retain all the chemical properties of the parent substance.
- The molecules are always in a state of random continuous motion.
- The molecules exert forces on one another. These forces depend upon intermolecular distance
- All collision between the particles of matter are perfectly elastic.

ILLUSTRATION : 1

What would have happened to the gas if the molecular collisions were not elastic?

SOLUTION :

On every collision, there would have been loss of energy. As a result, the molecules would have slowed down and ultimately settle down in the vessel. Moreover, the pressure would have gradually reduced to zero.

MOLECULAR NATURE OF THE MATTER

Matter is composed of the molecules formed by combination of atoms. As already stated, the molecules are very minute in size and mass. These molecules cannot be seen even with the most powerful microscope of your school. A substance appears to be composit, but there are wide gaps (interstices) between molecules which may expand or contract, the expansion or contraction of the bodies on heating or cooling is due to the change in the distances between the molecules.

The molecules of the substances are always in the state of constant motion. The molecules of the different substances move with the different speed while molecules of the same substance move with the same speed. The lighter molecules move with greater speed as compared to the heavier molecules. Further with the increase of temperature motion of the molecules also increases.

At high temperature the molecules move faster and push one another with greater force and the distance between the molecules increase. This explains why the bodies expand on heating. When a solid substance is heated upto its melting point, it changes to liquid state because the force of attraction between the molecules decreases and the distance between the molecules increase. The molecules of a liquid have a random motion, i.e., they can move from one place to another or in other words liquid can flow easily. If a liquid substance is heated upto its boiling point it changes to gaseous state. In this state the force of attraction becomes negligible. The distances between the molecules increase to a very great extent. Therefore, the molecules in gaseous state have free movement.

INTER-MOLECULAR FORCES

The particles of the matter are bonded together with a force called Inter-molecular force. In solid, the particles are bonded together with strong inter-molecular forces. When energy (say in the form of heat) is given, the bonds break, the arrangement of the molecules is disturbed and the solid is converted into liquid. If more energy is given, the inter-molecular forces are further decreased, the arrangement of the molecules is further disturbed and the liquid is converted into gas. Different solids possess inter-molecular force of different magnitude. If this force is more in any solid, more energy will be required to break the bonds between the molecules, i.e., more energy will be required to convert it into liquid.

As stated above there are forces of attraction between the molecules and these forces continuously scatter them because of their velocity. However, these forces are not uniform in the molecules of all the substances. In solids the force of attraction between the molecules is maximum and in gases it is minimum or negligible. In liquids the molecules are held together less firmly as compared to the solids. Therefore, liquid molecules get separated from one another easily. This explains that why some liquids evaporates even at low temperature.

CHECK *Point*

☛ **1. Arrange the solids, liquids and gases in the increasing order of inter molecular forces of attraction.**

2. Arrange solid, liquid and gas in order of energy, giving reasons.

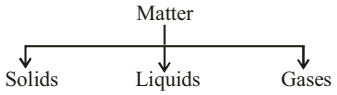
SOLUTION

1. Gases < Liquids < Solids.
2. Solid < Liquid < Gas. This is because a solid absorbs energy to change into a liquid which further absorbs energy to change into a gas.

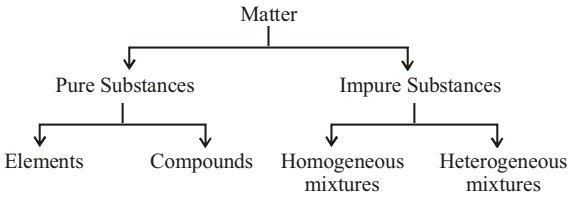
CLASSIFICATION OF MATTER

Matter can be classified into different categories depending upon their physical or chemical nature.

(i) Based on state (Physical Classification)

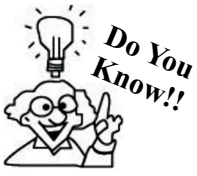


(ii) Based on purity/composition (Chemical Classification)



STATES OF MATTER

Matter is everything around us. Matter is anything made of atoms and molecules. Matter is anything that has mass and occupy space. Matter is also related to light and electromagnetic radiation. Up to 1995 scientists have identified five states of matter. These five main states of matter are solids, liquids, gases, plasmas and Bose-Einstein condensates. These all are different states of matter.



Each of these states is also known as a phase. Elements and compounds can move from one phase to another phase when special physical forces are present. One example of those forces is temperature. The phase or state of matter can change when the temperature changes. Generally, as the temperature rises, matter moves to a more active state. Phase describes a physical state of matter. The keyword to notice is physical. Things only move from one phase to another by physical means.

In the solid state, substances are rigid and have definite shapes. Volumes of solids do not vary much with changes in temperature and pressure. In the liquid state, the individual particles are confined to a given volume but they do not have definite shape. A liquid flows and assumes the shape of its container up to the volume of the liquid. Volumes of liquids changes to appreciable extent with change in temperature and pressure. Gases neither have definite shape nor volume. They occupy all parts of any vessel in which they are confined.

SOLID

The solids are characterised by incompressibility, rigidity and mechanical strength. It indicates that the molecules, atoms or ions that make up a solid are closely packed or in other words they are held together by strong forces and cannot move about. Due to the strong intermolecular attractive forces between the constituent particles, solids are rigid and possess a definite shape and volume. These have definite melting point, high density and low compressibility.

PROPERTIES OF SOLIDS

Important properties of solids can be described as follows:

(1) **Shape and volume :** A solid has a definite volume and definite shape. The molecules in a solid are in fixed positions and are close together because the intermolecular force of attraction between the particles is very strong. The molecules are strongly held and arranged in order. Although the molecules can still vibrate, they cannot move from one part of the solid to another part. As a result, a solid does not easily change its shape or its volume. If you force the molecules apart, you can change the shape and the volume of a solid by breaking it into pieces. However, each of those pieces will still be a solid and have its own particular shape and volume.

(2) **Compressibility :** A-solid is rigid and cannot be compressed easily. The molecules in a solid are closely packed and the intermolecular distance is very small which cannot be reduced further.

(3) **Diffusion :** A solid does not diffuse into another solid easily because intermolecular force of attraction in solid is very strong.

(4) A solid does not flow and can be stored in a container because intermolecular force of attraction is so strong that molecules do not flow and leave the surface of the solid.

(5) **Melting :** A solid on heating usually changes into its liquid state. This is because heating provides sufficient energy to molecules to overcome the intermolecular force of attraction. Intermolecular separation increases, changing the solid into liquid.

CONNECTING TOPIC

CLASSIFICATION OF SOLIDS

Solids are classified into two groups based on the arrangement of constituent practicles.

(a) Crystalline solids (b) Amorphous solids

(i) Amorphous Solids

Amorphous solids are those solids in which the constituent particles are arranged in haphazard manner and not in a regular fashion. These resemble liquids as they flow very slow at room temperature and thus termed as **super cooled liquids.**
The properties showing the difference between the crystalline and amorphous solids are listed in table.
These lose their shape on standing and flow under their own weight, e.g., glass, pitch, rubber, plastics, starch and proteins.

(ii) A Crystalline Solid

Crystalline solid consists of a large number of small units, called crystals, each of which possesses a definite geometric shape bound by plane surfaces called faces. A crystal is thus a solid figure with a definite geometrical shape, flat faces and sharp edges. The angle between two faces (interfacial angle) is a characteristic property of a crystal. A crystal may be cleaved not in all directions but in certain preferred directions to give smaller crystal which has the same characteristic as the parent.

Table : Distinction between Crystalline and Amorphous Solids

	Property	Crystalline solids	Amorphous solids
1.	Shape	They have a definite and regular geometrical form.	They do not have definite geometrical shape.
2.	M.P.	They have a sharp (definite) melting point.	They melt over a wide range of temperatures.
3.	Compressibility	They are rigid and incompressible.	They too are usually rigid and cannot be compressed to any appreciable extent. However, graphite is soft because of its unusual structure.
4.	Cutting with sharp edged tool	They give clean cleavage, i.e., they break into two pieces with plane surfaces.	They give irregular cleavage, i.e., they break into two pieces with irregular surfaces.
5.	Heat and fusion	They have a definite heat of fusion.	They do not have a definite heat of fusion.

6.	Isotropy/Anisotropy	Anisotropic. i.e., their mechanical and electrical properties depend on the direction along which they are measured.	Isotropic i.e., they have similar physical properties in all directions because the constituents are arranged in random manner.

Alternatively, solids can be classified into four types depending upon the nature of interparticle forces present between the constituent units.

(a) Ionic solids : Here, constituent units are ions of opposite charges and interparticle forces are ionic forces, e.g., NaCl, $BaCl_2$, KNO_3, etc.

(b) Covalent solids : Here, the constituent particles are atoms which are held together by covalent bonds. These solids are very hard becuase of strong interparticle covalent bonds. Examples are quartz, SiO_2, diamond, graphite, etc.

(c) Metallic solids : Here, the constituent units are positively charged kernels which are held together by a cloud of loosely bound eolectrons (metallic bonds). These electrons are free to move throughout the lattice, e.g., Na, Cu, Fe, Al, Ag, etc.

(d) Molecular solids : Here, the constituent units are covalent molecules and the interparticle forces are hydrogen bonds or van der Waal's forces, e.g., solid CO_2, I_2, S_8, urea, sugar etc.

CHECK Point

☛ **Why urea has a sharp melting point but glass does not?**

SOLUTION

Urea is a crystalline solid whereas glass is amorphous. Crystalline solids have sharp melting points whereas amorphous solids do not possess that melting points.

ILLUSTRATION : 2

Classify the following substances into ionic, covalent, molecular or metallic :

MgO, SO_2, I_2, H_2O (ice), SiO_2(quartz), brass.

SOLUTION :

MgO = Ionic, SO_2 = Polar molecular, I_2 = non-polar molecular, H_2O = Hydrogen bonded molecular, SiO_2 = Covalent or network, brass = metallic.

Knowledge ENHANCER

Interesting Property of Some Solids : Elasticity :

When a piece of rubber is stretched its length is increased, but on removing the force, the rubber gains its original shape. Similarly if a weight is hanged with a spring, the length of the spring is increased, but on removing the weight, the spring gets its original length. This property of a solid body by virtue of which it tends to regain its original state, when the deforming forces are removed, is known as elasticity. The bodies in which complete restoration of the initial state takes place, are called perfectly elastic bodies, while those bodies which do not show any such tendency are termed as non-elastic or plastics.

The property of elasticity can be explained on the basis of the molecular force between the molecules. The molecular force works between the molecules in such a way as if they are joined together by a spring. In normal conditions the solid retaining its shape and size. The molecules remain balanced unless some external force is applied. When force is applied the molecules begin to move towards the direction of the force. When the distance between the molecules increases they experience force of attraction and when the distance between the molecules decreased, they experience repulsion. When the external force is removed the molecules regain their original position.

Ice a Unique Solid :

Ice is considered as unique solid because it is less dense as a solid than it is as a liquid. Normally, a liquid becomes denser as it freezes and its molecules pack closer together. However, as water freezes, its molecules form a lattice network of hexagons containing empty spaces. These hexagons cause water to expand about 11% in volume when it freezes. This expansion means that ice has fewer molecules per cubic centimeter than water has, so it is less dense than water. To be precise, ice's density is 0.917 g/cm³ and water's maximum density is 1.00 g/cm^3 at 3.98° C.

LIQUID

Liquids have definite volume but do not have definite shape. They take the shape of the vessel in which they are kept. Molecules of liquid are more close to each other in comparison to the gas molecule due to strong attractive forces. Liquids have enough vacant space in comparison to solids. Thus liquid is an intermediate state between the complete disorder found in gas and highly ordered molecular state in solid. Example: water and milk.

Properties of Liquids :

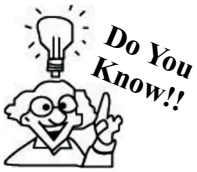
Important properties of liquid can be described as follows :

(1) Shape and volume :

Molecular forces between the liquid molecules are not so strong to keep molecules in a fixed position i.e., intermolecular attraction between molecules is less than that of solids. Therefore, liquids do not have a definite geometric shape. Due to appropriate attractive force they have definite volume in comparison to gas.

(2) Density :

In comparison to the gas, in liquids the molecules are more close to each other. Therefore, density of liquids is higher than that of gaseous state. For example, at one atmospheric pressure and 100°C the density of water is 0.958 gm cm^{-3} whereas under same conditions steam (gaseous water) has a density of 0.00059 gm cm^{-3}. That is water is almost 1600 times more dense than vapour.



It can be concluded that density of liquid is more in comparison to the gas due to their more closely packed molecules. There is negligible effect of pressure on the density of liquid. Liquids are incompressible.

$$\text{Density of any substance} = \frac{\text{Mass of that substance}}{\text{Volume of that substance}}$$

(3) Diffusion :

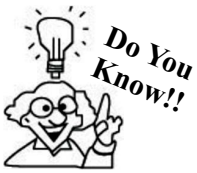
When two soluble liquids are placed close to each other then molecules of one liquid enter in between the molecules of the other and the two liquid mixed with each other. It is called diffusion. Diffusion is seen in liquids like gases.
It is a comparatively slow process, because the velocity of liquid molecules is very less in comparison to the gas molecules. Moreover vacant space is comparatively quite less in liquid than gas.

(4) Compressibility :

The vacant space in between the molecules of liquids is very less, so the compressibility of liquids is very less, as compared to gases. For example at 300K when the pressure of an ideal gas is changed from one atmosphere to two atmosphere then its volume reduces by 50% whereas when the same pressure is increased on water (liquid) its volume decreases by only 0.0045%.

(5) Evaporation :

Though the molecules of liquid are bonded to each other by, attractive force still they have a tendency of evaporation.
Therefore evaporation is that process in which liquid changes into vapour at room temperature. The kinetic energy of all liquid molecules is not same. But it is equal to the average value or near about it i.e. some molecules have more or some less. That is known that kinetic energy of molecules of liquid opposes the intermolecular force of attraction which keeps them close. Therefore some molecules evaporate from the surface and go to the vapour state. We will learn more about evaporation later in this chapter.



The pressure exerted by the vapours in equilibrium with its liquid at a given temperature is called vapour pressure of that particular liquid. This is also called saturated vapour pressure. The magnitude of vapour pressure depends upon the following two factors.

(i) Nature of liquid : *The vapour pressure of a liquid depends upon the nature of the liquid.*

(ii) Temperature of liquid : *The vapour pressure of a liquid increases with increase in temperature.*

CHECK Point

☛ **A liquid is transferred from a smaller vessel to a bigger vessel at the same temperature. What will be the effect on the vapour pressure?**

SOLUTION

No effect as it depends only on the nature of the liquid and temperature.

CONNECTING TOPIC

SURFACE TENSION

It is an important property of liquids, which is directly related to the intermolecular forces between the molecules. Liquid surface feel stretched due to surface tension. As mentioned previously, the molecules in liquids are held closely and hence attract each other. A molecule in the bulk of the liquid is attracted equally on all sides so that the net attractive pull on the molecule is zero. However, a molecule which lies at the surface (known as surface molecule) is subjected only to the attractive forces of the molecules below it. This is because there are no molecules above it. Therefore, surface molecules experience a resultant downward attractive force within the liquid. This creates an imbalance of forces at the surface. In other words, the liquid surface is under tension due to imbalanced forces. This effect is called **surface tension**.

Effect of temperature

Surface tension decreases with rise in temperature. The decrease of surface tension with increase of temperature is because of the fact that the kinetic energy (or speed) of the molecules increases. As a result, the intermolecular forces decrease and therefore, surface tension also decreases. For example, the clothes are washed more efficiently in hot water than in cold water due to decreased surface tension in hot water.

Surface tension and nature of liquid

Since, surface tension of a liquid is due to intermolecular attractive forces, therefore, the magnitude of surface tension is a measure of intermolecular attractive forces. When the attractive forces between the molecules are large, the surface tension is large.

Importance of Surface Tension

(i) Capillary action

When one end of a capillary tube is put into a liquid that wets glass the liquid rises into the capillary tube to a certain height and then stops. The rise of a liquid in capillary is called **capillary action**. The rise of liquid in a capillary is due to the inward pull of surface tension acting on the surface which pushes the liquid into the capillary tube. This phenomenon is very important. For example, water below the surface of the earth rises to the plants through the roots, oil rises into the wick of an oil lamp, ink rises in a blotting paper, are examples of capillary action.

(ii) Spherical shape of drops

The liquid drops have nearly spherical shapes. We have learnt that surface tension tries to decrease the surface area of a liquid to the minimum. Since the sphere has minimum surface area for the given volume of liquid.

GAS

Gas is the third state of matter. A gas differs from a solid and a liquid in a number of ways. A gas fills entire space available to it and therefore it has no definite shape or volume.

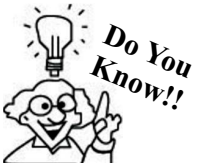
The molecules in a gas are in a continuous motion in all possible directions in the complete space available within the container in which it is enclosed. The average velocity of a gas particle is nearly 15000 ms^{-1} at ordinary temperature.

Due to very weak intermolecular forces in gases its molecules are in greater motion and show irregular movement. Therefore gases do not posses definite size, shape and volume. Gases have very low density and high compressibility.

Properties of Gasses

(1) Compressibility

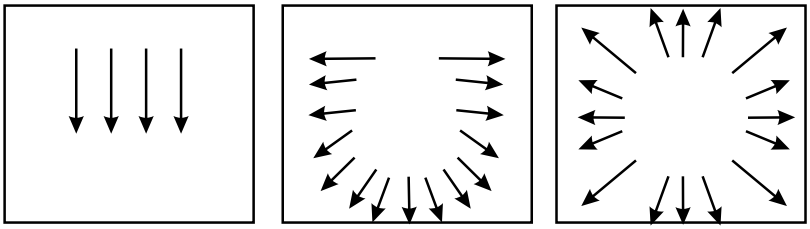
The gases can be compressed on applying external pressure. In case of gases the distances between the molecules are much greater as compared to the solids and liquids. Therefore, on applying external pressure the gases can be compressed easily and under such conditions the gas molecules come closer to each other and they occupies less space than before.



The property of liquids of incompressibility is useful for us in hydraulic machines. A simple system of automobile hydraulic brakes are a good example of this. The brake system cannot work correctly if there is any air (gas) in the system because the gas is compressible.

(2) Exertion of pressure

Solids exert pressure only in downward direction. Liquids exert pressure downward as well as to the sides. But gases exert pressure in all directions (a good example is a balloon) as shown in figure below. This pressure is due to bombardment of the particles against the walls of the container. Thus gases exert pressure equally in all directions.



Solid **Liquid** **Gas**

(3) Homogeneous nature

Gases have similar composition in all parts and are therefore homogeneous in nature.

(4) Liquefication

Gases can be liquefied by colling and by applying pressure.

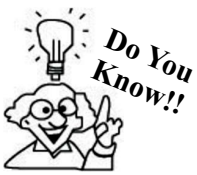
(5) Diffusion

When a bottle of ammonia is opened in one corner of the laboratory, its pungent smell can be experienced all over the laboratory. Similarly, when a bottle of perfume is opened in the drawing room its smell spreads and can be detected all over the room, In fact all gases possess this property of intermixing with one another without any mechanical aid to form a homogeneous mixture called diffusion.

Uses of Gaseous Diffusion

1. **Separation of gases :**
Gases can be separated from the mixture of gases by the use of process of diffusion. When a mixture of gases is diffused, the lighter gases will diffuse quickly than the heavier gases. In this way by repeating the process of diffusion, gases can be separated from the mixture.

2. **Relative densities and molecular weights of the gases :**
Graham's Law of diffusion (explained later in this chapter) can be used for the determination of relative densities and molecular weights of the gases.



Air, becomes impure because of the process of diffusion. Poisonous and foul smelling gases diffuses in the air and because of this dispersion, the air becomes foul smelling.

Knowledge ENHANCER

Plasma : *Plasmas are a lot like gases, but the atoms are different because they are made up of free electrons and ions of the element. You don't find plasmas too often when you walk around. They aren't things that happen regularly on Earth. If you have ever heard of the Northern Lights or ball lightning, you might know that those are types of plasmas. It takes a very special environment to keep plasmas going. They are different and unique from the other states of matter.*

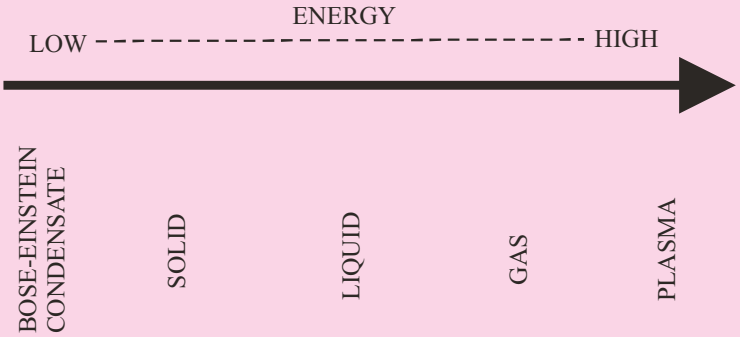
You won't find plasmas just anywhere. However, there may be some in front of you. Think about a fluorescent light bulb. They are not like regular light bulbs. Inside the long tube is a gas. Electricity flows through the tube when the light is turned on. The electricity acts as that special energy and charges up the gas. This charging and exciting of the atoms creates glowing plasma inside the bulb.

Another example of plasma is a neon sign. Just like a fluorescent light, neon signs are glass tubes filled with gas. When the light is turned on, the electricity flows through the tube. The electricity charges the gas, possibly neon, and creates plasma inside of the tube. The plasma glows a special color depending on what kind of gas is present inside the plasma.

You also see plasma when you look at stars. Stars are big balls of gases at really high temperature. The high temperatures charge up the atoms and create plasma. Fluorescent lights are cold compared to really hot stars. They are still both forms of plasma, even with different physical characteristics.

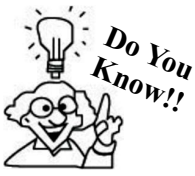
BOSE-EINSTEIN CONDENSATES : *Condensation happens when several gas molecules come together and form a liquid. It all happens because of a loss of energy. Gases are really excited atoms. When they lose energy, they slow down and begin to collect. They can collect into one drop. Water condenses on the lid of your pot when you boil water. It cools on the metal and becomes a liquid again. You would then have a condensate.*

In 1995, two scientists, Cornell and Weiman, finally created this new state of matter. Two other scientists, Satyendra Bose and Albert Einstein, had predicted it in the 1920. They didn't have the equipment and facilities to make it happen in the 20s. Now , we do. If plasmas are super hot and super excited atoms, the atoms in a Bose-Einstein condensate (BEC) are total opposites. They are super-unexcited and super-cold atoms.

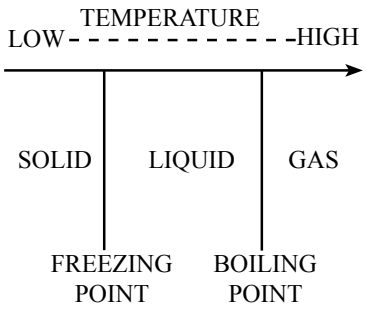


INTERCONVERSION OF MATTER INTO DIFFERENT STATE

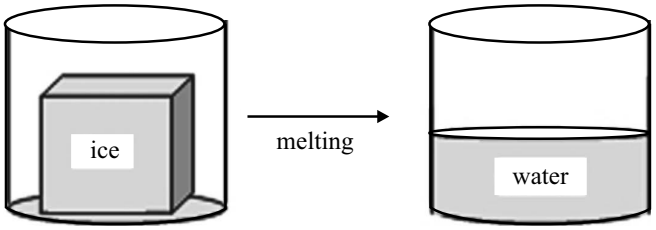
The phenomenon of change of matter from one state to another state and back to original state, by altering the condition of temperature and pressure, is called interconversion of matter. All matter can move from one state to another. It may require very low temperatures or very lower or high pressures, but it can be done. Phase changes happen when certain points are reached. when a liquid turns in to solid. Scientists use parameter called a freezing point to measure when that liquid turns into a solid.

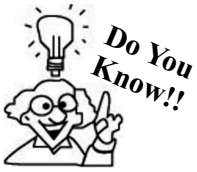


There are physical effects that can change the freezing point. Pressure is one of those effects. When the pressure surrounding a substance goes up, the freezing point also goes up. That means it's easier to freeze the substance at higher pressures. When it gets colder, most solids shrink in size. There are a few which expand but most shrink.



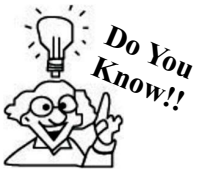
If you have a solid (cube of ice) and want to make it liquid water. You need some energy. Atoms in a liquid state have more energy than the atoms in a solid state. The easiest energy around is probably heat. There is a particular temperature for every solid substance called the melting point. When a solid reaches the temperature of its melting point it melts and get converted in to a liquid. For water the temperature has to be a little over zero degrees Celsius.





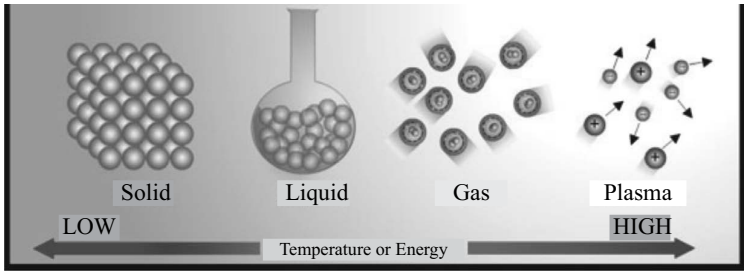
Melting point of a solid also depends upon the surrounding pressure. More will be the pressure more lower will be the melting point. Thus solid melts easily at higher pressure.

The reverse is true if you have a gas. You need to lose some energy from very excited gas atoms. The easy answer is to lower the surrounding temperature. When the temperature drops, energy will be sucked out of gas atoms. When the temperature of the condensation point is achieved it become a liquid. If you have the steam of a boiling pot of water and it hit the wall, the wall would be so cool that steam would quickly become a liquid.



Condensation point of gas also depends upon the surrounding pressure. More will be the pressure more closer will be molecules and thus greater will be the intermolecular forces of attraction. Thus more will be the surrounding pressure more easily gas gets condensed in to liquid.

A plasma can be made from a gas if a lot of energy is pushed inside. All of this extra energy makes the neutral atoms break apart into positively and negatively charged ions and free electrons. They wind up in a big gaseous ball.



The various state of matter can be interchanged into one another by altering the conditions of (1) Temperature (2) Pressure.

1. Altering the Temperature of Matter

(a) Interconversion of solid into liquid & vice versa:

The solids can be converted into liquids by heating them. Similarly, liquids can be cooled to form solids.
For e.g. : Ice at 0°C changes into water at 0°C, when heat energy is supplied to it.
The water at 0°C changes into ice at 0°C on freezing.

(i) Melting or fusion :

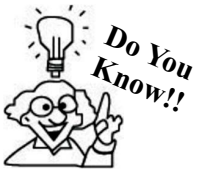
The process due to which a solid changes into liquid state by absorbing heat energy is called melting or fusion. The constant temperature at which a solid changes into liquid state at atmospheric pressure by absorbing heat energy is called melting point.

(ii) Freezing or solidification :

The process due to which a liquid changes into solid state by giving heat energy is called freezing or solidification. The constant temperature at which liquid changes into a solid state by giving out heat energy is called freezing point.

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

Latent Heat of Fusion : The amount of heat energy that is required to change 1 kg of solid into liquid at atmospheric pressure at its melting point is known as the latent heat of fusion. Latent heat of fusion of ice = 3.34×10^5 J/kg.



The numerical value of freezing point and melting point is same

- *Melting point of ice is 0°C(273.16K)*
- *Freezing point of water is 0°C*

0°C = 273.16 K

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

CHECK Point

☛ **Why during melting of solid temperature remains constant?**

SOLUTION

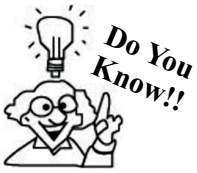
When melting point of solid is reached. Energy supplied further in the form of heat is utilised in phase transition from solid to liquid till solid gets converted in to liquid.

(b) Interconversion of liquid into gaseous state & vice versa:

Liquids can be converted into gases by heating them. Similarly, gases can be converted into liquids by cooling them.

(i) Boiling or vaporisation:

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



For water, the vapour pressure reaches the standard sea level atmospheric pressure of 760 mmHg at 100°C. Since the vapour pressure increases with temperature, it follows that for pressure greater than 760 mmHg (e.g., in a pressure cooker), the boiling point is above 100°C and for pressure less than 760 mmHg (e.g., at altitudes above sea level), the boiling point will be lower than 100°C. As long as a vessel of water is boiling at 760 mmHg, it will remain at 100°C until the phase change is complete. Rapidly boiling water is not at a higher temperature than slowly boiling water. The stability of the boiling point makes it a convenient calibration temperature for temperature scales.

(ii) Condensation or liquefaction

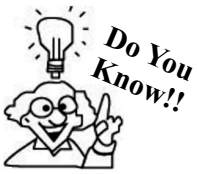
The process due to which a gas changes into liquid state by giving out heat energy is called condensation.

Condensation Point: The constant temperature at which a gas changes into liquid state by giving out heat energy at atmospheric pressure.

Explanation : When heat is supplied to water, particles start moving faster. At a certain temperature, a point is reached when the particles have enough energy to break the forces of attraction between the particles. At this temperature the liquid starts changing into gas. Boiling is a bulk phenomena. Condensation is the opposite of evaporation. It takes place when water vapour in the air condenses from a gas, back into a liquid form, and leaves the atmosphere, returning to the surface of the Earth.

You must have seen water droplets on glass containing ice cubes, it is due to condensation.

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



The numerical value of condensation point and boiling point is same.
Water changes into steam at 100°C
(273 + 100) = 373 K
Steam changes into water at 100°C
Particles in steam, that is water vapour at 373 K have more energy than water at the same temperature.

CHECK Point

☛ **Why steam cause more severe burns than boiling water (100°C)?**

SOLUTION

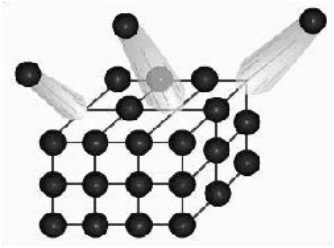
As steam have absorbed extra energy in the form of latent heat of vaporisation. Steam at 100°C will be more dangerous than water at 100°C.

(c) Direct Interconversion of solid into gaseous state & vice versa : Sublimation

Certain substances when heated, pass directly from the solid state to vapour state without being converted into liquid. The vapours when cooled give back the solid substance. This phenomenon is known as sublimation and the substance is called sublimate.

$$\text{Soild} \underset{\text{on cooling}}{\overset{\text{on heating}}{\rightleftharpoons}} \text{Vapours}$$

The examples of substances which can easily sublime are camphor, iodine, napthalene, ammonium chloride, etc. The force of attraction is not uniform in the molecules of all the solids. In some solids, the molecules are bonded together with stronger inter-moleculer forces and in the other, the molecules are bonded together with comparatively weak inter-molecular forces.

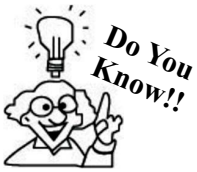


Sublimation depicted at submicroscopic level

The solids, having weak inter-molecular forces, when heated are directly converted into vapours (gaseous state) without being converted into liquids. Small amount of energy is sufficient to make the inter-molecular force of attraction negligible. This increases the inter molecular distance to a very great extent. Therefore, the solid is directly converted into vapours.

idea box

Take appropriate quantity of ammonium chloride in a china dish. Cover the dish with a perforated filter paper. Now place an inverted funnel over the dish. Plug the upper open end of the funnel with cotton. Now keep the entire apparatus as such for 3 days and after that check inverted funnel and record your observation. Now repeat the same after regular interval of 3 days for 15 days. Now repeat this experiment with camphor, iodine and naphthalene also. Record your observations and find out the role of perforated filter paper in this experiment. Also draw a conclusion on the basis of your experiment.



The process of sublimation is very helpful in separating a mixture of solids and also in the purification of the substances.

CHECK Point

☛ **Which phenomena is represented by below equation?**

$$\text{Soild} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{Gas}$$

SOLUTION

Sublimation

2. By Altering Pressure

The difference in various states of matter is due to the difference in intermolecular spaces between their particles. So when a gas is compressed the intermolecular space between its particles get decreases & ultimately it will convert into liquid. So high pressure & low temperature can liquify gases.

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

EVAPORATION

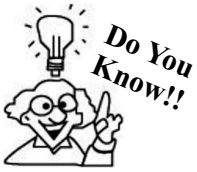
Perhaps one of the most accepted facts of life is that wet things eventually become dry. The liquid water has changed to the gaseous state in a process known as *vaporization*. When this process occurs below the boiling point, it is known as *evaporation*. In order for a molecule of a liquid to escape to the vapour state, however, it must overcome the intermolecular forces attracting it by its neighbours in the liquid. Two conditions allow a molecule in a liquid to escape the liquid state to the gaseous state. First, it must be at or near the surface of the liquid. Second, it must have at least the minimum amount of kinetic energy to overcome the intermolecular forces.

CHECK Point

☛ **Why do we see water droplets on the outer surface of a glass containing Ice-cold water ?**

SOLUTION

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



Evaporation is important to life on Earth. The heat of the sun evaporates water from earth's surface. The evaporated water goes high into the air. Then it cools down, forms clouds, and falls from the sky as rain or snow.

Evaporation is important for people too. When we sweat, water on our skin evaporates. The evaporation makes the skin feel cooler.

Why Evaporation Occurs :

Molecules in the liquid state are constantly moving, but at different speeds. Faster moving molecules at the surface of a liquid break away from the attraction of the other molecules, and escape into the air. Furthermore, heating makes liquids evaporate faster because there are more fast moving molecules and, therefore, more molecules can escape.

CHECK Point

☛ **Why should we wear cotton clothes in summer ?**

SOLUTION

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.

Factors Affecting Evaporation :

(i) Temperature (ii) Surface area (iii) Humidity (iv) Wind speed (v) Pressure

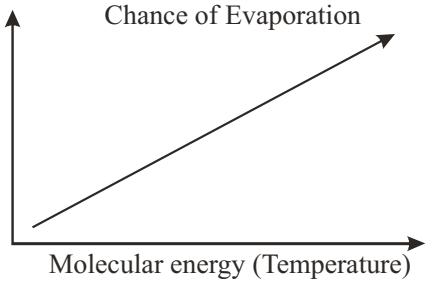
(i) Temperature:

With the increase in temperature the rate of evaporation increases.

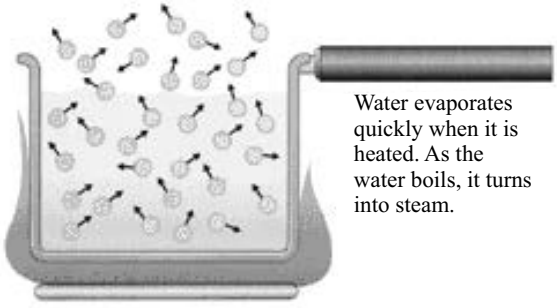
Rate of evaporation $\propto$ T.

Reason:

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



An increase in heat makes things evaporate faster. For example, if a person put the pan of water on the stove and then turned on the heat, the water would soon begin to boil. The person might see steam rise off on top of the water. Steam is water turning into vapour.



Water evaporates quickly when it is heated. As the water boils, it turns into steam.

(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.

CHECK Point

☛ **Two vessels one is of cylindrical and another is of cuboidal shape have same volumes. Both vessels are filled with equal amount of water. In which case rate of evaporation will be more.**

SOLUTION

Evaporation will be more in case of cuboid vessel as it has greater surface area.

(iii) Humidity of air :

$$\text{Rate of evaporation} \propto \frac{1}{\text{Humidity}}$$

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 evaporate very slowly.

(iv) Wind speed :

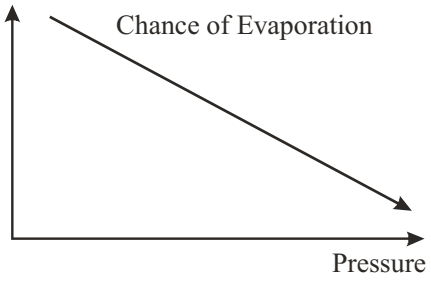
Rate of evaporation $\propto$ wind speed.

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 surrounding.

(v) Pressure :

The rate of evaporation can also increase with a decrease in the gas pressure around a liquid. Molecules like to move from areas of higher pressure to lower pressure. The molecules are basically sucked into the surrounding area to evenout the pressure. Once the vapour pressure of the area increases to a specific level, the rate of evaporation will slow down.



Some Common Student's Misconceptions About Evaporation :

(a) When liquid water evaporates, it changes from liquid to air.

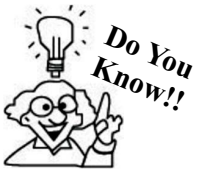
(b) When liquid water evaporates, water molecules change into air molecules.

(c) When liquid water evaporates, it disappears and is gone.

(d) When liquid water evaporates, it goes to clouds or forms clouds (but not necessarily stays in the air).

Cooling Caused by Evaporation

The process of evaporation is always accompanied by a cooling effect. For example, when a liquid evaporates from the skin, a cooling sensation results. The reason for this that only the most energetic molecules of liquid are lost by evaporation, so that the average energy of the remaining molecules decreases. The surface temperature, which is a measure of this average energy also decreases. Many refrigeration processes are based on this principle.

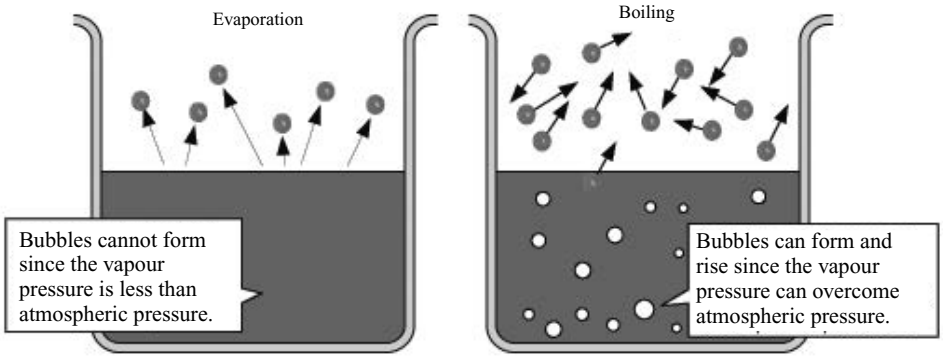


The cooling effect of evaporating water is important to health maintenance in warm climates. Perspiration covers our bodies with a layer of water when it is warm. The evaporation of this water cools our bodies and us along with it. The cool feeling after a hot shower is not just a feeling but a reality. Evaporation cools the liquid but heats the air. If water is allowed to evaporate under a vacuum, the evaporation process occurs faster. Infact, the water cools enough to freeze.

Difference between Boiling and Evaporation :

(1) Boiling takes place only at a particular temperature for a liquid. Whereas evaporation occurs at all temperatures.

(2) Boiling is Bulk phenomena i.e., the bubble formation occurs even below the surface. Whereas evaporation is surface phenomena, i.e., bubble formation occurs only on the surface of liquid.



idea box

Take two plastic containers and fill them with equal amount of water. Now tightly cap one of the containers and wrap the cap's diameter with plastic tape. Such that the container becomes air tight. Keep the other container as such open. Now place both the containers together at side of your room. After 2–3 days check level of water in both containers. Record your observations and on the basis of that draw a conclusion.

CONNECTING TOPIC

GAS LAWS

By changing the pressure or temperature of any gas its volume also changes. The nature of the change is almost same for all gases. Therefore many scientists studied them in detail and gave some laws which are known as Gas Laws.

Boyle's Law :

Boyle's Law is useful when we compare two conditions of the same gas with no change in temperature. (Remember, "Always Boyle's at the same temperature!")

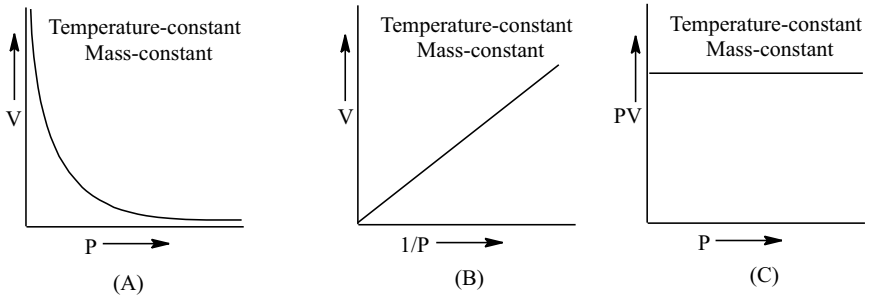
Boyle's law states that , "at constant temperature, the volume of a sample of a gas varies inversely with the pressure".

$\therefore \quad P \propto \frac{1}{V}$ (when temperature and number of moles are kept constant)

The proportionality can be changed into an equality by introducing a constant k, i.e. ,

$$P = \frac{k}{V} \text{ or } PV = k$$

Boyle's law can be verified by any one of the following three ways graphically.



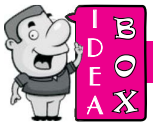
Alternatively, Boyle's law can also be stated as follows :

"Temperature remaining constant , the product of pressure and volume of a given mass of a gas is constant".

The value of the constant depends upon the amount of a gas and the temperature.

Mathematically, it can be written as, $P_1V_1 = P_2V_2 = P_3V_3 = ...$

It may be noted that Boyle's law is obeyed only by a hypothetical gas called ideal gas. However, gases like nitrogen, oxygen, carbon dioxide, etc. obey Boyle's law at low pressures and high temperatures and behave as ideal gases. At higher pressures and low temperatures, these gases do not obey Boyle's law.



idea box

Take a small baloon it should be so small that you can push all sides of it together between your hands without any of the baloon pouching out at any point. Now increase the pressure on air inside the baloon by squeezing one end of baloon. Record your observation and draw a conclusion on the basis of that.

ILLUSTRATION : 3

A given mass of a gas occupies 240 ml at 800 mm of Hg. What volume will the gas occupy if the pressure is increased to 1200 mm of Hg, temperature remaining constant?

SOLUTION :

P_1= 800 mm P_2=1200 mm, V_1= 240 ml, V_2 = ?

Applying Boyle's Law $P_1V_1 = P_2V_2$

Substituting the values

$$800 \times 240 = 1200 \times V_2$$

$$V_2 = \frac{800 \times 240}{1200}$$

Hence the new volume = 160 ml.

ILLUSTRATION : 4

A sample of gas occupies 10 litre under a pressure of 1 atmosphere. What will be its volume if the pressure is increased to 2 atmospheres? Assume that the temperature of the gas sample does not change.

SOLUTION :

Mass and temperature is constant hence we can use Boyle's law

$P_1V_1 = P_2V_2$

Given P_1 = 1 atm, V_1 = 10 litre, P_2 = 2 atm, V_2 = ?

$1 \times 10 = 2 \times V_2 \Rightarrow V_2 = 5$ litre

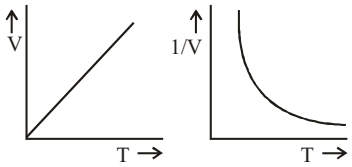
Charle's Law

It relates the volume and temperature of a given mass of a gas at constant pressure.
Charles' law can be stated as follows :
"The volume of a given amount of a gas at constant pressure varies directly as its absolute temperature".

$V \propto T$ (if pressure is kept constant)

or $\frac{V_t}{T} = \frac{V_0}{T_0}$

The graphs between V and T are shown.



idea box

Take a baloon such that at point of time between the begining of filling of a ballon and the maximum streching of a baloon, the change in internal pressure of a baloon is negligible as the baloon increases in size. Now fill that baloon partialy with air and first place it in a car on a hot day in summer. Now take that ballon out of car and put in to a refrigerator for some period of time. Record your observations and draw a conclusion on the basis of that.

Gay-Lussac Law

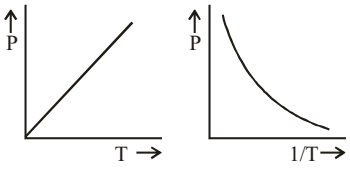
It relates the pressure and absolute temperature of a given mass of a gas at constant volume.

$P \propto T$ (if volume and number of moles are kept constant)

At constant volume, the pressure of a given amount of a gas is directly proportional to its absolute temperature.

At constant volume $\frac{P}{T}$ = constant or $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

The graphs between P and T are shown :



Avogadro's Law

(i) For solid, liquid and gas :

1 mole of any substance contains Avogadro's number (N_A) of Particles (molecules/atoms/ions) etc.

$N_A = 6.023 \times 10^{23}$

(ii) For gases:

In 1812, Amadeo Avogadro stated that samples of different gases which contain the same number of molecules (any complexity, size, shape) occupy the same volume at the same temperature and pressure. It follows from Avogadro's hypothesis that V ∝ n (T and P are constant).

$V \propto n\ (T,\ P \text{ constant}) \Rightarrow \frac{V_1}{n_1} = \frac{V_2}{n_2}$

Graham's Law of Diffusion

Diffusion is the tendency of any substance to spread throughout the space available to it. Diffusion will take place in all directions and even against gravity. The streaming of gas molecules through a small hole is called effusion.

According to Graham, the rate of diffusion (or effusion) of a gas at constant pressure and temperature is inversely proportional to the square root of its molecular mass.

$r \propto \sqrt{\frac{1}{M}}$, at constant P and T $\quad\therefore\quad \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$, at constant P and T

Since, molecular mass of gas = 2 × vapour density, $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}}$, at constant P and T

ILLUSTRATION : 5

N_2O and CO_2 have the same rate of diffusion under same conditions of temperature and pressure. Why?

SOLUTION :

Both have same molar mass (=44 g mol^{-1}). According to Graham's law of diffusion, rates of diffusion of different gases are inversely proportional to the square root of their molar masses under same conditions of temperture and pressure.

Dalton's Law of Partial Pressures

The total pressures of a mixture of gases, which do not react with each other,filled in a vessel is equal to the sum of partial pressures of the mixed gases.

$$P = P_1 + P_2 + ... + P_n$$

THE COMBINED GAS LAWS

Step I. Let us change the pressure of the gas from P_1 to P_2 at a constant temperature T_1. The volume will change from V_1 to new volume say V_x. Since temperature remains constant, therefore, by applying Boyle's law,

$$P_1V_1 = P_2V_x \qquad ...(i)$$

or $$V_x = \frac{P_1V_1}{P_2}$$

Step II. Let the temperature of the gas be now changed to T_2 at constant pressure P_2 so that volume may change from V_x to V_2. Thus, according to Charles' law,

$$\frac{V_x}{T_1} = \frac{V_2}{T_2} \quad \text{or} \quad V_2 = \frac{V_xT_2}{T_1} \qquad (ii)$$

Substituting the value of V_x from Eq. (i), we get

$$V_2 = \frac{P_1V_1}{P_2} \times \frac{T_2}{T_1}$$

Rearranging, we get

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Thus, $$\frac{PV}{T} = \text{Constant (K)}$$

ILLUSTRATION : 6

At 25° C and 760 mm of Hg pressure, a gas occupies 600 mL volume. What will be its pressure at a height where temperature is 10°C and volume of the gas is 640 mL.

SOLUTION :

$P_1 = 760$ mm Hg $\quad P_2 = ?$

$V_1 = 600$ mL $\quad V_2 = 640$ mL

$T_1 = 273 + 25 = 298$ K $\quad T_2 = 273 + 10 = 283$ K

According to combined gas law equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

or $$P_2 = \frac{P_1V_1T_2}{V_2T_1} = \frac{(760\,\text{mm Hg}) \times (600\,\text{mL}) \times (283\,\text{K})}{(640\,\text{mL})(298\,\text{K})} = 676.6 \text{ mm Hg}$$

IDEAL GAS EQUATION

According to Boyle's laws, for a fixed mass of a gas at constant temperature

$$V \propto \frac{1}{P} \qquad \text{(Constant T and } n\text{)} \qquad \text{...(i)}$$

According to Charles' law

$$V \propto T \qquad \text{(Constant P and } n\text{)} \qquad \text{...(ii)}$$

According to Avogadro's law

$$V \propto n \qquad \text{(Constant P and T} \qquad \text{...(iii)}$$

Combining equations (i), (ii) and (iii), the combined gas law can be written as:

$$V \propto \frac{nT}{P}$$

or $PV \propto nT$ or $PV = nRT$

where R is a constant of proportionality and is known as molar gas constant. The value of R is same for all gases. Therefore, it is also called universal gas constant. The above equation is known as ideal gas equation.

Numerical Value of R

(1) 0.0821 L atm K^{-1} mol^{-1} (2) 82.1 atm cm^3 K^{-1} mol^{-1} (3) 8.314 J mol^{-1} K^{-1}

ILLUSTRATION : 7

5g of ethane is confined in a bulb of one litre capacity. The bulb is so weak that it will burst if the pressure exceeds 10 atm. At what temperature will the pressure of gas reach the bursting value?

SOLUTION :

$$PV = nRT \Rightarrow 10 \times 1 = \frac{5}{30} \times 0.082 \times T$$

$$T = \frac{60}{0.082} = 731.70 \text{ K} = 458.70°\text{C}$$

1 EXERCISE

Fill in the Bla nks :

DIRECTIONS : *Complete the following statements with an appropriate word / term to be filled in the blank space(s).*

1. Matter is made up of small .....
2. The forces of attraction between the particles are ..... in solids, ... in liquids and ..... in gases.
3. ..... is the change of gaseous state directly to solid state without going through liquid state, and vice-versa.
4. Evaporation causes .....
5. Latent heat of fusion is the amount of heat energy required to change 1 kg of solid into liquid at its .....
6. Solid, liquid and gas are called the three ..... of matter.
7. The smell of perfume gradually spreads across a room due to .....
8. Rapid evaporation depends on the ..... area exposed to atmosphere.
9. As the temperature of a system increases, the pressure of the gases…....
10. As the volume of a specific amount of gas decreases, it's pressure.....
11. As the temperature of a gas decreases, its volume.....
12. Gas molecules at higher temperatures have more ..... than at cooler temperatures.
13. Usually the total charge of a plasma is .....
14. The pressure inside a sealed tube, if you raise the temperature go.....
15. Forces of attraction in liquids are ___ than in solids.
16. Liquids that move quickly downhill are described as having.....

True / False :

DIRECTIONS : *Read the following statements and write your answer as true or false.*

1. Boiling is a bulk phenomenon.
2. Evaporation is a surface phenomenon.
3. The rate of evaporation depends only on the surface area exposed to the atmosphere.
4. Latent heat of vaporisation is the heat energy required to change 1 kg of a liquid to gas at atmospheric pressure at its melting point.
5. Water at room temperature is a liquid.
6. Atoms in a liquid are farther apart than the atoms in a gas.
7. The molecules in a gas are in constant motion.
8. Gases present in air have the same pressure throughout the entire atmosphere.
9. All materials move from solid to liquid to gas as the temperature increases.
10. Because electrons have been stripped away from atoms in plasma, plasmas have a negative charge.
11. It is just as easy to compress a liquid, as it is to compress a gas.
12. Evaporation and boiling are the same processes because molecules move from a liquid to gaseous state.
13. If we pour liquid nitrogen (N_2) into a glass, it will change its state to a solid.
14. You may find plasma in a star.
15. A system that changes from a solid state to a liquid state gains energy.
16. Plasmas are all made of the same ions. They have different colours due to different amounts of electricity.

Match the Following :

DIRECTIONS : *Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in Column I have to be matched with statements (p, q, r, s) in Column II.*

1. Column II gives how rate of evaporation changes for factors given in column I match them correctly.

Column I	Column II
(A) Increase in surface area	(p) Increases
(B) Decrease in temperature	(q) Decreases
(C) Decrease in humidity	(r) Unchange
(D) Increase in wind speed	(s) May increase or decrease

2. Column II give properties for matter mentioned in column I match them correctly.

Column I	Column II
(A) Liquid	(p) Definite shape
(B) Solid	(q) Definite volume
(C) Plasma	(r) Super low energy
(D) Bose-Einstein condensate	(s) Super energetic

Very Short Answer Questions:

DIRECTIONS : *Give answer in one word or one sentence.*

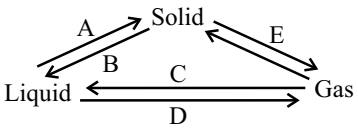
1. Name the three states of matter. Give one example of each.
2. What are the two ways in which the physical state of matter can be changed ?
3. Explain how gases can be liquified ?
4. What is sublimation ? Give examples.
5. Define latent heat of fusion.
6. Define latent heat of vaporization.

7. What produces more severe burns, boiling water or steam?
8. How can the boiling point of a liquid be raised, without adding any impurity ?
9. In how many forms did the earlier sceintists classify matter ?
10. Why does a summer rainstorm lower the temperature ?
11. A beaker of a liquid with a vapour pressure of 350 torr at 25°C is set alongside a beaker of water (Vapour pressure of 23.76 torr) and both are allowed to evaporate. In which liquid does the temperature change at a faster rate ? Why
12. At a given temperature, one liquid has a vapour pressure of 240 torr and another measures 420 torr. Which liquid probably has the lower boiling point ? Which probably has the lower heat of vaporization ?
13. A drop of dettol got evenly distributed in water. How ?
14. Liquid nitrogen is used as a commercial refrigerant to flash freeze foods. Nitrogen boils at –196°C. What is this temperature on the Kelvin temperature scale ?
15. What property or properties of gases can you point to support the assumption that most of the volume in a gas is empty space?

Short Answer Questions :

DIRECTIONS : *Give answer in 2-3 sentences.*

1. What is condensation ? How is the condensation of a gas carried out ?
2. Why do solids not diffuse ?
3. The following diagram shows the three states of matter and how they can be interchanged.
   Name the changes A to E.



4. Convert the following Kelvin temperatures to degrees Celsius.
   (i) 175 K (ii) 295 K
   (iii) 300 K (iv) 225 K
5. Explain the diffusion of copper sulphate into water.
6. Which state of matter is compressible ? Why ?
7. Why do the gases exert more pressure on the walls of the container than the solids ?
8. The process in which a solid is converted directly into a gas is called sublimation. Iodine is an element that sublimes. A sample of solid iodine in a stoppered flask was allowed to stand undisturbed for several days. Crystals of solid iodine grew on the sides of the flask. Explain at the molecular level what happened?
9. Describe why a drop of food coloring in a glass of water slowly becomes evenly distributed without the need for stirring?
10. Liquid mix more slowly than gases. Why ?

Long Answer Questions :

DIRECTIONS : *Give answer in four to five sentences.*

1. Explain why ?
   (i) A gas fill a vessel completely.
   (ii) Camphor disappears without leaving any residue.
   (iii) The temperature does not rise during the process of melting and boiling, though heat energy is constantly supplied.
   (iv) Water stored in an earthen vessel becomes cool.
   (v) An iron almirah is a solid at room temperature.
2. Which phenomenon occurs during the following changes?
   (i) Size of napthalene balls decrease.
   (ii) Wax melts in the sun.
   (iii) Drying of wet clothes.
   (iv) Formation of clouds.
   (v) Density of liquids is more than gases.
3. Define :
   (i) Melting point (ii) Boiling point
   (iii) Vapourisation (iv) Freezing
   (v) Brownian motion

2 EXERCISE

Text - Book Questions :

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

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

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

4. What are the characteristics of particles of matter?

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

$$\left(\text{Density} = \frac{\text{Mass}}{\text{Volume}}\right)$$

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

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

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.

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

9. Convert the following temperature to celcius scale.
(a) 300 K (b) 573 K

10. What is the physical state of water at
(a) 250°C (b) 100°C

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

12. Suggest a method to liquify atmospheric gases.

13. Why does a cooler cool better on a hot dry day?

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

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

16. We can sip hot tea from a saucer faster than from a cup?

17. What type of clothes should we wear in summer?

Text - Book Exercise :

1. Convert the following temperature to Celcius scale.
(a) 293 K (b) 470 K

2. Convert the following temperature to Kelvin scale.
(a) 25°C (b) 373°C

3. 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.

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

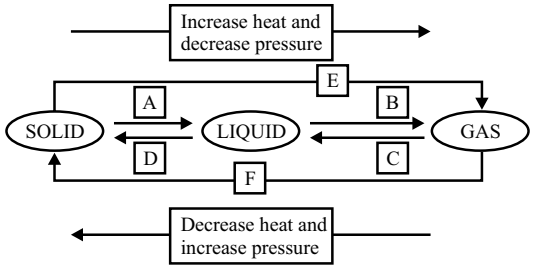
5. What is the physical state of water at
(a) 25°C (b) 0°C
(c) 100°C

6. Give two reasons to justify :
(a) water at room temperature is a liquid.
(b) an iron almirah is solid at room temperature.

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

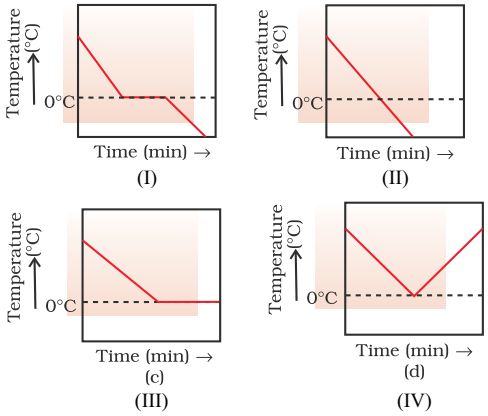
8. Why does steam produce more severe burns on the skin as compared to boiling water?

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



Exemplar Questions :

1. Alka was making tea in a kettle. Suddenly she felt intense heat from the puff of steam gushing out of the spout of the kettle. She wondered whether the temperature of the steam was higher than that of the water boiling in the kettle. Comment.
2. A glass tumbler containing hot water is kept in the freezer compartment of a refrigerator (temperature < 0°C). If you could measure of the temperature of the content of the tumbler, which of the following graphs (fig.) would correctly represent the change in its temperature as a function of time.



3. You want to wear your favourite shirt to a party, but the problem is that it is still wet after a wash. What steps would you take to dry it faster?
4. It is a hot summer day, Priyanshi and Ali are wearing cotton and nylon clothes respectively. Who do you think would be more comfortable and why?
5. Why does the temperature of a substance remain constant during its melting point or boiling point?

HOTS Questions :

1. When a jar of coffee is opened, people in all parts of the room soon notice the smell. Explain why this happens?
2. If water is boiling and the flame supplying the heat is turned up, does the water become hotter ? What happens?
3. Why we close the bottle of nail polish remover immediately after using it ?
4. Why does a desert cooler cools better on hot dry day ?
5. Which diffuses faster, the bad smell from a cat-pan due to ammonia or an expensive French perfume with an average molecular weight of 170 g/mol ? How much faster does the faster one diffuse?
6. Ethyl chloride boils at 13°C. When it is sprayed on the skin, it freezes a small part of the skin and thus serves as a local anaesthetic. Explain how it cools the skin?
7. Why is ice at 273 K more effective in cooling than water at the same temperature ?
8. A graduated cylinder was filled with water to the 15.0 mL mark and weighed on a balance. Its mass was 27.35g. An object made of silver was placed in the cylinder and completely submerged in the water. The water level rise to 18.3 mL. when reweighed, the cylinder, water, and silver object had a total mass of 62.00 g. Calculate the density of silver.
9. What volume in millilitres does a sample of nitrogen with a mass of 0.245g occupy at 21°C and 750 torr ?
10. The label on a cylinder of a noble gas become unreadeble, a student allowed some of the gas to flow into a 300 mL gas bulb until the pressure was 685 torr. The sample now weighed 1.45 g, its temperature was 27.0° C. What is the molecular mass of this gas?
11. What change or changes in the state of a gas bring about each of the following effects? (a) The number of impacts per unit time on a given container wall increases. (b) The average energy of impact of molecules with the wall of the container decreases. (c) The average distance between gas molecules increases. (d) The average speed of molecules in the gas mixture is increased.
12. 400 ml of a gas at 227°C is to be reduced to a volume of 300 ml. By what degrees Celsius, must the temperature be altered, keeping pressure constant.
13. 200 ml of a gas at 27°C and 1140 mm pressure is transferred to a vessel of 450 ml capacity. What temperature is to be applied, if the pressure applied is 1 atmosphere?
14. What are super cooled liquids?
15. How water below the surface of earth rises to plants through the roots?
16. What is implied by the word “equilibrium” in equilibrium vapour pressure ?
17. Why do the doctors advice to put strips of wet cloth on the forehead of a person having high temperature ?
18. When we smell the odour of a rose, our olfactory nerves are sensing molecules of the scent. Explain how smelling a rose demonstrates that molecules are always moving?
19. The volume of a given mass of gas, at 150°C is 400 ml. At what temperature, will it occupy a volume of 600 ml at the same pressure?
20. A gas occupies 500 ml at 40°C and 800 mm pressure. What volume will it occupy at 353°C and 600 mm pressure?

3 EXERCISE

Multiple Choice Questions :

DIRECTIONS : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.*

1. The quantity of matter present in an object is called its
(a) weight (b) gram
(c) mass (d) density

2. At higher altitudes
(a) boiling point of a liquid increases
(b) boiling point of a liquid decreases
(c) no change in boiling point
(d) melting point of solid increases

3. The boiling point of alcohol is 78°C. What is this temperature in Kelvin scale
(a) 373 K (b) 351 K
(c) 375 K (d) 78 K

4. In which phenomena water changes into water vapour below its B.P. ?
(a) Evaporation (b) Condensation
(c) Boiling (d) No such phenomena exist

5. The boiling point of water on celsius and Kelvin scale respectively is :
(a) 373, 273 (b) 0, 273
(c) 273, 373 (d) 100, 373

6. The liquid which has the highest rate of evaporation is
(a) petrol (b) nail-polish remover
(c) water (d) alcohol

7. When we put some crystals of potassium permanganate in a beaker containing water, we observe that after sometime whole water has turned pink. This is due to
(a) boiling
(b) melting of potassium permanganate crystals
(c) sublimation of crystals
(d) diffusion

8. The state of matter which consists of super energetic particles in the form of ionized gases is called
(a) gaseous state
(b) liquid state
(c) Bose-Einstein condensate
(d) plasma state

9. The force that binds the particles of matter together is known as
(a) intermolecular space (b) bond
(c) intermolecular force (d) nuclear force

10. The change of a liquid into vapour is called
(a) vapourization (b) solidification
(c) sublimation (d) None of these

11. Which of the following describes the liquid phase ?
(a) It has a definite shape and a definite volume
(b) It has a definite shape but not a definite volume
(c) It has a definite volume but not a definite shape
(d) It has neither a definite shape nor a definite volume

12. When a teaspoon of solid sugar is dissolved in a glass of liquid water, what phase or phases are present after mixing
(a) liquid only (b) still solid and liquid
(c) solid only (d) None of these

13. Non-reacting gases have a tendency to mix with each other. This phenomenon is known as
(a) chemical reaction (b) diffusion
(c) effusion (d) explosion

14. A gas can be compressed to a fraction of its volume. The same volume of a gas can be spread all over a room. The reason for this is that
(a) the volume occupied by molecules of a gas is negligible as compared to the total volume of the gas.
(b) gases consists of molecules which are in a state of random motion
(c) gases consist of molecules having very large inter-molecular space which can be reduced or increased under ordinary conditions
(d) None of these

15. What is the term used to describe the phase change of a liquid to a gas?
(a) Boiling (b) Condensation
(c) Melting (d) None of the above

16. What term is used to describe the phase change of a solid to a liquid?
(a) Freezing (b) Melting
(c) Boiling (d) None of the above

17. What is the term used to describe the phase change as a liquid becomes a solid?
(a) Evaporation (b) Condensation
(c) Freezing (d) None of the above

18. Which has the least energetic molecules?
(a) Solids (b) Liquids
(c) Gases (d) Plasmas

19. In which phase of matter would you expect alcohol exists at room temperature?
(a) Solid (b) Liquid
(c) Gas (d) Plasma

20. Which of these choices will not change the state of matter?
(a) Temperature (b) Crushing a crystal
(c) Pressure (d) Heat

21. If you leave water in a glass and some molecules turn into a gas, it is called...
(a) Egasoration (b) Evaporation
(c) Extinction (d) Solidification

22. As of the 1990s, scientists have proved the existence of how many states of matter?
(a) Two (b) Three
(c) Four (d) Five

23. Out of the following which is the densest state of matter?
(a) Solids (b) Liquids
(c) Gases (d) Plasmas

24. Select the one that is not a matter.
(a) Feeling of hot (b) Smoke
(c) Humidity (d) Water

25. Which is incorrect statement?
(a) Matter is continuous in nature.
(b) Of the three state of matter, the one that is most compact is solid state.
(c) In solid state interparticles space (i.e., empty space) is minimum.
(d) The density of solid is generally more than that of a liquid.

26. Select the one that when used would be considered as best condition for liquification of a gas.
(a) Increasing the temperature.
(b) Decreasing the pressure.
(c) Increasing the pressure and decreasing the temperature.
(d) Decreasing the pressure and increasing the temperature.

27. Select the correct order of evaporation for water, alcohol, petrol and kerosene oil
(a) water > alcohol > kerosene oil > petrol
(b) alcohol > petrol > water > kerosene oil
(c) petrol > alcohol > water > kerosene oil
(d) petrol > alcohol > kerosene oil > water

28. Which one is a sublime substance?
(a) Table salt (b) Sugar
(c) Iodine (d) Potassium Iodide

29. S.I. unit of temperature is
(a) Celcius (b) Fahrenheit
(c) Kelvin (d) None of these

30. 10 K is equal to
(a) 283°C (b) –263°C
(c) 263°C (d) –283°C

31. The process of change of liquid state into gaseous state at constant temperature is known as
(a) boiling (b) melting
(c) fusion (d) evaporation

32. Dry ice is
(a) ice having no water of crystallisation
(b) ice that has been dried
(c) solid carbon dioxide
(d) None of these

33. Which one is a surface phenomenon?
(a) Evaporation (b) Boiling
(c) Both (a) and (b) (d) None of these

34. Rate of diffusion depends upon
(a) temperature
(b) surface area
(c) both temperature and surface area
(d) None of these

35. Which of the following processes is known as fusion?
(a) Change of liquid to solid
(b) Change of solid to liquid
(c) Change of liquid to vapour
(d) Change of gaseous state to solid state

36. The evaporation of a liquid can best be carried out in a
(a) flask (b) china dish
(c) test tube (d) beaker

37. The one, in which interparticle forces are strongest, is
(a) sodium chloride (b) hydrogen
(c) ether (d) carbon dioxide

38. The melting point temperature of the solid state of a substance is 40°C. The freezing point temperature of the liquid state of the same substance will be
(a) 35°C (b) 40°C
(c) 45°C (d) can't predict.

39. Which one will help to accelerate the process of evaporation of a liquid kept in an open china dish?
(a) Keeping dish in open
(b) Blowing air into the liquid
(c) Keeping the dish under a running fan
(d) All the above

40. When a gas is compressed keeping temperature constant, it results in
(a) increase in speed of gaseous molecules
(b) increase in collision among gaseous molecules
(c) decrease in speed of gaseous molecules
(d) decrease in collision among gaseous molecules.

41. Pressure of air at sea level is
(a) one atmosphere (b) 76 cm of Hg
(c) 760 mm of Hg (d) All are correct.

More than One Option Correct :

DIRECTIONS : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONE OR MORE may be correct.*

1. Which of the following substance(s) can sublime ?
(a) Camphor
(b) Solid carbon dioxide
(c) Ammonium chloride
(d) Sodium bicarbonate

2. The correct statement(s) amongst the following is/are
(a) gases diffuse at different rates
(b) diffusion also takes place in liquids
(c) diffusion of liquid and a gas is known as intimate mixing
(d) some liquids diffuses at rate equal to gases

3. Which of the following statement(s) about evaporation is/are correct?
(a) It is a bulk phenomena
(b) It causes cooling
(c) Results into increase in temperature
(d) It is a surface phenomena

4. Which of the following properties of liquid increases with increase of temperature?
   (a) Vapour pressure (b) Viscosity
   (c) Surface tension (d) Evaporation
5. Which of the following properties is different for solids liquids and gases?
   (a) Movement of molecules
   (b) Particle size of the substance
   (c) Mass of the substance
   (d) Density
6. Gases can be liquified either by lowering the temperature, applying pressure. This shows that
   (a) molecules of a gas repel each other
   (b) there exists a kind of intermolecular attraction between molecules of a gas
   (c) molecules of a gas are in a state of random motion
   (d) intermolecular forces between gas molecules increases when distance between molecules decreases.
7. Which of these statement(s) is are/true?
   (a) Gases have high density.
   (b) Gases can be compressed more than solids.
   (c) Gases have very specific shapes.
   (d) Gases undergoes diffusion fastest
8. Which of these choices is defined as "Standard Pressure?"
   (a) 14.7 psi (b) 1 atm
   (c) 760 torr (d) 1 pascal
9. All liquids have different
   (a) density (b) viscosity
   (c) solubility (d) rate of evaporation
10. Which of the following statement(s) is/are applicable for amorphous solids?
   (a) Are more flexible at higher temperatures.
   (b) Include glasses.
   (c) Do not have specific melting points.
   (d) Have sharp melting points
11. Which of the following statement(s) about solids is/are incorrect ?
   (a) Expand largely when the temperature rises.
   (b) Change shape easily.
   (c) Have a low density.
   (d) Generally solids have high density
12. Which of these choices is / are example(s) of a plasma?
   (a) Aurora Borealis (b) Fluorescent Light Bulb
   (c) Neon Sign (d) Incandescent Light Bulb
13. Which of the following statement(s) is /are true for gases?
   (a) Gases do not have a definite shape and volume
   (b) Volume of the gas is almost equal to the volume of the container confining the gas
   (c) Confined gas exerts uniform pressure on the walls of its container in all directions
   (d) Mass of the gas cannot be determined by weighing a container in which it is enclosed

Passage Based Questions :

DIRECTIONS : *Study the given paragraph(s) and answer the following questions.*

During evaporation, the heat needed is absorbed from the surroundings which is therefore cooled according to the kinetic theory, particles in a liquid are in continuous random motion at different speeds. However, the average kinetic energy of the particles remains constant provided the temperature of the liquid does not change collisions between particles produce some fast-moving particles these particles, especially those near the surface, can escape from the intermolecular force of attraction of their neighbouring particles and jump out of the liquid This, the liquid loses its more energetic particles while the less energetic ones are left behind the average kinetic energy of the remaining particles is therefore reduced. This results in a a fall in temperature or a a cooling effect.

1. During evaporation particles of a liquid change into vapours.
   (a) from the surface (b) from the bulk
   (c) from the bottom (d) from all over the liquid.
2. Which of the following liquid on evaporation causes maximum cooling?
   (a) Acetone (b) Water
   (c) Ethanol (d) Vinegar
3. The process of evaporation causes
   (a) Cooling (b) Dryness
   (c) Heating (d) All of the above

Assertion & Reason :

DIRECTIONS : *Each of these questions contains an Assertion followed by reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.*

(a) If both **Assertion** and **Reason** are **correct** and Reason is the **correct explanation** of Assertion.
(b) If both **Assertion** and **Reason** are correct, but Reason is **not the correct explanation** of Assertion.
(c) If **Assertion** is **correct** but **Reason** is **incorrect**.
(d) If **Assertion** is **incorrect** but **Reason** is **correct**.

1. **Assertion :** It is easier to cook food at hill.
   Reason : The boiling point of water increases at hill.
2. **Assertion :** During evaporation of liquid the temperature of the liquid remains unaffected.
   Reason : Kinetic energy of the molecules is directly proportional to absolute temperature.
3. **Assertion :** At room temperature, the evaporation of a liquid takes place at constant rate.
   Reason : During evaporation of a liquid, the temperature of the liquid remains unaffected.

Multiple Matching Questions :

DIRECTIONS : *Following question has four statements (A, B, C and D) given in Column I and four statements (p, q, r and s) in Column II. Any given statement in Column I can have correct matching with one or more statement(s) given in Column II. Match the entries in Column I with entries in Column II.*

1.

	Column I		**Column II**
(A)	Diffusion	(p)	Solids
(B)	Definite shape	(q)	Liquids
(C)	Definite volume	(r)	Gases
(D)	Compressibility	(s)	Plasma

	A	B	C	D
(a)	q, r	p	p, q	r
(b)	q, r	r	p	s
(c)	p, q	r	s, p	p, q, s
(d)	q	r	p, q	s

Integer Type Questions :

DIRECTIONS : *Following are integer based questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive).*

1. From the given factors, how many affect Evaporation? Temperature, Pressure, Surface area, Volume of liquid, Density of liquid, Humidity, Wind speed.

2. In how many states does the matter exists?

4 ADVANCED EXERCISE BASED ON CONNECTING TOPICS

DIRECTIONS (Qs. 1 to 18) : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.*

1. Volume of a gas at a particular temperature and on atmospheric pressure is 200 ml. Keeping the temperature constant if pressure is increased to 5 atmosphere, then volume of the gas will be
(a) 100 ml. (b) 40 ml.
(c) 200 ml. (d) 205 ml.

2. Boyle's law states that the
(a) pressure of a gas is directly proportional to the temperature at constant volume
(b) pressure of a gas is inversely proportional the volume at constant temperature
(c) volume is directly proportional to the temperature at constant pressure
(d) None of the above

3. All gases will occupy zero volume when the temperature is reduced to
(a) 273°C (b) 273°A
(c) –273°C (d) 0°C

4. A gas which obeys the gas laws is known as
(a) an ideal gas (b) a heavier gas
(c) a lighter gas (d) a real gas

5. Which of the following expression at constant pressure represents Charle's law?
(a) $V \propto \frac{1}{T}$ (b) $V \propto \frac{1}{T^2}$
(c) $V \propto T$ (d) $V \propto d$

6. For an ideal gas number of moles per litre in terms of its pressure P, gas constant R and temperature T is
(a) PT/R (b) PRT
(c) P/RT (d) RT/P

7. Rate of diffusion of a gas is
(a) directly proportional to its density
(b) directly proportional to its molecular mass
(c) inversely proportional to the square root of its density
(d) inversely proportional to the square root of its molecular mass

8. Boyle's law states that the
(a) pressure of a gas is directly proportional to the temperature at constant volume
(b) pressure of a gas is inversely proportional the volume at constant temperature
(c) volume is directly proportional to the temperature at constant pressure
(d) None of the above

9. Equal volumes of all gases under similar conditions of temperature and pressure contain equal numbers of molecules. This statement was made by
(a) Gay-Lussac (b) Avogadro
(c) Berzilius (d) John Dalton

10. Select one correct statement. In the gas equation, PV = nRT
(a) n is the number of molecules of a gas
(b) V denotes volume of one mole of the gas
(c) n moles of the gas have a volume V
(d) P is the pressure of the gas when only one mole of gas is present.

11. Correct gas equation is :
(a) $\frac{V_1T_2}{P_1} = \frac{V_2T_1}{P_2}$ (b) $\frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$
(c) $\frac{P_1T_2}{V_1} = \frac{P_2V_2}{T_2}$ (d) $\frac{V_1V_2}{T_1T_2} = P_1P_2$

12. The total pressure exerted by a number of non-reacting gases is equal to the sum of the partial pressures of the gases under the same conditions is known as
(a) Boyle's law (b) Charle's law
(c) Avogadro's law (d) Dalton's law

13. Kinetic theory of gases proves
(a) only Boyle's law (b) only Charles' law
(c) only Avogadro's law (d) All of these

14. Generally , liquid drops assume spherical shape because:
(a) a sphere has maximum surface area
(b) a sphere has minimum surface area
(c) sphere is symmetrical in shape
(d) None of these

15. The total pressure of a mixture of two gases is :
(a) The sum of the partial pressures
(b) The difference between the partial pressures
(c) The product of the partial pressures
(d) The ratio of the partial pressures.

16. Graph between P and V at constant temperature is
(a) straight
(b) curved increasing
(c) straight line with slope
(d) none of these

17. The surface tension of which of the following liquid is maximum?
(a) C_2H_5OH (b) CH_3OH
(c) H_2O (d) C_6H_6

18. If temperature increases, the surface tension of a liquid

(a) increases (b) decreases

(c) remains the same (d) increases then decreases

DIRECTIONS (Qs. 19 to 21) : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONE OR MORE may be correct.*

19. Which of the following is/are value(s) of gas constant R ?

(a) 0.0821 L atm $K^{-1}mol^{-1}$

(b) 8.21 L torr $K^{-1}mol^{-1}$

(c) 82.1 atm mL $K^{-1}mol^{-1}$

(d) 8.314 J $mol^{-1}K^{-1}$

20. At constant temperature, in a given mass of an ideal gas

(a) the ratio of volume and temperature always remains constant

(b) volume always remains constant

(c) pressure always remains constant

(d) the product of pressure and volume always remains constant

21. If a gas is expanded at constant temperature :

(a) the pressure decreases

(b) the kinetic energy of the molecules remains the same

(c) the kinetic energy of the molecules decreases

(d) the number of molecules of the gas increases

DIRECTIONS (Qs. 22 to 24) : *Study the given paragraph(s) and answer the following questions.*

Chlorine is widely used to purify municipal water supplies and to treat swimming pool waters suppose that the volume of a particular sample of Cl_2 gas is 9.22 L at 1124 torr and 24°C.

22. How many grams of Cl_2 are in the sample?

(a) 39.7 g (b) 37.9 g

(c) 40.2 g (d) 39.5 g

23. What volume will the Cl_2 occupy at STP?

(a) 13.5 L (b) 8.5 L

(c) 12.5 L (d) 8.43 L

24. At what temperature will the volume be 15.00 L if the pressure is 8.76×10^2 torr?

(a) 400 K (b) 384.5 K

(c) 373 K (d) 377 K

DIRECTIONS (Qs. 25 and 26) : *Each of these questions contains an Assertion followed by reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.*

(a) If both **Assertion** and **Reason** are **correct** and Reason is the **correct explanation** of Assertion.

(b) If both **Assertion** and **Reason** are correct, but Reason is **not the correct explanation** of Assertion.

(c) If **Assertion** is **correct** but **Reason** is **incorrect**.

(d) If **Assertion** is **incorrect** but **Reason** is **correct**.

25. **Assertion :** Ideal gas equation is valid at low pressure and high temperature.

Reason : Molecular interactions are negligible under this condition.

26. **Assertion :** Plot of P Vs. 1/V (volume) is a straight line.

Reason : Pressure is directly proportional to volume.

DIRECTIONS (Q. 27) : *Following question has four statements (A, B, C and D) given in Column I and four statements (p, q, r and s) in Column II. Any given statement in Column I can have correct matching with one or more statement(s) given in Column II. Match the entries in Column I with entries in Column II.*

27.

	Column I		**Column II**
(A)	Boyle's law	(p)	Temperature
(B)	Charle's law	(q)	Pressure
(C)	Gay-Lussac law	(r)	Volume
(D)	Ideal gas equation	(s)	Number of moles of a gas

	A	B	C	D
(a)	p,q,r	q,r	p,q	r
(b)	q,r	p,r	p,q	p,q,r,s
(c)	p,q	r	s	s
(d)	q	r	p,q	s

DIRECTIONS (Qs. 28 and 29) : *Following are integer based questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive).*

28. A gas was allowed to expand from a volume of 400 ml to 2000 ml at a constant temperature. The initial pressure of the gas was 3 atmospheres. If the final pressure of the gas in terms of x is x/10. Find the value of x.

29. A gas occupies 3.25 litres at 0°C. What volume will it occupy at –20°C, pressure remaining constant?

SOLUTIONS

Brief Explanations of Selected Questions

1 EXERCISE

Fill in the Blanks :

1. particles
2. maximum, intermediate, minimum
3. Sublimation
4. cooling
5. melting point
6. states
7. diffusion
8. surface
9. increases
10. increases
11. decreases
12. kinetic energy
13. zero
14. up
15. weaker
16. low viscosity

True / False :

1. True
2. True
3. False
4. False
5. True
6. False
7. True
8. False
9. True
10. False
11. False
12. False
13. False
14. True
15. True
16. False

Match the Following :

1. (A) → (p); (B) → (q); (C) → (p); (D) → (p)
2. (A) → (q); (B) → (p, q); (C) → (s); (D) → (r);

Very Short Answer Questions :

1. Solids, liquids and gases are three states of matter and their examples are ice, water and steam respectively.
2. Melting and boiling are two ways in which the physical state of matter can be changed.
3. Gases can be liquefied by increasing pressure or by lowering temperature.
4. Sublimation is a phenomena of interconversion of solid into gases and vice-versa.

$$\text{solid} \rightleftharpoons \text{gases}$$

e.g., solid CO_2 gets directly converted into gaseous form.

5. Latent heat of fusion : The amount of heat energy that is required to change 1 kg of solid into liquid at atmospheric pressure at its melting point is known as the latent heat of fusion.
6. Latent heat of vaporisation : The amount of heat which is required to convert 1 kg of the liquid (at its boiling point) to vapour or gas without any change in temperature.
7. Steam produces more severe burn as it is in a gaseous phase thus have absorbed extra energy in the form of latent heat of vaporisation.
8. By increasing pressure on liquid.
9. They classified the matter in four forms: air, earth, fire and water.
10. Water evaporates quickly on a hot day and thus lowers the air temperature.
11. The liquid other than water. The higher the vapour pressure, faster the liquid evaporates more quickly it cools and lower will be its temperature.
12. The liquid with the higher vapour pressure (420 torr) has the lower boiling point. It also probably has the lower heat of vaporization.
13. This is because there is enough space between the particles of water and dettol particles gets into the spaces between the particles of other matter (water).
14. K = °C + 273 = – 196 + 273 = 77 K
15. The fact that gases are readily compressible supports the assumption that most of the volume of a gas sample is empty space.

Short Answer Questions :

1. The process due to which a gas changes into liquid state by giving out heat energy is called condensation. When a gas is compressed it loses its heat energy there by consequently decreasing intermolecular distance between molecules and increasing intermolecular forces of attraction between molecules. Thus, resulting into liquefaction of gas.
2. This is because the forces of attraction between the particles of a solids are very strong and there is very little space for the particles to move around.
3. A–freezing, B–melting, C–condensation
   D–evaporation, E–sublimation
4. (i) –98°C (ii) 22°C
   (iii) 27°C (iv) – 48°C
5. Copper sulphate crystals are blue in colour. When we put some crystals of copper sulphate at the bottom of the beaker containing water, the water slowly turns blue. This is because the particles of copper sulphate mix with the particles of water. This mixing of particles will continue till the whole solution turns blue. This phenomenon is called diffusion.
6. The gaseous state is compressible because the distance between the molecules are greater and on applying external pressure, the gas molecule come closer to each other and occupies less space than before. Thus gas gets compressed.
7. In gases, the particles move randomly at high speed and they collide with each other and with walls of the container. Due to this collision with walls of the container, the gases exert more pressure than solids.

8. Iodine molecules sublime from the crystals at the bottom of the flask into the gas phase, where their presence imparts a pale violet color to the gas. Some of these molecules then condense on the surface (sides) of the flask, forming crystals.

9. Both the liquid molecules and food coloring molecules are in motion. Through constant motion and collisions the food colouring molecules eventually become dispersed.

10. Since gas molecules are far apart, therefore intermolecular forces of attraction between a particular gas molecules are less in comparision to liquids. Thus gas molecules of one type mix more easily with gas molecules of another type in comparison to liquids.

Long Answer Questions :

1. (i) This is because intermolecular forces of attraction between gas molecules is almost negligible. Thus gases occupy the volume of container in which they filled in.

(ii) This is because camphor is a sublime substance. Thus it gets converted into gaseous form directly from solid state without first being converted into liquid.

(iii) This is because during melting and boiling the heat energy supplied is utilised in a phase transition like solid to liquid in case of melting and liquid to gas in case of boiling. Therefore, temperature remains constant.

(iv) As the earthen pot is made up of mud and having many pores in it. These pores serves as air cavities. The water evaporates through the air cavities present in earthen pot which results in cooling of remaining water. This is somewhat similar to the process of sweating in our body which keeps our body cool during summers.

(v) Iron atoms have very less interatomic spaces between them and are thus firmly packed. That's why iron is rigid solid at room temperature and have high melting and boiling point.

2. (i) Napthalene is a sublime substance it gets converted into gaseous form directly without being first converted into liquid state. Thus the size of napthalene balls decreases automatically due to sublimation.

(ii) Wax is a solid it absorbs heat energy from sun and starts melting.

(iii) Wet clothes absorb heat energy from sun and water molecules evaporates off to atmosphere.

(iv) Water vapours formed from ocean and other water bodies of earth when reaches up to atmosphere, there they got cooled up and release their energy and undergoes condensation to form clouds.

(v) In comparison to gases, in liquids the molecules are close to each other. Therefore, density of liquids is higher than that of gaseous state.

3. (i) The constant temperature at which a solid changes into liquid state at atmospheric pressure by absorbing heat energy is called melting point.

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

(iii) The process due to which a liquid changes into gaseous state by absorbing heat energy is called vapourisation.

(iv) The process due to which liquid changes into solid state by giving heat energy is called freezing or solidification.

(v) The zig-zag movement of small solid particles suspended in a liquid or gas is called Brownian motion.

2 EXERCISE

Text - Book Questions :

1. The following are matter.

Chair, air, almonds, cold-drink, smell of perfume.

[Note: Love, hate, smell and thought are not matter as they neither have mass, nor occupy space.

2. The particles of aroma in hot sizzling food mix with the particles of air around us. Due to this spreading of particles, we are able to get the smell even at a distance (i.e., several metres away). Thus, it is the result of diffusion which increases with increase of temperature. We know that the rate of diffusion increases on heating so the smell of hot sizzling food reaches us several metres away but to get smell from cold food we have to go close.

3. It shows the property of compressibility in case of liquid state (water is a liquid). Due to large interparticle space in liquids (water) diver is able to cut through water.

4. The characteristics of particles of matter are :

(i) They have space between them.

(ii) They are continuously moving.

(iii) They attract each other.

5. In increasing order of density, they can be arranged as follows :

air < exhaust from chimneys < water < honey < cotton < iron.

6. (a) Differences in the characteristics of mattter :

	Property	Solids	Liquids	Gases
1.	Shape	They have a definite shape.	They take the shape of container and have no definite shape.	They take the shape of the container and have no definite shape.
2.	Volume	They have a fixed volume.	They have a fixed volume.	The volume is not fixed. They completely occupy the available volume. Their volume is equal to the volume of container.
3.	Density	The density of solids is higher than other states of matter.	The densities of liquids are more as compared to gases.	Their densities are least.
4.	Intermolecular forces	The intermolecular forces of attraction are maximum.	The intermolecular forces of attraction are stronger than those of gaseous particles.	The intermolecular forces of attraction are minimum.
5.	Intermolecular space	The intermolecular space is minimum	The intermolecular space is more than those of solids but less than those of gases.	The intermolecular space is maximum.
6.	Compressibility	Compressibility is least	Compressibility more than that of solids but less than that of gases.	Compressibility is maximum.
7.	K.E.	Kinetic energy possessed by particles is minimum.	Kinetic energy possessed by particles is more than those of solids but less than those of gases.	Kinetic energy is maximum
8.	Diffusion	Show negligible diffusion	In them the process of diffusion is slow.	In them process of diffusion is very fast.

(b) (i) **Rigidity:** It refers to the property shown by solids. Because of, the absence of property of flow in solids they are considered as rigid. It is due to low value of K.E. in solids.

(ii) **Compressibility:** It is the property which depends upon the availability of interparticle space. Because in solids the intermolecular space is quite less. So they are incompressible, whereas gases show the property of compressibility to maximum extent.

(iii) **Fluidity:** It is the property to flow. It is shown by liquids and gases which are collectively known as fluids. It is maximum for gases.

(iv) **Filling of gas in cylinder:** The gases have maximum compressibility and due to this a large volume of gas can be compressed under pressure to a very small volume. The LPG and CNG cylinders contain gases compressed under pressure.

(v) **Shape:** Solids have a definite shape, liquids and gases do not have a definite shape and they take the shape of the container.

(vi) **Kinetic energy:** It is the energy possessed by molecules by virtue of their motion. The kinetic energy is maximum in case of particles of gases and least in case of particles of solids.

(vii) **Density:** It is the ratio of mass to volume. The density of solids is more than the density of liquids and gases. The density of gases is lowest due to large intermolecular space in them.

7. (a) Since, the interparticle force of attraction between gaseous particles is very small. So they neither have a definite shape nor a definite volume. The gas completely fills the vessel in which it is kept and its volume is the same as that of the vessel. It is due to very high rate of diffusion in case of gases.
[Note: The actual volume occupied by gaseous molecules is negligible as compared to the volume of the gas].

(b) Gaseous particles are in a state of random motion at high speed. Due to random motion particles hit each other and also the walls of the container. The pressure exerted by the gas is because of the force exerted by gas particles per unit area on the walls of the container.

(c) Since, the wooden table has a definite shape and definite volume. So, it should be classified as a solid.
The other properties associated with solids are that they have distinct boundaries, rigidity and incompressibility. These are the properties of wooden table also. So, it is a solid.

(d) Air is a gas. In gaseous state there is maximum interparticle distance and so they are highly compressible. Due to this property of compressibility we can easily move our hand in air but solids are incompressible and in them the constituent particles are quite close. So we need a large force to move our hands through a block of solid. This can be done only by a Karate expert.

8. Ice (a solid at room temperature) is lighter and floats on water (a liquid at room temperature) because ice has a cage-like structure in which there are large vacant space between various water molecules which are linked to form ice. In water molecule, such spaces are negligible. Thus, we can say that ice floats on water because the structure of ice is more porous than that of water. Due to this the density of water is more than that of ice and so ice floats over water.

9. To change temperature on Kelvin scale (K) to celcius scale (°C) you have to subtract 273.16 from the given temperature on Kelvin scale.
(a) 300 K = (300 – 273.16)°C = 26.84°C (or 27°C)
(b) 573 K = (573 – 273.16)°C = 299.84°C (or 300°C)
[Note: In ordinary calculations we use 273.0 instead of 273.16].

10. (a) The boiling point of water is 100°C and above this temperature it is in gaseous state. At 250°C, water is present in gaseous state only.
(b) At 100°C, there is equilibrium between gaseous state and liquid state i.e., both states liquid and gaseous are present.

11. The temperature remains constant during the change of state because the heat supplied is used up in changing the state by overcoming the intermolecular forces of attraction. This heat energy is known as latent heat.

12. The atmospheric gases can be liquified by applying pressure and reducing temperature.

13. On a hot dry day the amount of water vapour present in air is less. (i.e., humidity is low) and so, the rate of evaporation increases. Due to this a cooler cool better on a hot dry day.

14. The earthen pot has a large number of tiny pores which provide a large surface area for evaporation of water kept in it. Evaporation cause cooling. The rate of evaporation increases with rise of temperature. Since, the temperature is high during summer so rate of evaporation increases and the water kept in an earthen pot become cool.

15. Acetone or petrol or perfume particles gain energy from our palm for evaporation and this gives a feeling of coolness and we feel a cooling sensation.

16. Surface area of saucer is more as compared to that of a cup. Due to increase in surface area, the rate of evaporation increases and thus the temperature of the hot tea in saucer gets lowered and we can sip it faster than from a cup.

17. We should wear light colour and cotton clothes in summer. Light colour because it reflects heat. Cotton clothes because it has pores in it. It absorbs sweat and allows the sweat to evaporate faster thereby gives cooling effect.

Text - Book Exercise :

1. (a) 293 K = (293 – 273.16)°C
= 19.84°C [or 20°C]
(b) 470 K = (470 – 273.16)°C
= 196.84°C [or 197°C]

2. (a) 25°C = (25 + 273.16) K
= 298.16 K [or 298.0 K]
(b) 373°C = (373 + 273.16) K
= 646.16 K [or 646.0 K]

3. (a) Naphthalene is a sublime substance. It changes from solid state to gaseous state without passing through the liquid state. When kept in open the naphthalene balls get sublimed and the vapours go to atmosphere and no solid is left and the balls disappear.
(b) The particles of perfume which is a mixture of number of pleasant smelling vapour mix with the particles of air around us and spread out. Due to this spreading we are able to get the smell even sitting several metres away.

4. We know that the forces of attraction between particles are maximum in case of solids and minimum in case of gases. Thus the correct order is
oxygen < water < sugar
(gas) (liquid) (solid)

5. (a) Freezing point of water is 0°C and its boiling point is 100°C between these two temperatures it is in liquid state i.e. at 25°C water is in liquid state.
(b) It represent freezing point of water and both solid and liquid states are in equilibrium.
(c) It is boiling point of water and at this temperature both liquid and vapour (gaseous) state are in equlibrium.

6. (a) At room temperature water is liquid because it has no definite shape. It takes the shape of the container. It has a definite volume. Water shows the property of fluidity.
(b) An iron almirah has a definite shape and also a definite volume. So, it is a solid at room temperature.

7. When ice (a solid) melts at 273 K (m.p. of ice) it absorbs energy from its surroundings in order to overcome the forces of attraction present in solid particles. Due to this the temperature of surroundings gets lowered and cooling is caused. In case of liquid, water at 0°C there is no such tendency of changing to vapour state and so it has almost negligible tendency to absorb any energy from surroundings. Therefore, it will cause comparatively less cooling.

8. When water is boiled at 100°C (373 K) it absorbs certain amount of heat energy (latent energy) to get converted into steam. It results in more energy in steam than in water at 100°C. Due to this (i.e., more energy) steam produces more severe burns on the skin as compared to boiling water.

9. A = Fusion (or melting)
B = Vapourisation
C = Condensation (or liquidification)
D = Solidification (or freezing)
E = Sublimation
F = Sublimation

Exemplar Questions :

1. The temperature of both boiling water and steam is 100°C, but steam has more energy because of latent heat of vapourisation.

2. The water will cool initially till it reaches 0°C, the freezing point. At this stage the temperature will remain constant till all the water will freeze. After this temperature would fall again. Hence (I) is correct.

3. Conditions that can increase the rate of evaporation of water are
(i) an increase of surface area by spreading the shirt
(ii) an increase in temperature by putting the shirt under the sun
(iii) increase the wind speed by spreading it under the fan

4. Cotton being a better absorber of the water than nylon helps in absorption of sweat followed by evaporation which leads to cooling. So Priyanshi is more comfortable, whereas Ali is not so comfortable.

5. The temperature of a substance remains constant at its melting and boiling points untill all the substance melts or boils because, the heat supplied is continuously used up in changing the state of the substance by overcoming the forces of attraction between the particles. This heat energy absorbed without showing any rise in temperature is given the name latent heat of fusion/latent heat of vapourisation.

HOTS Questions :

1. This is due to diffusion. Some particles with high kinetic energy leave the coffee jar and spread out through the air in the room in a haphazard and random way. That's why we notice the smell of coffee in a room.

2. The water does not become hotter, but it will boil faster.

3. Nail polish remover contains acetone which has a high rate of evaporation. To stop the evaporation of acetone, we have to close the bottle immediately after using it.

4. Cooling by 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 increases the rate of evaporation of water and dryness of air (less humidity in air) also increases the rate of evaporation. Evaporation removes all the particles of high kinetic energy and the particles left behind have low kinetic energy and this causes cooling.

5. As the molar mass of ammonia is only 17 g/mol which is less than molar mass of expensive French perfume (170g/mol)

According to Graham's law of difussion rate of diffusion

$$\propto \sqrt{\frac{1}{\text{Molar mass of gas}}}$$

Molar mass of perfume is 10 times more than NH_3. Thus bad smell of cat-pan diffuses.

10 times faster than French perfume.

6. Ethyl chloride is a highly volatile and inflammable gas. It condenses to liquid at 13°C, and is kept in sealed tubes under pressure. On striking the warm skin, it vaporizes with such a rapidity that it freezes the tissues. This makes it a local anaesthesia of a moments duration, during which a small cut, as of an abscess or infected finger may be made without pain.

7. Cooling takes place when we removes heat from the system. At 273 K, the ice will take away the latent heat from the medium and convert itself into water. Thus, in case of ice at 273 K there will be a change in physical state whereas in case of water at 273 K, there will be no change in state. Hence, in case of water, lesser energy will be taken away from the medium.

8. Mass of silver = 62.00 g – 27.35 g = 34.65 g
Volume of silver = 18.3 mL – 15 mL = 3.3 mL
Density of silver = (mass of silver) / (volume of silver)
= (34.65g) / (3.3 mL) = 11 g/mL

9. We will use the ideal gas law. First we need to know the number of moles of nitrogen :

No of moles of N_2

$$= (0.245\text{g } N_2)\left(\frac{1\text{ mol } N_2}{28.02\text{ g } N_2}\right) = 8.74\times10^{-3}\text{ mol } N_2$$

$$V = \frac{nRT}{P} = \frac{(8.74\times10^{-3}\text{ mol})\,(0.0821\text{ L atm / mol K})\,(294\text{ K})}{(750\text{ torr})\left(\frac{1\text{ atm}}{760\text{ torr}}\right)}$$

$$= 0.214\text{ L} = 214\text{ mL}$$

10. Since, $PV = nRT$, then $n = PV/RT$

$$n = \frac{PV}{RT} = \frac{(685\text{ torr})\left(\frac{1\text{ atm}}{760\text{ torr}}\right)(0.300\text{L})}{\left(0.0821\frac{\text{L atm}}{\text{mol K}}\right)(300.2\text{ K})}$$

$$\text{molar mass} = \frac{1.45\text{g}}{0.0110\text{mol}} = 132\text{ g mol}^{-1}$$

11. (a) Increase in temperature at constant volume or decrease in volume or increase in pressure (b) decrease in temperature (c) increase in volume, decrease in pressure (d) increase in temperature

12. $V_1 = 400$ ml, $V_2 = 300$ ml
$T_1 = (227^oC + 273) = 500$ K $T_2 = ?$

Applying Charle's law , $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Hence, $T_2 = \frac{T_1 \times V_2}{V_1}$

Substituting the values, $T_2 = \frac{500\times300}{400}$ or $T_2 = 375$ K

T_2 in degree Celsius = 375 – 273 =102°C
Alteration of temperature = 227°C – 102°C = 125°C
The temperature should be reduced by 125°C.

13. $P_1 = 1140$ mm, $P_2 = 760$ mm, $V_1 = 200$ ml,
$V_2 = 450$ ml
$T_1 = 27^oC + 273 = 300$ K, $T_2 = ?$

Applying gas equation, $\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$

Hence, $T_2 = \frac{P_2V_2T_1}{P_1V_1} = \frac{760\times450\times300}{1140\times200} = 450$ K

Temperature to be applied = 450 K – 273K = 177°K.

14. Amorphous solids in which constituent particles are arranged in haphazard manner. They resemble liquids as these flow very slowly at room temperature and thus termed as super cooled liquids.

15. It is due to capillary action. The rise of liquid in a capillary is due to the inward pull of surface tension acting on the surface which pushes the liquid into the capillary tube.

16. Equilibrium refers to a state where opposing forces are balanced in the case of a liquid in equilibrium with its vapour, it means that a molecule escaping to the vapour is replaced by one condensing to the liquid.

17. We put strips of wet cloth on the forehead of a person having high temperature. This is because when the water evaporates, it takes away the necessary heat from the body of the patient and thus lowers the body temperature.

18. The molecules that give roses their aroma evaporate from the surface of the flower. Once in the gas phase, they collide countless times with other gas molecules, moving slowly away from the rose, when they reach a nose, they are sensed by the olfactory sensors.

19. $V_1 = 400$ ml $V_2 = 600$ ml

$T_1 = 15^oC + 273 = 288$ K, $T_2 = ?$

Applying Charles' law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Hence, $T_2 = \frac{T_1 \times V_2}{V_1}$

Substituting the values

$$T_2 = \frac{288 \times 600}{400}$$

$$T_2 = 432 \text{ K}$$

T_2 in degree Celsius = 432 – 273 =159°C

The new temperature = 159°C.

20. $P_1 = 800$ mm of Hg, $P_2 = 600$ mm of Hg

$V_1 = 500$ ml , $V_2 = ?$

$T_1 = 40^oC + 273 = 313$ K, $T_2 = 353^oC + 273 = 626$ K

Applying gas equation , $\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$

Hence, $V_2 = \frac{P_1 V_1 T_2}{T_1 P_2}$

$$V_2 = \frac{800 \times 500 \times 626}{313 \times 600} = 1333.33 \text{ ml}$$

New volume = 1333.33 ml.

3 EXERCISE

Multiple Choice Questions :

1. (c) The mass of an object is a fundamental property of the object, a numerical measure of inertia, a fundamental measure of the amount of matter in the object.

2. (b) At higher altitudes atmospheric pressure decrease. Therefore at lower temperature vapour pressure becomes equal to atmospheric pressure. Thus boiling point of a liquid decreases.

3. (b) K = 273 + t°C
K = 237 + 78 = 351 K

4. (a) Boiling point of water is 100°C whereas evaporation of water into water vapours occurs at room temperature.

5. (d) Boiling point of water = 100°C = 100 + 273 = 373K

6. (a) As intermolecular forces are least in case of petrol. Thus, it has highest rate of evaporation.

7. (d) This is due to diffusion of particles of potassium permanganate into intermolecular spaces between particles of water.

8. (d) **9.** (c)

10. (a) During vapourization energy is supplied to liquid in the form of heat. Liquid reaches its boiling point and get converted into gas (vapours).

11. (c)

12. (a) Sugar molecules occupy the intermolecular spaces present in water molecules. Thus after dissolution only liquid is left.

13. (c) Effusion is the process in which individual molecules flow through a hole without collisions between molecules.

14. (c) **15.** (a) **16.** (b) **17.** (c)

18. (a) As order of energy for different states of matter is following
Bose-Einstein < Solids < Liqiuds < Gases < plasmas condensate.

19. (b) Alcohol, because of presence of intermediate magnitude of inter molecular forces is liquid at room temperature.

20. (b) Crystal is a solid and even on crushing it you will get smaller crystals (solid).

21. (b)

22. (d) After 1990s five states of matter are known solid, liquid, gas, plasma and Bose Einstein condensate.

23. (a) **24.** (a) **25.** (a) **26.** (c)
27. (d) **28.** (c) **29.** (c) **30.** (b)
31. (a) **32.** (c) **33.** (a) **34.** (c)
35. (b) **36.** (b) **37.** (a) **38.** (b)
39. (d) **40.** (d) **41.** (d)

More than One Option Correct :

1. (a, b, c) Camphor, solid CO_2 and ammonium chloride all are sublimate and get directly converted into gases or vice-versa.

2. (a, b, c) As rate of diffusion of a gas depends upon its molar mass and each gas have different molar mass. Mix one liquid of any colour with water entire mixture after some becomes cloured means liquid to show phenomena of diffusion. Moreover no liquid diffuse as fast as gases.

3. (b, d) During evaporation molecules having greater kinetic energy leaves liquid surface there by causing cooling. Moreover only the molecules present on surface escapes thus it is a surface phenomena.

4. (a, d) More will be temperature more number of molecules possess enough kinetic energy to escape liquid surface thereby increasing vapour pressure. It also increase rate of evaporation.

5. (a, d) **6.** (b, d)

7. (b, d) Gases have very low intermolecular force between their molecules thus they can be compressed and undergoes rapid diffusion.
8. (a, b, c)
9. (a, b, c, d) Different liquids have different density, viscosity, solubility and rate of evaporation.
10. (a, b, c) Amorphous solids like glass and plastic do not have a sharp melting point.
11. (a, b, c)
12. (a, b, c) Plasma is a superenergetic state of matter consisting superexited atoms.
13. (a, b, c) The mass of gas can be determined by weighing the container, filled with gas and again weighing this container after removing the gas. The difference between the two weights gives the mass of the gas.

Passage Based Questions :

1. (d) **2.** (a) **3.** (a)

Assertion & Reason :

1. (c) The higher the altitude, the lower the atmospheric pressure. Lower pressure in turn causes water to evaporate more quickly, and water boils at a lower temperature.
2. (d) During evaporation molecules at surface possess more kinetic energy and escapes to atmosphere. Therefore, resulting liquid undergoes cooling.
3. (c) During evaporation of a liquid, the temperature of the liquid falls.

Multiple Matching Questions :

1. (a) A-(q, r); B-(p); C-(p, q); D-(r)

Integer Type Questions :

1. **5**
Evaporation does not depends upon volume and density of liquid.
2. **5**
Solid, Liquid, Gas, Plasmas and Bose-Einstei'n condensates.

4 EXERCISE

1. (b) $P_1 = 1$ atm, $V_1 = 200$ml
$P_2 = 5$ atm $V_2 =$
According to Boyle's law
$P_1V_1 = P_2V_2$
$V_2 = \frac{P_1V_1}{P_2} = \frac{1\times 200\text{ml}}{5} = 40$ ml
2. (b) Boyle's law
$P \propto \frac{1}{V}$
$P = \frac{K}{V}$
$PV = K$
3. (d)
4. (a) An ideal gas is one which obeys gas laws under all conditions of temperature, pressure and volume.
5. (c) According to Charle's law $V \propto T$ or $\frac{V}{T} = k$.
6. (c) $PV = nRT$ $\therefore \frac{n}{V} = \frac{P}{RT}$
7. (d) According to Graham's law of diffusion,
$D \propto \frac{1}{\sqrt{\rho}}$ or $\rho = \frac{M}{V}$ (M = molar mass)
8. (b) Boyle's law
$P \propto \frac{1}{V}$
$P = \frac{K}{V}$
$PV = K$
9. (b)
10. (c) In the equation PV = nRT, n moles of the gas have volume V.
11. (b) $\frac{PV}{T} = \text{constant}$ $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
$\Rightarrow \frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$
12. (d) The statement of Dalton's law is
$P = P_A° + P_B° + \ldots\ldots\ldots\ldots P_n°$
Where P is the total pressure $P_A°$, $P_B°$ ..... are the partial pressure of the components of gaseous mixture.
13. (d) Kinetic theory of gases proves all the given gas laws.
14. (b) Liquid drops assume spherical shape because a sphere has minimum surface area.
15. (a) By Dalton's law of partial pressures, the total pressure of a mixture of two gases is the sum of the partial pressures.
16. (d) $P \propto \frac{1}{V}$ (at constant T)
PV = constant.
17. (c) Due to intermolecular H-bonding the surface tension of H_2O is more than other liquid. One H_2O molecule is joined with 4 another H_2O molecule through H–bond. Hydrogen bonding is in order $H_2O > C_2H_5OH > CH_3OH$.
18. (b)
19. (a, c, d)
20. (a, d) According to Boyle's law, $V \propto \frac{1}{P}$
PV = constant
According to Charle's law at constant pressure
$\frac{V}{T} = \text{constant}$
21. (a, b) At constant temp., when gas expands the K.E. of the molecules remains the same, but the pressure decreases.
$\left(\because P \propto \frac{1}{V}\right)$

(Sol. 22-24)

$V = 9.22\ L \quad P = 1124\ torr = \frac{1124}{760}\ atm = 1.47\ atm$

$T = 24°C = 24 + 273 = 297\ K$

From ideal gas equation

$PV = nRT$

$n = \frac{PV}{RT}$

$= \frac{1.47\ atm \times 9.22\ L}{0.0821\ L\ atm\ mol^{-1}K^{-1} \times 297K} = 0.56\ mol$

22. (a) No. of moles of $Cl_2 = \frac{\text{Given gram of } Cl_2 \text{ in sample}}{\text{Molecular mass of } Cl_2}$

$0.56 = \frac{\text{Given grams of } Cl_2 \text{ in sample}}{70.906}$

Given grams of Cl_2 in sample = 39.7 g

23. (c) At STP $P_2 = 1$ atm

$T_2 = 273$ K

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{1.47\ atm \times 9.22L}{297K} = \frac{1\ atm \times V_2}{273K}$

$V_2 = \frac{1.47\ atm \times 9.22L \times 273K}{297K}$

$V_2 = 12.458\ L = 12.5\ L$

24. (d) $V_2 = 15$ L $\quad P_2 = 876$ torr

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{1124\ torr \times 9.22L}{297K} = \frac{876\ torr \times 15L}{T_2}$

$T_2 = \frac{876\ torr \times 15L \times 297K}{1124\ torr \times 9.22L}$

$T_2 = \frac{3902580}{10363.28}K$

$T_2 = 376.577\ K$

$T_2 = 377\ K$

25. (a) With the increase in temperature when pressure is low the distance between molecules increases and intermolecular forces becomes almost negligible. Thus under those conditions a gas behaves like ideal gas.

26. (c) Assertion is true but reason is false.

Pressure is inversaly proportional to volume (Boyle's law). $P \propto \frac{1}{V}$ (n, T constant)

27. (b) A-(q, r); B-(p, r); C-(p, q); D-(p, q, r, s)

28. **6**

$P_1 = 3$ atm $\quad P_2 = \frac{x}{10}$

$V_1 = 400$ ml $\quad V_2 = 2000$ ml

According to Boyle's law

$P_1V_1 = P_2V_2$

$3 \times 400 = \frac{x}{10} \times 2000$

$x = \frac{3 \times 400 \times 10}{2000} = 6$

29. **3**

$V_1 = 3.25$ L $\quad V_2 = ?$

$T_1 = 0°C = 0 + 273 = 273K$

$T_2 = -20°C = -20 + 273 = 253K$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (P is constant)

$\frac{3.25}{273} = \frac{V_2}{253}$

$V_2 = 3$ L