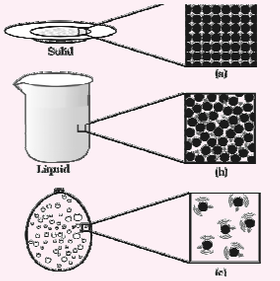
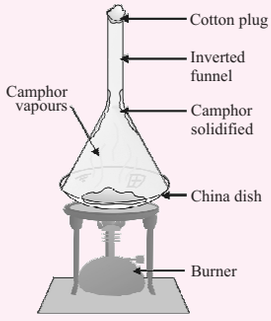
Chapter

1 Matter in Our Surroundings

Learning Objectives

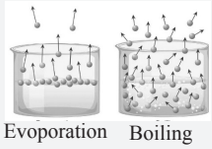
- What is Matter?
- States of Matter
  - Solid
  - Liquid
  - Gas
- Interconversion of Matter into Different States
- Evaporation





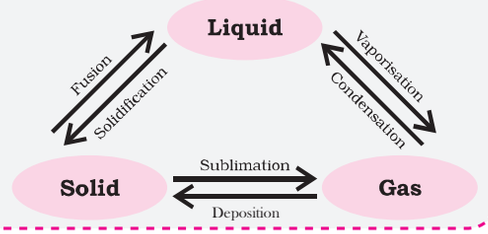
Exam Mirror

- Latent Heat
- Factor Affecting Evaporation



Critical Concepts

- Characteristics of Particles of matter
- Vaporisation



WHAT IS MATTER?

Everything that is around us and the presence of which can be felt with the help of any of our five senses, *i.e.*, sight, touch, smell, hearing and taste is called *matter*. In fact, this whole universe is made up of only two things, *viz*, matter and energy. Experience has shown that all types of matter possess mass and occupy space. Hence, Matter is defined as any thing that occupies space, possesses mass and the presence of which can be felt by any one or more of our five senses.

The examples of matter are innumerable. A few of these include clothes, iron, gold, plastics, wood, water, milk, petrol, kerosene oil, air etc.

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

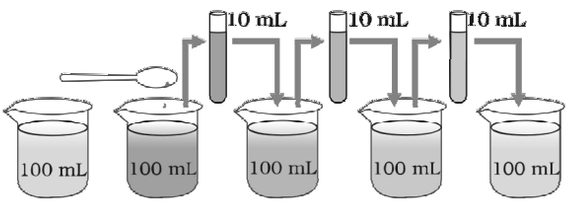
The concept about the nature of matter is very old. According to the ancient Hindu and Greek philosophers, the matter is composed of very small particles which cannot be further sub-divided. John Dalton was the first person who gave scientific explanation about the nature and composition of matter.

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 colourless 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. Every time solution will become purple colour.



DID YOU KNOW?

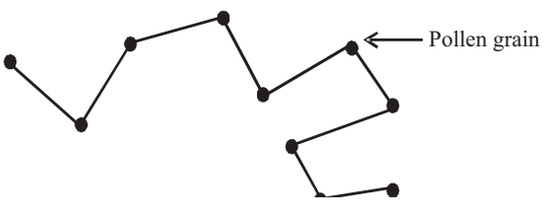
Reason for diffusion of particles of matter is that they are continuously in random motion as they possess kinetic energy. As kinetic energy depends upon temperature. The rate of diffusion becomes faster with increase in temperature.

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 and they can divide themselves into smaller particles. This clearly indicates 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.

(b) Movement of Pollen Grains in Water

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



DID YOU KNOW?

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

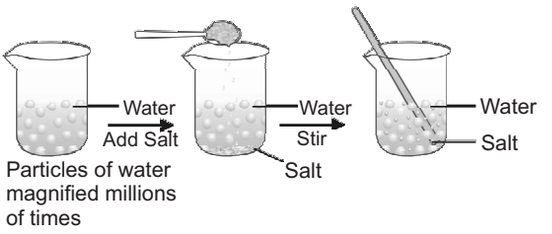
The pollen grains move on the surface of water because they are constantly being hit by fast moving particles of water. This type of *zig-zag* movement of the small particles suspended in a liquid (or gas) is called *Brownian motion*.

Characteristics of Particles of Matter

(a) The particles of matter are very, very small : The matter is composed of small particles : To understand particle nature of matter let us perform an experiment. Take a beaker full of water. Now place a small crystal of blue vitriol (copper sulphate) in water. You will observe that the water begins to appear 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.

(b) 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 water.



Also particles of salt dissolve in water because of vacant space between the particles of 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 in glass with a 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. These vacant spaces are occupied by the particles of the sugar and water level goes down.

(c) 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".

Example : When a perfume bottle is opened at 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.

DID YOU KNOW?

We have seen that the particles of matter in liquid and gaseous states 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 motion also. We may conclude that particles of matter are mobile, whether the matter is in solid, liquid or gaseous state. The motion of particles is fast in case of gaseous state, slow in liquid state and very slow in solid state.

Let's Do Activity

Aim :

To demonstrate that particles of matter move continuously.

- *Take two beakers one contains hot water and other contain cold water.*
- *Add a crystal of copper sulphate in both the beakers.*
- *Keep both the beakers aside and do not stir the beakers.*
- *Observe, what happens as time passes ?*

Observations :

- *Particles of copper sulphate mix on their own in both the beakers with water and blue colour solution is formed.*
- *Rate of intermixing is high in hot water.*

Conclusion :

- *Particles of matter intermix on their own with each other. This intermixing of particles of two different types of matter on their own is called diffusion.*

(d) 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.

Illustration 1 :

What is nature of matter is it continuous or particulate?

Solution : Particulate

CHECK POINT-1

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

(a) weight (b) gram

(c) mass (d) density

2. Select the one that is not a matter.

(a) Feeling of hotness (b) Smoke

(c) Humidity (d) Water

3. 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.

Sol. 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. (a) 3. (a)

CONNECTING TOPIC

Intermolecular Forces

Intermolecular forces are the forces of attraction and repulsion between interacting particles (atoms and molecules). Attractive intermolecular forces are called *van der Waals forces*. Some of the van der Waal's forces are discussed below.

(a) Dispersion Forces or London Forces :

These forces arises in atoms and non-polar molecules by momentary displacement of their electron cloud. These forces are important only at short distances and their magnitude depends on the polarisability of the particle.

(b) Dipole-Dipole Forces :

These forces act between the molecules possessing permanent dipole. The polar molecules interact with neighbouring molecules as shown below for HCl :

$$\overset{\delta+}{H}-\overset{\delta-}{Cl}\cdots\overset{\delta+}{H}-\overset{\delta-}{Cl}\cdots\overset{\delta+}{H}-\overset{\delta-}{Cl}$$

This interaction is stronger than London forces and weaker than ion-ion interaction.

(c) Dipole-Induced Dipole Forces :

These forces operate between polar molecules having permanent dipole and molecules lacking permanent dipole. Induced dipole moment depends upon the dipole moment present in the permanent dipole and the polarisability of the electrically neutral molecule.

(d) Hydrogen Bond :

It arises in molecules in which highly polar N–H, O–H or H–F bonds are present. H–bonds are formed by highly electronegative elements like N, O and F. For example,

$$\overset{\delta+}{H}-\overset{\delta-}{F}\cdots\cdots\overset{\delta+}{H}-\overset{\delta-}{F}$$

H-Bond

Thus, H-bonding is a special case of dipole-dipole interaction.

Let's Connect

1. The force that binds the particles of matter together is known as :

(a) intermolecular space (b) bond

(c) intermolecular force (d) nuclear force

2. The correct order of increasing intermolecular forces of attractions between the particles of solid, liquid and gases is–

(a) liquid < solid < gas (b) gas < liquid < solid

(c) solid < gas < liquid (d) solid < liquid < gas

Sol. 1. (c) 2. (b)

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 solid, liquid, gas, plasma and Bose-Einstein condensate. These all are different states of matter.

DID YOU KNOW?

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.

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:

(a) **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.

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

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

(d) 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.

(e) **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. As intermolecular separation increases, solid changes into liquid state.

CONNECTING TOPIC

Classification of solids

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

(a) Amorphous solids (b) Crystalline solids

(a) 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.

These lose their shape on standing and flow under their own weight, e.g., glass, pitch, rubber, plastics, starch and proteins.

(b) 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.

The properties showing the difference between the crystalline and amorphous solids are listed in table.

Let's Connect

1. Which of the following is a amorphous solid ?

(a) Glass (b) Diamond

(c) Graphite (d) Non of the above

2. Which of the following is correct regarding crystalline solids ?

(a) They melt over a wide range of temperature.

(b) They do not have a definite heat of fusion.

(c) They are isotropic in nature.

(d) They are anisotropic in nature

Sol. 1. (a) 2. (d)

CHECK POINT-2

1. Which of the following is least compressible ?

(a) Ice (b) Steam

(c) Carbon dioxide gas (d) Oxygen gas

2. A solid has _____.

(a) Definite volume (b) Definite shape

(c) Both (a) and (b) (d) Indefinite volume

Sol. 1. (a) 2. (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. Example: water and milk.

Properties of Liquids :

Important properties of liquid can be described as follows :

(a) Shape and volume : Molecular forces between the liquid molecules are not strong enough 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.

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

DID YOU KNOW?

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.

$$\text{Density of a substance} = \frac{\text{Mass of the substance}}{\text{Volume of the substance}}$$

(c) 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 get 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 in gas.

(d) Compressibility : The vacant space in between the molecules of liquid 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 is reduced by 50% whereas when the same pressure is increased on water (liquid), its volume is decreased by only 0.0045%.

(e) 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. Average kinetic energy of the molecules of liquid is called its thermal energy. 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.

DID YOU KNOW?

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 interaction between the liquid molecules.*

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

Illustration 2 :

When 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.

CHECK POINT-3

1. Liquids have _____.

(a) Definite shape (b) Definite volume

(c) Indefinite shape (d) Both (b) and (c)

2. Which of the following has highest density ?

(a) Liquid water (b) Ice

(c) Water vapours (d) All have equal densities.

Sol. 1. (d) 2. (a)

CONNECTING TOPIC

Surface Tension

It is an important property of liquids, which is directly related to the intermolecular forces between the molecules. Liquid surface feels 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, 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 : 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. The liquid drops have nearly spherical shape.

Let's Connect

1. Water has highest surface tension at

(a) 40°C (b) 10°C

(c) 70°C (d) 4°C

2. Which of the following liquid has highest surface tension ?

(a) liquid water (b) Honey

(c) Alcohol (d) Petrol

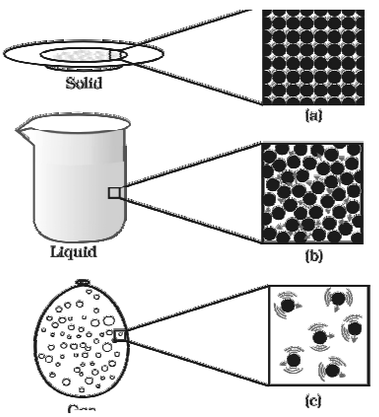
Sol. 1. (d) 2. (b)

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 of gases enclosed in the container are in continuous motion, along all possible directions with in the complete space available. 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.



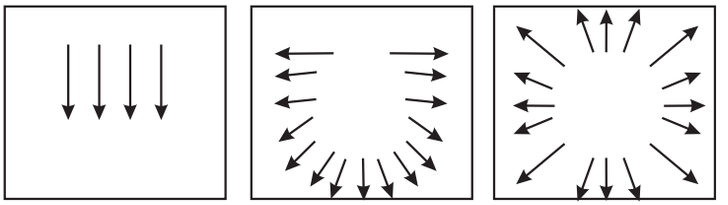
Properties of Gases :

(a) Compressibility : In case of gases the distance 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 occupy less space than before.

DID YOU KNOW?

The property of incompressibility of liquids is useful for us in hydraulic machines. A simple system of automobile hydraulic brakes is 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.

(b) 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

(c) Homogeneous nature : Gases have similar composition in all parts and are therefore homogeneous in nature.

(d) Liquefication : Gases can be liquefied by cooling and by applying pressure.

(e) 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 called diffusion without any mechanical aid to form a homogeneous mixture.

Uses of Gaseous Diffusion :

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.

DID YOU KNOW?

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

CHECK POINT-4

1. 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 rest.

(c) gases consist of molecules having very large inter-molecular space which can be reduced or increased under ordinary conditions.

(d) None of these

2. 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.

Sol. 1. (c) 2. (b)

CONNECTING TOPIC

Other States of Mater :

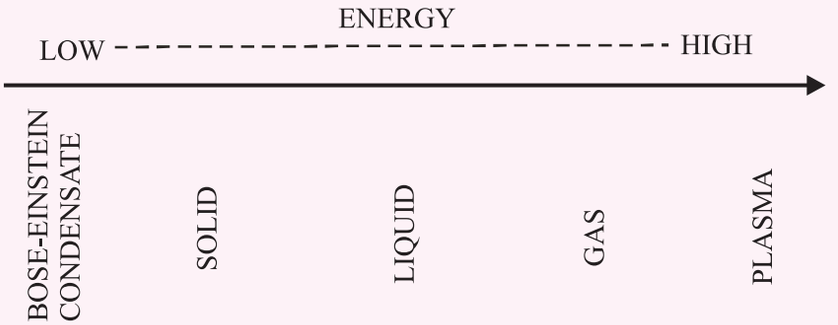
Plasma : Plasma is the fourth state of matter. They are different and unique from the other states of matter. Think about a fluorescent light bulb. They are not like regular light bulbs. Inside the long tube is a gas. Electricity flows through the tube when the light is turned on. The electricity acts 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 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 : It is the fifth state of matter. 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.



Let's Connect

1. 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

2. 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

3. Which has the least energetic molecules?

(a) Solid (b) Liquid (c) Gas (d) Plasma

4. In which phase of matter would you expect alcohol exists at room temperature?

(a) Solid (b) Liquid (c) Gas (d) Plasma

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

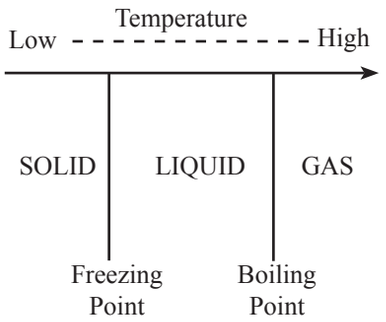
2. (d)

3. (a) As order of energy for different states of matter is following :
Bose-Einstein < Solids < Liqiuds < Gases < plasma.

4. (b) Alcohol due to presence of intermediate magnitude of inter-molecular forces is liquid at room temperature.

INTERCONVERSION OF MATTER INTO DIFFERENT STATES

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 high pressures. 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.



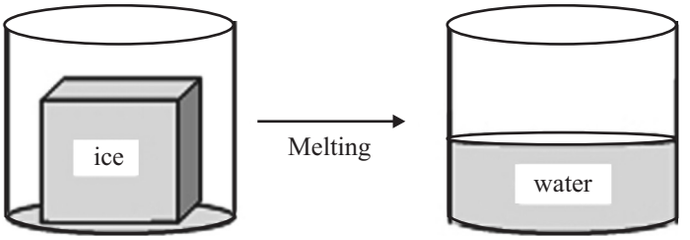
DID YOU KNOW?

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 is easier to freeze the substance at higher pressures. When it gets colder, most solids shrink in size. There are a few which expands 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. As heat is applied to a solid, its temperature will increase until the melting point is reached. There is a particular temperature for every solid substance at which it changes state from solid to liquid, called the melting point. If more heat is applied, then it will be used for the conversion of solid into liquid with no temperature change. Therefore, melting point is the temperature at which the solid and liquid forms of a pure substance can exist in equilibrium.

DID YOU KNOW?

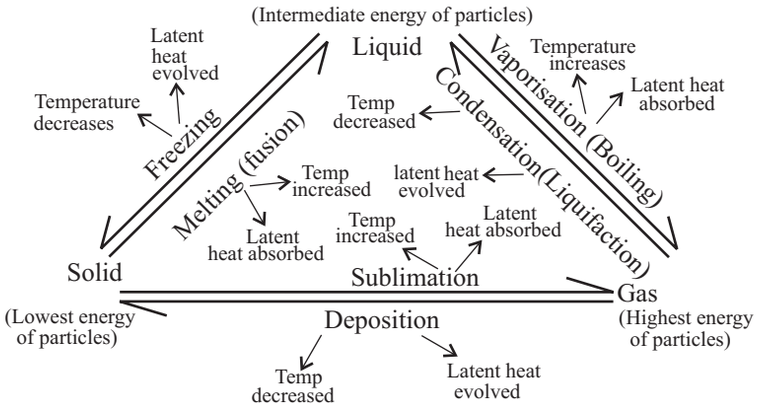
Melting point of a solid also depends upon the surrounding pressure. More will be the pressure lower will be the melting point. Thus solid melts easily at higher pressure.



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 becomes liquid. If steam of a boiling pot of water hits the wall, the wall would be so cool that steam would quickly become a 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.

DID YOU KNOW?

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 and more, easily gas gets condensed into liquid.



Inter conversion of three statues of mater

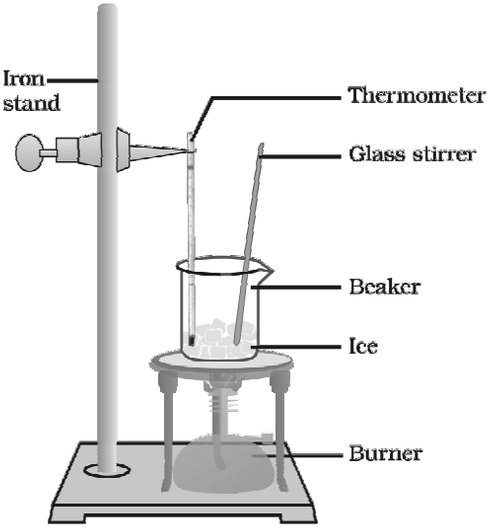
The various state of matter can be interchanged into one another by altering the conditions of (1) Temperature (2) Pressure.

1. Altering the Temperature of Matter

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

For example : Ice changes into water at 0°C, when heat energy is supplied to it.

The water 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*.

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.

(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*.

DID YOU KNOW?

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 = 273.16 K*

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

Illustration 3 :

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 and 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*.

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.

DID YOU KNOW?

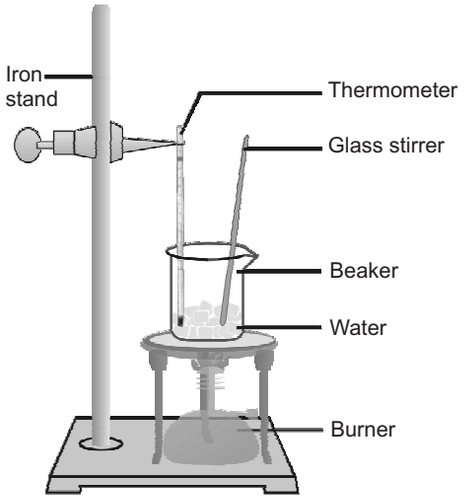
For water, the vapour pressure reaches the standard sea level atmospheric pressure of 760 mmHg at 100°C. Since the vapour pressure increases with temperature, it follows that for pressure greater than 760 mmHg (e.g., in a pressure cooker), the boiling point is above 100°C and for pressure less than 760 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.

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.

(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.



DID YOU KNOW?

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.

Illustration 4 :

Why steam, causes 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.

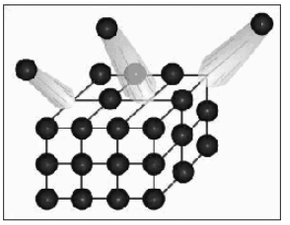
(c) Direct Interconversion of solid into gaseous state & vice versa : Sublimation : Certain substances when heated, pass directly from the solid state to vapour state without being converted into liquid. The vapours when cooled give back the solid substance. This phenomenon is known as *sublimation* and the substance is called *sublimate*.

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

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

DID YOU KNOW?

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



Sublimation depicted at submicroscopic level

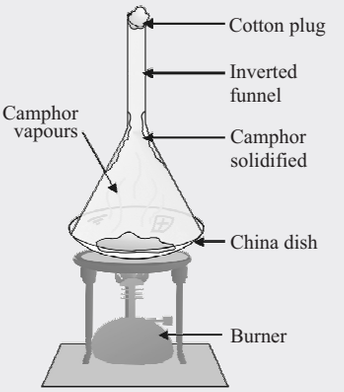
The solids, having weak inter-molecular forces, when heated are directly converted into vapours (gaseous state) without being converted into liquids. Small amount of energy is sufficient to weaken the inter-molecular force of attraction. This increases the inter molecular distance to a very great extent.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

Let's Do Activity

Aim :

To demonstrate that process of sublimation.

- ***Take some camphor, crush it and put it in a china dish.***
- ***Put an inverted funnel over china dish.***
- ***Put a cotton plug on the stem of the funnel.***
- ***Now, heat slowly and observe.***



Observations :

- ***On heating camphor sublimes and deposits in the neck of the inverted funnel.***

Conclusion :

- ***During sublimation solid directly converts into gas without changing into liquid state.***

Illustration 5 :

Which phenomena is represented in the following equation?

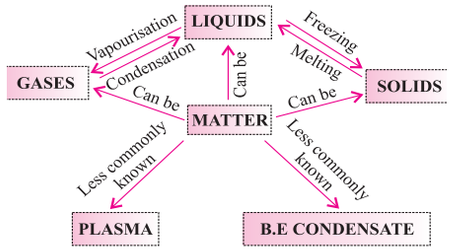
$$\text{Soild} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{Gas}$$

Solution : Sublimation

CASE STUDY-1 : Can Matter Effected by Change in Temperature and Pressure ?

CASE - I :

In general condition, the particles of gas are far from each other. They move independently and rapidly in all directions. The force of attraction is negligible between the particles of gas. When pressure is applied on the gas, its particles come closer to each other. On further increasing the pressure, the particles of gas start attracting each other. The space between the particles of gas also decreases with increase in pressure. At very high pressure a lot of heat is evolved, which increases the kinetic energy was utilised for movement of gas particles . So, while applying high pressure to compress the gas, temperature is kept low to overcome the evolution of heat. Thus, they get closely packed at a certain high pressure, at this stage they get bonded with each other and turned into liquid.



CASE - II :

Matter can be changed from one state to another state. A solid can be changed into liquid and a liquid can be changed into gas. Several matters, which are solid, turn into liquid on heating and turn into vapour on further heating. The change of state of matters depends mainly upon two factors. i.e. pressure and temperature.

Effect of pressure:

Solid: There is no effect of pressure on solids. Solids are non compressible, i.e. solids cannot be compressed as there is no space between their particles which could allow compression. When the pressure is increased on a solid, it is deformed and finally broken.

Liquid: There is no effect of pressure on liquid. Liquids are non compressible, i.e. liquids cannot be compressed since there is not enough space between their particles to get compressed.

Gas: The volume of gas decreases with increase in pressure. Since there is lot of space between the particles, gas is highly compressible. Large volume of gas can be compressed to a small volume. Because of high compressibility, gases can be easily transported after compressing to a small volume in cylinders.

Natural gas is compressed to small volume and packed in cylinders. It is used widely as fuel to running vehicles. Because of compression it is called Compressed Natural Gas or simply known by CNG (Compressed Natural Gas).

Oxygen is compressed and packed in small cylinders, which is used to save life in hospitals.

Effect of Temperature:

- Solids change into liquid with increase in temperature. (Melting)
- Liquid changes into gas by increase in temperature. (Vaporization)
- Gas changes into liquid by decrease in temperature. (Condensation)

CASE - III :

Plasma and Bose-Einstein condensate are two other states of matter. They have following properties

Plasma:

- Plasma has neither a definite volume nor a definite shape.
- Plasma is seen in ionized gases.
- Plasma is distinct from a gas because it possesses unique properties. Free electrical charges (not bound to atoms or ions) cause plasma to be electrically conductive.
- Plasma may be formed by heating and ionizing a gas.
- For example: stars, lightning, neon signs the fluorescent lights, etc.

Bose- Einstein Condensate: Indian physicist Satyendra Nath Bose had done some calculations for a fifth state of matter. Based on his calculations, Albert Einstein predicted a new state of matter – the Bose- Einstein Condensate (BEC).

- BEC is formed by cooling a gas of extremely low density.
- Bose-Einstein condensate refers to the collapse of atoms into a single quantum state.
- It is found at low temperatures when atoms are not able to move at all.

Hence, both plasma and BEC are states of matter. They are basically opposite to each other. When matter is cooled to a great extent (beyond fusion), its particles get compressed to a state where they get an identity, forming BEC. On the other hand, when matter is heated to a great extent, the particles get an overload of energy (kinetic) and the electrons break off, turning the particles into ions. Matter in that state is called Plasma.

Think Out of the Box

Q.1 As the temperature is increased, ice converts into water and on further heating water converts into vapour. Why?

Q.2 Which state of matter makes a fluorescent tube to glow and why?

Q.3 What is dry ice? What conditions are needed to prepare it?

2. By Altering Pressure

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

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

CHECK POINT-5

1. 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

2. 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

3. 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

Sol. 1. (a) 2. (b) 3. (c)

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.

Illustration 6 :

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.

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.

DID YOU KNOW?

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.

Illustration 7 :

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

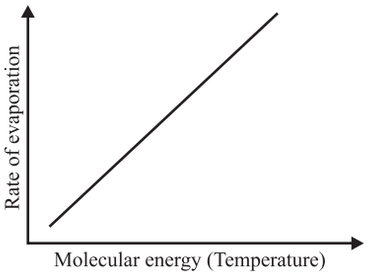
(i) Temperature:

With increase in temperature the rate of evaporation increases.

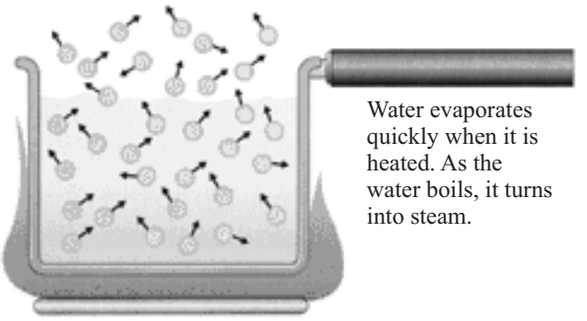
Rate of evaporation $\propto$ Temperature

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 will observe that steam rise off on top of the water.



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

(ii) Surface area :

With increase in surface area the rate of evaporation increases.

Rate of evaporation $\propto$ of surface area

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

Illustration 8 :

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 :

With decrease in humidity rate of evaporation increases

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

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 readily. When humidity of air is high, the rate of evaporation is low and water evaporates slowly.

(iv) Wind speed :

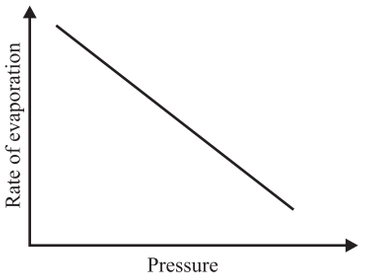
With the increase in windspeed rate of evaporation increases.

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 even out the pressure. Once the vapour pressure of the area increases to a specific level, the rate of evaporation will slow down.



Misconceptions About States and Changes of Matter (Water)

Misconception	Reality
When water boils and bubbles, the bubbles are air, oxygen or heat.	Bubbles formed by boiling water consist of water vapour (steam).
Steam is hot air.	Steam is water vapour.
When steam is no longer visible, it becomes air.	When water vapour condenses in the air it is visible as tiny water droplets.
Water in an open container is absorbed by the container, disappears, changes into air, or dries up and goes into the air.	Water in an open container evaporates, changing from a liquid to a gas.
Ice molecules are colder than water molecules.	Ice molecules have less kinetic energy than water molecules.
Condensation is when air turns into a liquid.	Condensation is water vapour in the air that cools enough to become a liquid.
Condensation on the outside of a container is water that seeped (or sweated) through the walls of the container.	Condensation of water vapour occurs when the water vapour in air comes in contact with a cool surface.
Expansion of matter is due to the expansion of the particles rather than increased space between the particles.	Matter expands when heated because the molecules are vibrating more quickly, loosening bonds, and increasing the space between adjacent atoms or molecules.

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 is that only the most energetic molecules of liquid are lost by evaporation, so 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.

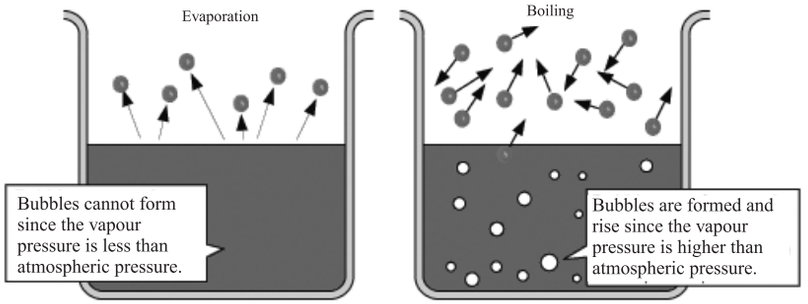
DID YOU KNOW?

The cooling effect of evaporating water is important for 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 body. The cold 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 :

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

(b) 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.



CHECK POINT-6

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

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

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

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

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

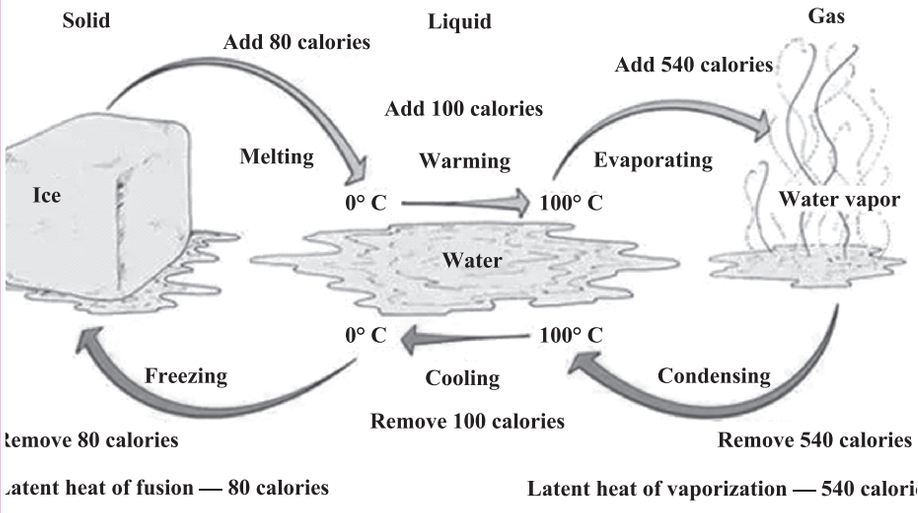
Sol. 1. **(a)** Boiling point of water is 100°C whereas evaporation of water into water vapours occurs at room temperature.

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

3. **(b)** China dish will give large surface area to liquid.

4. (A) → (p); (B) → (q); (C) → (p); (D) → (p)

CASE STUDY-2 : Can Matter Change its State?



CASE - I :

Normally when heat energy is added or removeds from an object, the temperature of the object change; however during phase change the temperature of an object remains constant. The temperature remains the same because energy is utilised for phase changing process of an object. During the melting of ice, heat is continuously supplied by the environment, but the temperature does not increase. Where does this energy lost? The answer lies in the concept of latent heat. Latent heat is the heat energy in hidden form which is supplied or extracted to change the state of a substance without changing its temperature. This heat does not increase the kinetic energy of the ice particles and hence no rise in temperature takes place during the melting of ice. This heat is known as latent heat of fusion.

CASE - II :

The particles of water attract to each other with certain forces. These forces hold the water particles together in the liquid state. The heat which is supplied to water during boiling is used to break the attraction forces so that they become totally free and change into steam. This heat does not increase the kinetic energy of the water and hence no rise in temperature takes place during the changing into steam. Thus, once the water has begun to boil, the temperature remains constant until all the water has changed into steam. This heat is known as latent heat of vaporization.

CASE - III :

The spirit evaporates rapidly and is more effective in cooling as compared to water at same temperature due to its lower boiling temperature spirit takes more heat (latent heat of vaporization) from skin and cools the hand more effectively. On the other hand, water at same temperature cannot take away any such latent heat to such as extent from the hand and hence, does not cool it more effectively.

Think Out of the Box

Q.1 Why burns caused by steam are much more severe than caused by boiling water?

Q.2 The latent heat of fusion of ice is 3.34×10^5 J/kg. What does it mean?

Q.3 When we take a piece of ice in our palm, it feels very cold. Why?

CONNECTING TOPIC

Gas Laws

The characteristics of gases are described in terms of four measurable parameters which are:

(a) Mass (b) Volume (c) Pressure (d) Temperature

There are certain laws which relate the above four parameters. These are called gas laws.

Boyle's Law

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

$$P_1V_1 = P_2V_2$$

Charle's Law

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

"The volume of a given amount of a gas at constant pressure varies directly as its absolute temperature".

$$\Rightarrow \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Gay-Lussac Law or Amonton's Law

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

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 $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Avogadro's Law

(a) For solid, liquid and gas : 1 mole of any substance contains Avogadro's number (NA) of particles (molecules/atoms/ions) etc.

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

(b) For gases: In 1811, Amedeo 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 directly proportional to n (T and P are constant).

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

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.

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

Ideal Gas Equation

On combining Boyle's law, charles' law and Avogadro's law we get ideal gas equation.

$$PV = nRT$$

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}

Let's Connect

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. 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?

(a) 432°C (b) 455°C

(c) 159°C (d) 165°C

3. All gases will occupy zero volume when the temperature is reduced to

(a) 273°C (b) 253°C

(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

Sol. 1. (b) 2. (c) 3. (c) 4. (a)

Walk Through the Chapter

Matter in Our Surroundings

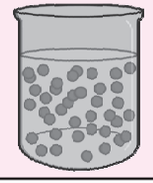
States of Matter

Solid
- Definite volume and shape
- Rigid
- Have high intermolecular force of attraction

Properties
- Have definite volume and shape
- Highly in compressible
- Does not diffuse easily in other solids
- Does not flow
- Have high m.p. and b.p.
- Have high density.
- Particles of solid cannot move but they can vibrate.

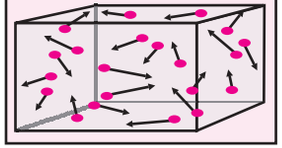
Liquid
- Have high intermolecular force of attraction than gases.
- Density of liquid is higher than gaseous state
- Compressibility of liquid is less than gas

Properties
- Have fixed volume but not shape
- Two soluble liquids diffuses in each other
- Liquids have property of evaporation



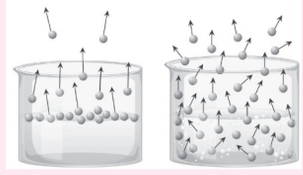
Gas
- Gases can be easily compressed
- Gases exert pressure equally in all directions
- Gases can be liquified by cooling

Properties
- Highly compressible
- Do not have fixed volume and shape
- Gases diffuse in each other
- Gases can be separated from mixture of gases by the use of process of diffusion.



Evaporation

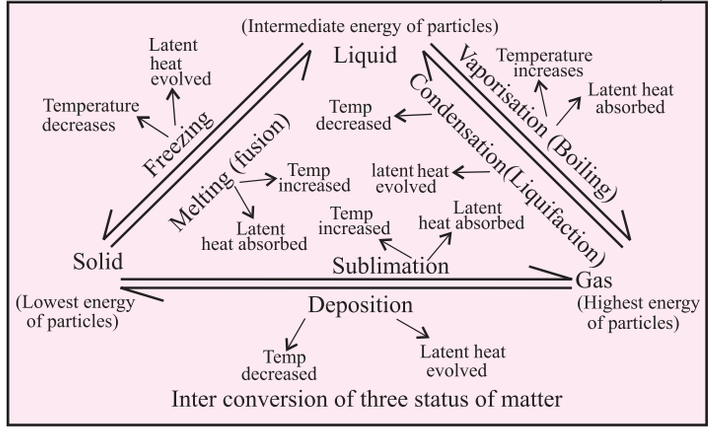
Evaporation
- Conversion of liquids into vapour is called evaporation.
- Evaporation occurs below the boiling point.
- Evaporation causes cooling.
- **Factors Affecting evaporation.**
  - $\propto$ Temperature
  - $\propto$ Surface Area
  - $\propto \frac{1}{\text{Humidity}}$
  - $\propto$ Wind speed



Evaporation Boiling

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

Interconversion of state



Inter conversion of three status of matter

Let's Revise Through FIB & T/F

1. Matter is made up of small ..... .
2. The forces of attraction between the particles are ..... in solids, ... in liquids and ..... in gases.
3. The smell of perfume gradually spreads across a room due to ..... .
4. Solid, liquid and gas are called the three ..... of matter.
5. ..... is the change of gaseous state directly to solid state without going through liquid state, and vice-versa.
6. As the temperature of a system increases, the pressure of the gases…..... .
7. Atoms in a liquid are farther apart than the atoms in a gas. **(T/F)**
8. The molecules in a gas are in constant motion. **(T/F)**
9. Gases present in air have the same pressure throughout the entire atmosphere. **(T/F)**
10. All materials move from solid to liquid to gas as the temperature increases. **(T/F)**
11. It is just as easy to compress a liquid, as it is to compress a gas. **(T/F)**
12. As the volume of a specific amount of gas decreases, it's pressure..... .
13. As the temperature of a gas decreases, its volume.....
14. Gas molecules at higher temperatures have more .....than at lower temperatures.
15. Evaporation causes ..... .
16. Latent heat of fusion is the amount of heat energy required to change 1 kg of solid into liquid at its .....
17. Boiling is a bulk phenomenon. **(T/F)**
18. Evaporation is a surface phenomenon. **(T/F)**
19. The rate of evaporation depends only on the surface area exposed to the atmosphere. **(T/F)**
20. 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. **(T/F)**
21. Water at room temperature is a liquid. **(T/F)**
22. Usually the total charge of a plasma is ..... .
23. The pressure inside a sealed tube, if you raise the temperature go..... .
24. Forces of attraction in liquids are ..... than in solids.
25. Because electrons have been stripped away from atoms in plasma, plasmas have a negative charge. **(T/F)**
26. Evaporation and boiling are the same processes because molecules move from a liquid to gaseous state. **(T/F)**
27. Liquids that move quickly downhill are described as having..... .
28. If we pour liquid nitrogen (N_2) into a glass, it will change its state to a solid. **(T/F)**
29. You may find plasma in a star. **(T/F)**
30. A system that changes from a solid state to a liquid state gains energy. **(T/F)**
31. Plasmas are all made of the same ions. They have different colours due to different amounts of electricity. **(T/F)**
32. Rapid evaporation depends on the ..... area exposed to atmosphere.

EXERCISE-1 Master Board

Multiple Choice Questions (MCQs)

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

1. Which of the following does not undergo sublimation process?
   (a) Sodium chloride (b) Ammonium chloride
   (c) Iodine (d) Naphthalene
2. Which among the following can termed as fluid?
   (a) Sulphur (b) Carbon
   (c) Oxygen (d) Phosphorus
3. On increasing the temperature of diffusing substance rate of diffusion:
   (a) Decreases (b) Increases
   (c) Unchanged (d) Either (a) or (b)

4. Solid carbon dioxide can change to gaseous carbondioxide when left open in air by
   (a) increasing pressure
   (b) decreasing pressure
   (c) decreasing temperature
   (d) none of these.

5. A form of matter has no fixed shape but it has a fixed volume. An example of this form of matter is :
   (a) Krypton (b) Kerosene
   (c) Carbondioxide (d) Coal

6. 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.

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 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

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

10. The change of a liquid into vapour is called
   (a) vapourization (b) solidification
   (c) sublimation (d) liquefaction

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

15. If you leave water in a glass and some molecules turn into vapours, it is called...
   (a) freezing (b) evaporation
   (c) extinction (d) solidification

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

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

18. 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

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

20. S.I. unit of temperature is :
   (a) Celsius (b) Fahrenheit
   (c) Kelvin (d) None of these

21. 10 K is equal to :
   (a) 283°C (b) –263°C
   (c) 263°C (d) –283°C

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

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

24. 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

Assertion & Reason Questions

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 :** Tiny dust particles suspended in air shows Brownian motion.
Reason : The zig-zag movement of small particles suspended in liquid or gas is called brownian motion.

2. **Assertion :** Gases are easily compressible.
Reason : Intermolecular space is minimum for gases.

3. **Assertion :** Dissolved gases like carbondioxide and oxygen are essential for the survival of aquatic plants and animals.
Reason : This is an example of diffusion of gases into liquid.

4. **Assertion :** The melting point of ice on celsius scale of temperature is 0°C and on kelvin scale it is –273 K.
Reason : Temp. on kelvin scale = temp on celsius scale + 273 K

5. **Assertion :** freezing is reverse of melting.
Reason : The process of changing a liquid into a solid by reducing its temperature is called freezing.

Passage/Case Based Questions

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

There are four substance W, X, Y and Z. The substance W is a dark violet solid having diatomic molecules. A solution of W in alcohol is used as a common antiseptic C. The substance X is a white solid which is usually recovered from sea water on a large scale. The substance Y is white solid which is insoluble in water and used in the form of small balls for the safe storage of woolen clothes. The substance Z is a yet another white solid which is used in making commonly used dry cells.

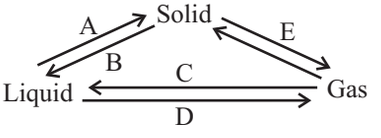
1. Name (i) W (ii) X (iii) Y and (iv) Z.
2. Out of W, X, Y and Z which substance/substances can undergo sublimation?
3. Which substance is organic in nature ?
4. what is the name of substance C?
5. Which substance belongs to the halogen family ?

Very Short Answer Questions

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 liquefied ?
4. What is sublimation ? Give examples.
5. Define latent heat of fusion.
6. Define latent heat of vaporization.
7. How can the boiling point of a liquid be raised, without adding any impurity ?
8. In how many forms did the earlier scientists classify matter?
9. 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 and Why?
10. At a given temperature, a 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 ?
11. A drop of dettol got evenly distributed in water. How ?
12. 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 ?
13. 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

1. What is condensation ? How is the condensation of a gas carried out ?
2. The following diagram shows the three states of matter and how they can be interchanged.
Name the changes A to E.



3. Why does a summer rainstorm lower the temperature? **(Reasoning)**
4. Why solids do not diffuse ? **(Reasoning)**
5. Convert the following Kelvin temperatures to degree Celsius.
   (i) 175 K (ii) 295 K
   (iii) 300 K (iv) 225 K
6. Which state of matter is compressible ? Why ? **(Reasoning)**
7. Why do the gases exert more pressure on the walls of the container than the solids ? **(Reasoning)**
8. Liquid mix more slowly than gases. Why ? **(Reasoning)**
9. Explain the diffusion of copper sulphate into water.
10. Why do gases have neither a fixed volume nor a fixed shape? **(Reasoning)**
11. 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?
12. Why honey is more viscous than water? **(Reasoning)**
13. Why diffusion occurs more quickly in a gas than in liquid? **(Reasoning)**
14. Describe why a drop of food color in a glass of water slowly becomes evenly distributed without the need for stirring?
15. Why is solid carbondioxide known as dry ice? **(Reasoning)**
16. Why does evaporation cools nearby surface? **(Reasoning)**

Long Answer Questions

1. Explain why ?
   (i) Camphor disappears without leaving any residue.
   (ii) The temperature does not rise during the process of melting and boiling, though heat energy is constantly supplied.
   (iii) An iron almirah is a solid at room temperature.
2. Which phenomenon occurs during the following changes?
   (i) Size of naphthalene 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

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. 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?
5. 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.
6. What are super cooled liquids?
7. How water below the surface of earth rises to plants through the roots?
8. What is implied by the word “equilibrium” in equilibrium vapour pressure ?
9. Why do the doctors advice to put strips of wet cloth on the forehead of a person having high temperature ?
10. 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?

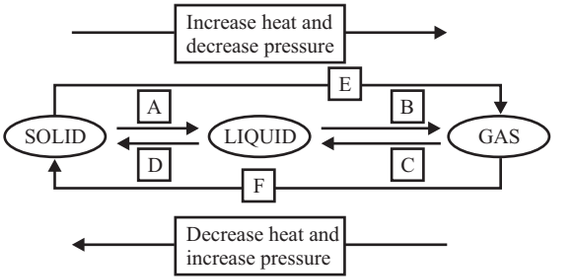
EXERCISE-2 NCERT Questions

Intext-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, exhausting 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 celsius 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 liquefy 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 Celsius 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. Which one of the following sets of phenomena would increases on raising the temperature?
(a) Diffusion, evaporation, compression of gases
(b) Evaporation, compression of gases, solubility
(c) Evaporation, diffusion, expansion of gases
(d) Evaporation, solubility, diffusion, compression of gases

2. Seema visited a Natural Gas compressing Unit and found that the gas can be liquefied under specific conditions of temperature and pressure. While sharing her experience with friends she got confused. Help her to identify the correct set of conditions.
(a) Low temperature, low pressure
(b) High temperature, low pressure
(c) Low temperature, high pressure
(d) High temperature, high pressure

3. The property to flow is unique to fluids. Which one of the following statements is correct?
(a) Only gases behave like fluids
(b) Gases and solids behave like fluids
(c) Gases and liquids behave like fluids
(d) Only liquids are fluids

4. During summer, water kept in an earthen pot becomes cool because of the phenomenon of
(a) diffusion (b) transpiration
(c) osmosis (d) evaporation

5. A few substances are arranged in the increasing order of 'forces of attraction' between their particles. Which one of the following represents a correct arrangement?
(a) Water, air, wind
(b) Air, sugar, oil
(c) Oxygen, water, sugar
(d) Salt, juice, air

6. On converting 25°C, 38°C and 66°C to kelvin scale, the correct sequence of temperature will be
(a) 298 K, 311 K and 339 K
(b) 298 K , 300 K and 338 K
(c) 273 K, 278 K and 543 K
(d) 298 K, 310 K and 338 K

7. Choose the correct statement of the following.
(a) Conversion of solid into vapours without passing through the liquid state is called vaporisation.
(b) Conversion of vapours into solid without passing through the liquid state is called sublimation.
(c) Conversion of vapours into solid without passing through the liquid state is called freezing.
(d) Conversion of solid into liquid is called sublimation.

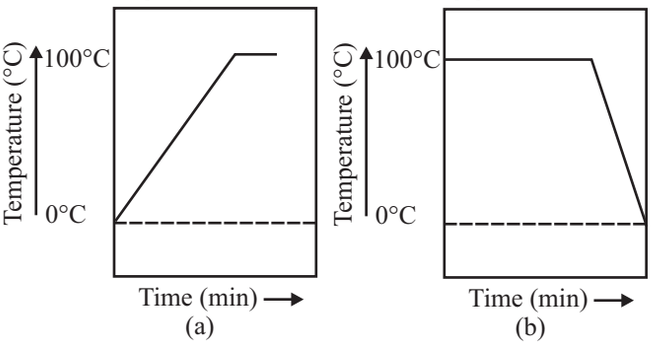
8. The boiling points of diethyl ether, acetone and n - butyl alcohol are 35°C, 56°C and 118°C, respectively. Which one of the following correctly represents their boiling points in kelvin scale?
(a) 306 K, 329 K, 391 K
(b) 308 K, 329 K, 392 K
(c) 308 K, 329 K, 391 K
(d) 329 K, 392 K, 308 K

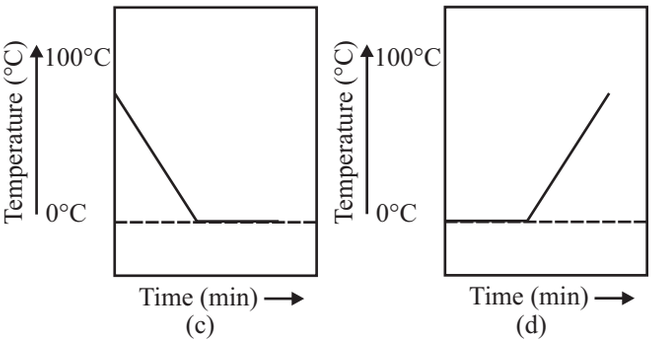
9. Which condition out of the following will increase the evaporation of water?
(a) Increase in temperature of water
(b) Decrease in temperature of water
(c) Less exposed surface area of water
(d) Adding common salt to water

10. In which of the following conditions, the distance between the molecules of hydrogen gas would increase?
(i) Increasing pressure on hydrogen contained in a closed container.
(ii) Some hydrogen gas leaking out of the container.
(iii) Increasing the volume of the container of hydrogen gas.
(iv) Adding more hydrogen gas to the container without increasing the volume of the container.
(a) (i) and (ii) (b) (i) and (iv)
(c) (ii) and (iii) (d) (ii) and (iv)

11. A sample of water under study was found to boil at 102°C at normal temperature and pressure. Is the water pure? Will this water freeze at 0°C? Comment.

12. A student heats a beaker containing ice and water. He measures the temperature of the content of the beaker as a function of time. Which of the following would correctly represent the result? Justify your choice.





13. 'Osmosis is a special kind of diffusion'. Comment.

14. Classify the following into osmosis/ diffusion.

(a) Swelling up of a raisin on keeping in water.

(b) Spreading of virus on sneezing.

(c) Earthworm dying on coming in contact with common salt.

(d) Shrinking of grapes kept in thick sugar syrup.

(e) Preserving pickles in salt.

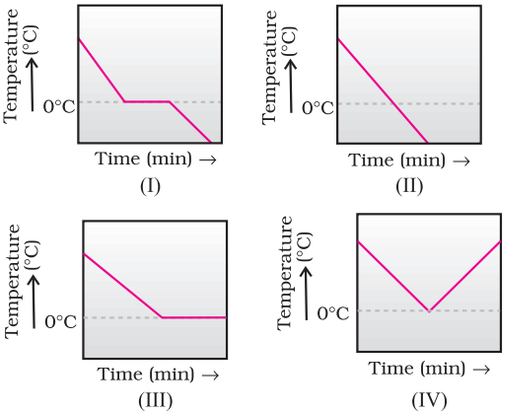
(f) Spreading of smell of cake being baked through out the house.

(g) Aquatic animals using oxygen dissolved in water during respiration.

15. Water as ice has a cooling effect, whereas water as steam may cause severe burns. Explain these observations.

16. 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.

17. A glass tumbler containing hot water is kept in the freezer compartment of a refrigerator (temperature < 0°C). If you could measure 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.



18. 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?

19. 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?

20. Why does the temperature of a substance remain constant during its melting point or boiling point?

21. Comment on the following statements.

(a) Evaporation produces cooling.

(b) Rate of evaporation of an aqueous solution decreases with increase in humidity.

(c) Sponge though compressible is a solid.

EXERCISE-3 Foundation Builder

Multiple Choice Questions (MCQs)

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. Select the one that when used would be considered as best condition for liquefaction 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.

2. Dry ice is :

(a) ice having no water of crystallisation

(b) ice that has been dried

(c) solid carbon dioxide

(d) None of these

3. The one, in which interparticle forces are strongest, is

(a) sodium chloride (b) hydrogen

(c) ether (d) carbon dioxide

4. 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

5. 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

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

7. What happens when a fixed amount of oxygen gas is taken in a cylinder and compressed at constant temperature? **[NTSE]**
(i) Number of collisions of oxygen molecules at per unit area of the wall of the cylinder increase.
(ii) Oxygen (O_2) gets converted into ozone (O_3).
(iii) Kinetic energy of the molecules of oxygen gas increases.
(a) (i) and (ii) (b) (ii) and (iii)
(c) (iii) only (d) (i) only

8. KE (Kinetic Energy) of molecules in gases is directly proportional to **[JSTSE]**
(a) Temperature
(b) Pressure
(c) Temperature and Pressure
(d) Atmospheric Pressure

9. According to Graham's law, the rate of diffusion of CO, O_2, N_2 and CO_2 follows the order **[KVPY]**
(a) $CO = N_2 > O_2 > CO_2$
(b) $CO = N_2 > CO_2 > O_2$
(c) $O_2 > CO = N_2 > CO_2$
(d) $CO_2 > O_2 > CO > N_2$

10. At 100°C steam has more heat energy than the energy of boiling water because **[JSTSE]**
(a) Steam has lesser kinetic energy than boiling water
(b) Steam has latent heat of vaporization
(c) Steam has lesser potential energy than boiling water
(d) All the reasons given above

11. The correct order of increasing intermolecular forces of attraction in the following substances is **[JSTSE]**
(a) water < sugar < carbon dioxide < acetone
(b) carbon dioxide < acetone < water < sugar
(c) sugar < water < acetone < carbon dioxide
(d) carbon dioxide < water < acetone < sugar

12. At a constant pressure p, the plot of volume (V) as a function of temperature (T) for 2 moles of an ideal gas gives a straight line with a slope 0.328 LK^{-1}. The value of p (in atm) is closest to
[Gas constant, R = 0.0821 L atm mol^{-1} K^{-1}] **[KVPY]**
(a) 0.25 (b) 0.5
(c) 1.0 (d) 2.0

13. Which of the following statements is correct for the melting of ice? **[JSTSE]**
(a) At 0°C water exists only in the solid state
(b) At 0°C water exist in solid as well as in liquid state
(c) At 0°C vapour pressure of ice is equal to vapour pressure of liquid water
(d) Both (b) and (c) are correct

14. Arrange the following in increasing order of their intermolecular force of attraction **[JSTSE]**
(i) Salt
(ii) Water
(iii) Carbon dioxide (CO_2)
(a) (iii) < (ii) < (i) (b) (i) < (ii) < (iii)
(c) (ii) < (i) < (iii) (d) (iii) < (i) < (ii)

15. If 20 mL of ethanol is present in 50 mL of its aqueous solution. The concentration of this solution is: **[JSTSE]**
(a) 20% (b) 25% (c) 30% (d) 40%

16. The number of moles of water present in a spherical water droplet of radius 1.0 cm is
[Given: density of water in the droplet = 1.0 g cm^{-3}] **[KVPY]**
(a) $\frac{\pi}{18}$ (b) $\frac{2\pi}{27}$ (c) 24π (d) $\frac{2\pi}{9}$

17. Which is the most favourable condition of liquefaction of ammonia? **[JSTSE]**
(a) High pressure, high temperature
(b) High pressure, low temperature
(c) Low pressure, low temperature
(d) Low pressure, high temperature

18. Which of the following has more heat content? **[JSTSE]**
(a) 10 g of ice at 0°C (b) 10 g of water at 0°C
(c) Both have the same (d) Can't say

19. Which of the following weighs is maximum? **[JSTSE]**
(a) 0.5 mole of H_2O (b) 0.5 mole of C_2H_6
(c) 1 mole of NH_3 (d) 0.1 mole of CO_2

20. Which of the following represents the correct increasing order of the rigidity of the given substances? **[Olympiad]**

(a) Milk < Nitrogen < Book
(b) Stone < Oxygen < Oil
(c) Alcohol < Salt < Carbon dioxide
(d) Hydrogen < Petrol < Wooden block

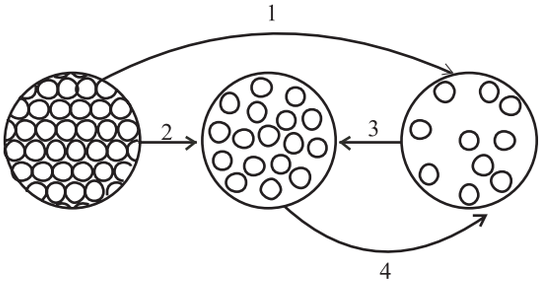
21. Consider the following statements. **[Olympiad]**

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.

Which of the following statements are correct ?

(a) A and B (b) B and D
(c) A, C and D (d) A, B and C

22. The following figure shows the changes in the three states of matter of a substance X. **[Olympiad]**



Select the incorrect statements about these changes.

I. Change 1 requires a decrease in temperature and an increase in pressure and is also called sublimation.
II. Change 3 can be carried out by decreasing pressure and increasing temperature.
III. Change 2 can be brought by heating the given substance.
IV. Change 4 can be carried out in the presence of heat.

(a) I and IV only (b) II and III only
(c) I and II only (d) III and IV only

23. Boyle's law states that

(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

24. Which of the following expression at constant pressure represents Charle's law?

(a) $V \propto \frac{1}{T}$ (b) $\propto$ —

(c) $V \propto T$ (d) $V \propto d$

25. 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

26. 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.

27. 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

28. 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.

29. 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) $\frac{V_1V_2}{T_1T_2} = P_1P_2$

30. 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

31. Kinetic theory of gases proves

(a) only Boyle's law (b) only Charles' law
(c) only Avogadro's law (d) All of these

32. 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

33. 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.

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

35. 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

36. If temperature increases, the surface tension of a liquid:
(a) increases
(b) decreases
(c) remains the same
(d) increases then decreases

37. Which diffuses faster and by how much, the bad smell from a cat-pan due to ammonia or an expensive French perfume with an average molecular weight of 170 g/mol?
(a) Cat-pan diffuses 100 times slower than French perfume.
(b) Cat-pan diffuses 10 times faster than French perfume.
(c) Cat-pan diffuses 10 times slower than French perfume.
(d) Cat-pan diffuses 100 times faster than French perfume.

38. 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.
(a) 11 g/mL (b) 10.8 g/mL
(c) 10.5 g/mL (d) 11.5 g/mL

39. What volume in millilitres does a sample of nitrogen with a mass of 0.245g occupy at 21°C and 750 torr ?
(a) 213 (b) 210 (c) 196 (d) 200

40. The label on a cylinder of a noble gas become unreadable, 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 (in g/mol)?
(a) 122 (b) 133 (c) 210 (d) 156

41. 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?
(a) 102°C (b) 105°C
(c) 110°C (d) 125°C

42. 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?
(a) 177 K (b) 450 K
(c) 178 K (d) 476 K

43. A gas occupies 500 mL at 40°C and 800 mm pressure. What volume will it occupy at 353°C and 600 mm pressure?
(a) 1031 mL (b) 1355.12 mL
(c) 1256.21 mL (d) 1333.33 mL

44. When does a gas deviate the most from its ideal behaviour? **[NTSE]**
(a) At low pressure and low temperature
(b) At low pressure and high temperature
(c) At high pressure and low temperature
(d) At high pressure and high temperature

45. Which of the following is not an assumption of the kinetic theory of gases? **[NTSE]**
(a) Gas particles have negligible volume.
(b) A gas consists of many identical particles which are in continual motion.
(c) At high pressure, gas particles are difficult to compress.
(d) Collisions of gas particles are perfectly elastic.

46. The number of water molecules is maximum in :
(a) 18 molecules of water **[JSTSE]**
(b) 1.8 gram of water
(c) 18 gram of water
(d) 18 moles of water

47. Equal moles of hydrogen and oxygen gases are placed in a container with a pin-hole through which both can escape. What fraction of the oxygen escapes in the time required for one-half of the hydrogen to escape ? **[JSTSE]**
(a) 1/8 (b) 1/4
(c) 3/8 (d) 1/2

48. An unknown chlorohydrocarbon has 3.55% of chlorine. If each molecule of the hydrocarbon has one chlorine atom only, chlorine atoms present in 1g of chlorohydrocarbon are:
(Atomic wt. of Cl = 35.5u; Avogadro constant = 6.023×10^{23} mol^{-1}) **[NTSE]**
(a) 6.023×10^{9} (b) 6.023×10^{23}
(c) 6.023×10^{21} (d) 6.023×10^{20}

49. In which case is number of molecules of water maximum?
(a) 18 mL of water **[JSTSE]**
(b) 0.18 g of water
(c) 10^{-3} mol of water
(d) 0.00224 L of water vapours at 1 atm and 273 K

50. The number of moles of hydrogen molecule required to produce 20 moles of ammonia through Haber's process is: **[NTSE]**
(a) 10 (b) 20 (c) 30 (d) 40

51. A mixture of N2 and Ar gases in a cylinder contains 7 g of N2 and 8 g of Ar. If the total pressure of the mixture of the gases in the cylinder is 27 bar, the partial pressure of N2 is:
[Use atomic masses (in g mol–1) : N = 14, Ar = 40]
(a) 12 bar (b) 15 bar **[JSTSE]**
(c) 18 bar (d) 9 bar

52. Which one of the followings has maximum number of atoms ? **[JSTSE]**
(a) 1 g of Mg(s) [Atomic mass of Mg = 24]
(b) 1 g of O2(g) [Atomic mass of O = 16]
(c) 1 g of Li(s) [Atomic mass of Li = 7]
(d) 1 g of Ag(s) [Atomic mass of Ag = 108]

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) It 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 liquefied by lowering the temperature and 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 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.

14. 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 $mol^{-1}k^{-1}$

15. 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.

16. 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.

Assertion & Reason Questions

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 decreases 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.

4. **Assertion :** Ideal gas equation is valid at low pressure and high temperature.
Reason : Molecular interactions are negligible under this condition.

5. **Assertion :** Plot of P vs. $1/v$ is a straight line.
Reason : Pressure is directly proportional to volume.

Passage/Case Based Questions

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

Passage-I

During evaporation, the heat needed is absorbed from the surrounding 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 thus, 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 fall in temperature or 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

Passage-II

Chlorine is widely used to purify municipal water supplies and to treat swimming pool water. In most private swimming pods, chlorine itself is not used, but rather. Sodium hypochlorite, formed from chlorine and sodium hydroxide, or solid tablets of chlorinated isocyanurates. The drawback of using chlorine in swimming pools is that the chlorine reacts with the protein in human hair and skin. Suppose that the volume of a particular sample of Cl_2 gas is 9.22 L at 1124 torr and 24°C.

4. 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

5. 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

6. 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

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)

2.

	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)

Integer/Numerical Value Type Questions

DIRECTIONS : *Following are integer/numerical value type questions. Each question, when worked out will result in one integer/numerical value.*

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?

3. 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*.

4. 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

Let's Revise Through FIB & T/F

1. particles
2. maximum, intermediate, minimum
3. diffusion
4. states
5. Sublimation
6. increases
7. False
8. True
9. False
10. True
11. False
12. increases
13. decreases
14. kinetic energy
15. cooling
16. melting point
17. True
18. True
19. False
20. False
21. True
22. zero
23. up
24. weaker
25. False
26. False
27. low viscosity
28. False
29. True
30. True
31. False
32. surface

EXERCISE-1 **Master Board**

Multiple Choice Questions (MCQs)

1. **(a)** Sodium chloride
2. **(c)** Oxygen
3. **(b)** When the temperature of a substance increased by heating kinetic energy of its particle increases which increases rate of diffusion.
4. **(b)** decreasing pressure and increasing atmospheric temperature.
5. **(b)** Liquid has no fixed shape but it has a fixed volume.
6. **(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.
7. **(d)** This is due to diffusion of particles of potassium permanganate into intermolecular spaces between particles of water.
8. **(b)** $K = 273 + t°C$

   $K = 273 + 78 = 351$ K
9. **(d)** Boiling point of water = 100°C = 100 + 273 = 373K
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. **(b)** Crystal is a solid and even on crushing it you will get smaller crystals (solid).
15. **(b)**
16. **(d)** After 1990s five states of matter are known solid, liquid, gas, plasma and Bose Einstein condensate.
17. **(a)** 18. **(d)** 19. **(c)** 20. **(c)**
21. **(b)** $TK = 273 + t\ °C$

    $10K = 273 + t\ °C$

    $t\ °C = -263\ °C$
22. **(a)** 23. **(c)** 24. **(b)**

Assertion & Reason Questions

1. **(b)** Tiny dust particles move here and there and constantly hit by the fast moving particles of air. Hence they show brownian motion.
2. **(c)** Intermolecular space is maximum for gases.
3. **(b)** Aquatic plant uses dissolved carbondioxide for photosynthis process and aquatic animals uses dissolved oxygen for breathing.
4. **(d)** Melting point of ice on kelvin scale is 273 K.
5. **(a)**

Passage/Case Based Questions

1. (i) Iodine (ii) Sodium chloride (Common Salt) (iii) Naphthalene (iv) Ammonium chloride
2. W (iodine), Y (naphthalene) and Z (ammonium chloride)
3. Y (Naphthalene)
4. Tincture of Iodine
5. W (Iodine)

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

   solid $\rightleftharpoons$ gases

   e.g., solid CO_2 gets directly converted into gaseous form.
5. 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. 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. By increasing pressure on liquid.
8. They classified the matter in four forms: air, earth, fire and water.
9. Higher the vapour pressure, faster the liquid evaporates, more quickly it cools and lower will be its temperature.
10. The liquid with the higher vapour pressure (420 torr) has the lower boiling point. It also probably has the lower heat of vaporization.
11. This is because there is enough space between the particles of water and dettol particles go into the spaces between the particles of other matter (water).
12. K = °C + 273 = – 196 + 273 = 77 K
13. 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. A–freezing, B–melting, C–condensation
   D–evaporation, E–sublimation
3. Water evaporates quickly on a hot day and thus lowers the air temperature.
4. 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.
5. (i) –98°C (ii) 22°C
   (iii) 27°C (iv) – 48°C
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 gaseous 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. Since gas molecules are far apart, therefore intermolecular forces of attraction between a particular gas molecules are less in comparison to liquids. Thus gas molecules of one type mix more easily with gas molecules of another type in comparison to liquids.
9. 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.

10. Intermolecular force of attraction in gases is negligible. Molecules are far away from each other in gases and thus they do not have fixed shape because the position of its particle is not fixed. A gas also does not have fixed volume because spaces between the particles is not fixed. Gaseous particle are in the state of constant random motion. They take the shape and volume of its container.
11. 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.
12. Molecules of honey are much closer than water. Therefore intermolecular force of attraction between the molecules of honey is greater than water which make honey more viscous than water.
13. Intermolecular force of attraction between the molecules in liquid is much more than in gaseous state. It results into greater intermolecular distance in gaseous state. As the gaseous molecules are further away from each other therefore they can easily diffuse into the surrounding as compared to molecules in liquid state.
14. Both the liquid molecules and food color molecules are in motion. Through constant motion and collisions the food color molecules eventually become dispersed among the water molecules.
15. Solid carbondioxide directly changes to carbondioxide gas or sublimes. It does not melt to produce liquid like ordinary ice. Therefore it is called as dry ice. Dry ice is used to deep freeze food and it is more effective for cooling than ordinary ice.
16. Evaporation is surface phenomenon. The particles of liquid absorb energy from the surroundings to regain the energy lost during the process of evaporation. Absorption of energy from nearby surface reduces the temperature and hence causes cooling of the nearby surface.

Long Answer Questions

1. (i) Camphor is a substance which undergo sublimation easily. Thus it gets converted into vapour form directly from solid state without first being converted into liquid.
   (ii) 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.
   (iii) 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 has high melting and boiling point.
2. (i) Naphthalene balls gets converted into vapour form directly without being first converted into liquid state. Thus the size of naphthalene 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, the molecules in liquids are close to each other. Therefore, density of liquids is higher than the gases.
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.

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 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. 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 short duration, during which a small cut in an abscess or infected finger may be made without pain.
5. (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
6. A super cooled liquid is liquid which has not crystallized to freeze below its freezing point.
7. 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.
8. 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.
9. 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.
10. 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.

EXERCISE-2 NCERT Questions

Intext-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 matter :

	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	The process of diffusion is slow.	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 container: 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 mixture gases. 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 also 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 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 celsius 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 vapour state. At 250°C, water is present in vapour state only.

(b) At 100°C, there is equilibrium between vapour state and liquid state i.e., both states liquid and vapours 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 liquefied 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 reflects heat. Cotton clothes 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 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 vapours mixes 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 equilibrium.

6. (a) Liquid state has some molecular force of attraction which is greater than that in the vapour state. Room temperature does not provide sufficient amount of energy to overcome that molecular force of attraction. Therefore water remains in liquid state at room temperature.

(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 surrounding gets lowered and cooling occurs. 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 liquefaction)
D = Solidification (or freezing)
E = Sublimation
F = Sublimation

Exemplar Questions

1. **(c)** **Evaporation, diffusion** and **expansion** of gases increase on raising the temperature. Evaporation rate increases because on increasing temperature, kinetic energy of molecules increases, so the molecules present at the surface of the liquid leave the surface quickly and go into the vapour state. Diffusion and expansion of gases also increase as the molecules move more rapidly and try to occupy more space.

2. **(c)** Low temperature and high pressure are required to liquefy gases to liquids. There is a lot of space between the particles of a gas. On applying high pressure, the particles of gas move get so close that they start attracting each other sufficiently forming a liquid, When gas is compressed too much heat is produced, so it is necessary to cool it. Cooling lowers the temperature of compressed gas and helps in liquefying it. Hence, a gas can be liquefied by applying high pressure and lowering the temperature (cooling).

3. **(c)** Gases and liquids behave like fluids Both gases and liquids tend to flow due to less force of attraction between their particles. Also, they require vessel to keep them, Solids do not flow.

4. **(d)** During summer, water kept in an earthen pot becomes cool because of the phenomenon of evaporation. Earthen pot has a large number of tiny pores in its walls and some of the water molecules continuously keep seeping through these pores to outside the pot.

This water evaporates continuously and take the latent heat required for vaporisation from the remaining water. In this way, the remaining water loses heat and gets cooled.

5. **(c)** The correct order of increasing 'force of attraction' between their particles is

Oxygen < Water < Sugar

It is because the force of attraction increases in the order i.e., Gas < Liquid < Solid.

6. **(a)** Therefore, the correct sequence of temperature will be 298 K, 311 K and 339 K. On converting 25°C, 38°C and 66°C, to kelvin scale, we get the following temperatures

25° C + 273 = 298 K $\Rightarrow$ 38°C + 273 = 311 K $\Rightarrow$ 66°C + 273 = 339K

Therefore, the correct sequence of temperature will be 298 K, 311 K and 339 K.

7. **(b)** Conversion of solid into vapours on heating or vapours into solid on cooling without undergoing in liquid state is called **sublimation**.

The conversion of liquid into gas (vapour) is called vapourisation.

The conversion of liquid into solid is called **freezing**.

The conversion of solid into liquid is called **melting**.

8. **(c)** The correct order of boiling points of diethyl ether, acetone and *n*-butyl alcohol in kelvin scale is 308 K, 329 K and 391 K, which can be explained as ($\because$ T°C + 273 = TK).

Boiling point of diethyl ether

= 35°C + 273 = 308 K

Boiling point of acetone = 56°C + 273 = 329 K

Boiling point on *n*-butyl alcohol

= 1178°C + 273 = 391 K

9. **(a)** Increase in temperature of water will increase the evaporation of water. It is because, on increasing the temperature, kinetic energy of water molecules increases and more particles get enough kinetic energy to go into the vapour state.

This increases the rate of evaporation. Evaporation is the surface phenomenon so it depends upon the exposed surface area. Higher the exposed surface area of water, higher will be the evaporation. When common salt is added to water then surface is occupied by the solvent as well as non - volatile solute particles.

So, the escaping tendency of solvent particles decreases and thus the evaporation of water decreases. Therefore, other options (b), (c) and (d) will decrease the evaporation of water.

10. **(c)** (ii) and (iii) are the correct options because in option (ii) hydrogen gas leaking from the container leaves some vacant space inside the container. So, hydrogen gas molecules inside the container occupy all the space available and the distance between the molecules of hydrogen gas will be increased.

In option (iii), on increasing the volume of the container of hydrogen gas, more space will be available inside the container and hydrogen gas molecules will occupy all the space available and hence distance between in molecules will be increased.

In option (i) on increasing pressure, hydrogen molecules will come closer and the distance between them will be decreased.

In option (iv) more hydrogen gas molecules are available in less volume, so the distance between them will be decreased.

11. No, the water is not pure. It is because, the boiling point of pure water is 100°C but the given sample boils at 102°C. It indicates that it has some dissolved impurities.

No, the water will not freeze at 0°C. Instead it will freeze below 0°C as it has impurities dissolved in it.

12. Figure (d) would correctly represent the result. Because when heat is provided to the mixture of water and ice at 0°C, the ice absorbs this heat and converts it into the water at 0°C. During this period, there is no rise in temperature. On further heating, the temperature starts rising.

This is because, in ice (solid), the particles attract one another with strong forces. The heat which we supply to ice during melting is all used up to overcome the forces of attraction between ice particles, so that they become loose and form liquid water.

This heat does not increases the kinetic energy of particles and hence no rise in temperature takes place during the melting of ice. When all the ice has melted forming water, further heating increases the kinetic energy of water, due to which the temperature of water, starts rising sharply.

13. Diffusion is the process in which molecules of a substance move from the place of their higher concentration to the place of their lower concentration (no membrane is required). But during osmosis, the solvent (water) molecules move from the place of their higher concentration to the place of their lower concentration through a semi - permeable membrane. Thus, osmosis is termed as a special kind of diffusion.

14. *Osmosis* occurs in

(a) Swelling up of a raisin on keeping in water.

(c) Earthworm dying on coming in contact with common salt.

(d) Shrinking of grapes kept in thick sugar syrup.

(e) Preserving pickles in salt.

Diffusion occurs in

(b) Spreading of virus on sneezing.

(f) Spreading of smell of cake being baked throughout the house.

(g) Aquatic animals using oxygen dissolved in water during respiration.

15. When ice melts, it absorbs the energy equal to the latent heat of fusion from the surroundings, therefore causes cooling effect. But steam releases the extra heat (equal to the latent heat of vaporisation) which it has absorbed when water was converted into steam. So, steam produces severe burn.

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

17. 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.

18. 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.

19. 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.

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

21. (a) Evaporation produces cooling. This is based on the fact that when a liquid evaporates, it takes (or draws) the latent heat of vaporisation from 'another matter' which it touches. This 'another matter'. looses heat and gets cooled. Therefore, evaporation causes cooling.

(b) If humidity is high, then air is already saturated with water vapours, i.e., it has a lot of water vapours. Therefore, it will not take more water vapours easily. Hence, rate of evaporation decreases.

(c) Sponge has minute holes in which air is trapped. The material is also not so rigid. On pressing this, air is expelled out, that is why it can be compressed but it is solid as it has a definite shape and volume and does not change its shape unless compressed.

EXERCISE-3 **Foundation Builder**

Multiple Choice Questions (MCQs)

1. (c) **2.** (c)
3. (a) **4.** (b)
5. (d) **6.** (d)

7. (d) On compressing the gas, pressure increases and volume decreases therefore number of collision of molecules at per unit area of the wall of the cylinder increases.

8. (a) KE $\propto$ temperature

9. (a) According to Graham's law,

$$r \propto \frac{1}{\sqrt{M}}$$

Therefore, the order of rate of diffusion will be

$CO = N_2 > O_2 > CO_2$

10. (b) At 100°C steam has more heat energy than the energy of boiling water because steam has latent heat of vaporization.

11. (b) Increasing order of intermolecular forces of attraction

carbon dioxide < acetone < water < sugar

12. (b) According to ideal gas equation

$pV = nRT$ = slope

Given, slope = 0.328, n = 2

$$\therefore \quad p = \frac{nR}{\text{slope}} = \frac{2 \times 0.0821}{0.328} = 0.500 \text{ atm}$$

13. (d) At melting point both state exists together & both have same vapour pressure.

14. (a)

15. (d) Vol.% = volume of solute / volume of solution × 100

= 20/50 × 100

= 40%

16. (b) Volume of a spherical water droplet

$$= \frac{4}{3}\pi r^3 = \frac{4}{3}\pi (1)^3$$

$$V = \frac{4}{3}\pi \text{ cm}^3$$

Mass of spherical water droplet

$$= P \times V = 1 \times \frac{4}{3}\pi = \frac{4}{3}\pi \text{ g}$$

18 g of water = 1 mol

No. of moles of water in a spherical water droplet

$$= \frac{4\pi}{3 \times 18} = \frac{2\pi}{27}$$

17. (b) The most favourable conditions for liquefaction of ammonia are high pressure and low temperature.

18. (b) The heat content of 10 g of water at 0°C is more than 10 g of ice at 0°C because it has more energy which is equal to latent of fusion.

19. (c) 0.5 mole of $H_2O = 0.5 \times 18 = 9g$

0.5 mole of $C_2H_6 = 0.5 \times 30 = 15g$

1 mole of $NH_3 = 1 \times 17 = 17g$

0.1 mole of $CO_2 = 0.1 \times 44 = 4.4g$

$\therefore$ 1 mole of NH_3 weighs is maximum.

20. (d) The interparticle forces of attraction are maximum in solids, intermediate in liquids and minimum in gases. Hence, solids are most rigid, followed by liquids, then gases. Thus, the increasing order of rigidity of the given substances is:

Hydrogen < Petrol < Wooden block

21. (d) 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.

22. (c) Change 1 = Sublimation, requires heating and thus an increase in temperature. Thus, I is incorrect.

Change 2 = Fusion, requires heating and thus increase in temperature. Thus, III is correct.

Change 3 = Liquefaction , requires a decrease in temperature and increase in pressure. Thus, II is incorrect.

Change 4 = Evaporation, requires boiling (increase in temperature). Thus, IV is correct.

23. (b) Boyle's law

$$P \propto \frac{1}{V}; \quad P = \frac{k}{V}$$

$PV = k$ (where k is a constant)

24. (c) According to Charle's law $V \propto T$ or $\frac{V}{T} = \text{constant}$

25. (c) $PV = nRT$

$$\therefore \frac{n}{V} = \frac{P}{RT}$$

26. (d) According to Graham's law of diffusion,

$$d \propto \frac{1}{\sqrt{\rho}} \text{ or } \rho = \frac{M}{V} \quad (M = \text{molar mass})$$

27. (b)

28. (c) In the equation $PV = nRT$, n moles of the gas have volume V.

29. (b) $\frac{PV}{T} = \text{constant} \quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

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

30. (d) The statement of Dalton's law is

$P = P_A^\circ + P_B^\circ + \ldots\ldots\ldots\ldots P_n^\circ$

Where P is the total pressure P_A°, P_B° ..... are the partial pressure of the components of gaseous mixture.

31. (d) Kinetic theory of gases proves all the given gas laws.

32. (b) Liquid drops assume spherical shape because a sphere has minimum surface area.

33. (a) By Dalton's law of partial pressures, the total pressure of a mixture of two gases is the sum of the partial pressures.

34. (d) $P \propto \frac{1}{V}$ (at constant T)

PV = constant

35. (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 $H_2O > C_2H_5OH > CH_3OH$.

36. (b)

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

According to Graham's law of difussion

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

Molar mass of perfume is 10 times more than NH_3. Thus bad smell of ammonia diffuses 10 times faster than French perfume.

38. (c) Mass of silver = 62.00 g – 27.35 g = 34.65 g

Volume of silver = 18.3 mL – 15 mL = 3.3 mL

Densityofsilver=(massofsilver)/(volumeofsilver)

= (34.65g) / (3.3 mL) = 10.5 g/mL

39. (a) We will use the ideal gas law. First we need to know the number of moles of nitrogen :

No of moles of N_2

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

$$V = \frac{nRT}{P}$$

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

$= 0.213$ L $= 213$ mL

40. (b) Since, $PV = nRT$, then $n = PV/RT$

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

$$\text{Molar Mass} = \frac{1.45\text{g}}{0.0109\text{mol}} = 133\text{ g mol}^{-1}$$

41. (d) $V_1 = 400$ mL, $V_2 = 300$ mL

$T_1 = (227^\circ\text{C} + 273) = 500$ 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.

42. (a) $P_1 = 1140$ mm, $P_2 = 760$ mm, $V_1 = 200$ mL, $V_2 = 450$ mL

$T_1 = 27^\circ\text{C} + 273 = 300$ 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

43. (d) $P_1 = 800$ 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, $V_2 = \frac{P_1 V_1 T_2}{T_1 P_2}$

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

New volume = 1333.33 mL

44. (c) At high pressure and low temperature, gaseous atoms or molecules get closer to each other and van der Waal forces operates. So molecules or atoms start attracting each other. Hence a gas deviate the most from its ideal behaviour. While in ideal behaviour we consider that gases do not attract each, *i.e.*, there is no intermolecular forces of attraction.

45. (c) At high pressure real gas particles are easily compressed.

46. (d) No. of moles of water

In 1.8 g of H_2O = 0.1 moles

In 18 g of H_2O = 1 moles

1 mole contain 6.022×10^{23} molecules of water

therefore maximum number of molecules is in 18 moles of water.

47. (a) Given, $n_{H_2} = n_{O_2}$ and $t_{H_2} = t_{O_2}$

According to Graham's law of diffusion for two different gases.

$$\frac{r_{H_2}}{r_{O_2}} = \frac{v_1 / t_1}{v_2 / t_2} \Rightarrow \sqrt{\frac{M_{O_2}}{M_{H_2}}} = \sqrt{\frac{32}{2}}$$

$$\frac{1/2}{1/x} = \sqrt{16} = 4$$

$$\frac{x}{2} = 4$$

$\therefore x = 8$

$\therefore$ Fraction of $O_2 = 1/8$

48. (d) Given percentage of chlorine in an hydrocarbon = 3.55% i.e.,

100 g of chlorohydrocarbon has 3.55 g of chlorine.

1 g of chlorohydrocarbon will have

$\frac{3.55}{100} = 0.0355$ g

of chlorine.

Atomic wt. of Cl = 35.5 g/mol

Number of moles of Cl $= \frac{0.0355 \text{ g}}{35.5 \text{ g/mol}} = 0.001$ mole

Number of atoms of Cl

$= 0.001$ mole $\times 6.023 \times 10^{23}$ mol^{-1}

$= 6.023 \times 10^{20}$

49. (a)

(a) Mass of water = $18 \times 1 = 18$ g

Molecules of water = mole $\times N_A$

$= \frac{18}{18} N_A = N_A$

(b) Molecules of water = mole $\times N_A$

$= \frac{0.18}{18} N_A = 10^{-2} N_A$

(c) Molecules of water = mole $\times N_A = 10^{-3} N_A$

(d) Moles of water $= \frac{0.00224}{22.4} = 10^{-4}$

50. (c) $N_2 + 3H_2 \longrightarrow 2NH_3$

1 Mol $NH_3 = \frac{3}{2}$ mol H_2

20 mol $NH_3 = \frac{3}{2} \times 20$ mol $H_2 = 30$ mol H_2

$\therefore$ 30 moles of H_2 are required.

51. (b) $n_{N_2} = \frac{7}{28} = \frac{1}{4} = 0.25$

$n_{Ar} = \frac{8}{40} = \frac{1}{5} = 0.20$

Now, applying Dalton's law of partial pressure,

p_{N_2} = mole fraction of $N_2 \cdot P_{Total}$

$\frac{0.25}{0.45} \times 27 = \frac{5}{9} \times 27 = 15$ bar

52. (c) Number of atoms

$$= \frac{W}{\text{Molar mass}} \times N_A \times \text{atomicity}$$

(a) Number of Mg atoms $= \frac{1}{24} \times N_A \times 1$

(b) Number of O atoms $= \frac{1}{32} \times N_A \times 2$

(c) Number of Li atoms $= \frac{1}{7} \times N_A \times 1$

(d) Number of Ag atoms $= \frac{1}{108} \times N_A \times 1$

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 sometime becomes coloured that means liquid show phenomena of diffusion. Moreover no liquid diffuses 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.

14. (a, c, d)

15. (a, d) According to Boyle's law, $V \propto \frac{1}{P}$

$PV = \text{constant}$

According to Charle's law at constant pressure

$$\frac{V}{T} = \text{constant}$$

16. (a, b) At constant temperature, when gas expands the K.E. of the molecules remains the same, but the pressure decreases.

$\left(\because P \propto \frac{1}{V}\right)$

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

$T = 24°\text{C} = 24 + 273 = 297\ \text{K}$

From ideal gas equation

$PV = nRT$

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

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

Assertion & Reason Questions

1. (d) 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.

4. **(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.

5. **(c)** Assertion is true but reason is false.

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

Passage/Case Based Questions

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

4. **(a)** $PV = nRT$

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

$$= \frac{\frac{1124}{760} \times 9.22}{0.0821 \times 297}$$

$$n = 0.559 \approx 0.56$$

$$\text{No. of moles of } Cl_2 = \frac{\text{gram of } Cl_2 \text{ in sample}}{\text{Molecular mass of } Cl_2}$$

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

grams of Cl_2 in sample = 39.7 g

5. **(c)** At STP $P_2 = 1$ atm

$T_2 = 273$ K

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

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

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

$$V_2 = 12.458 \text{ L} \approx 12.5 \text{ L}$$

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

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

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

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

$$T_2 = 376.577 \text{ K} \approx 377 \text{ K}$$

Multiple Matching Questions

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

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

Integer/Numerical Value Type Questions

1. **(5)** Evaporation does not depends upon volume and density of liquid.

2. **(5)** Solid, Liquid, Gas, Plasmas and Bose-Einstein condensates.

3. **(6)** $P_1 = 3$ atm; $P_2 = \frac{x}{10}$

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

According to Boyle's law

$P_1V_1 = P_2V_2$

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

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

4. **(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)

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

$V_2 = 3.01 \text{ L} \approx 3\text{L}$

Think Out of the Box

Case Study-1

1. On heating, the solid particles get more kinetic energy and they start moving rapidly, with the result space between the particles increases. When the kinetic energy of particles and space between them become equal to the liquid, a solid changes into liquid.

On further heating the liquid particles receive more energy and they start moving more rapidly. due to increase in temperature kinetic energy and inter space of the particles increase. Hence, force of attraction between particles decreases enough, the particles of liquid start moving with great speed. In this condition a liquid is changed into the gas.

2. Plasma state of matter is responsible for fluorescent tube to glow. When the light is turned on, the electric power heats up the cathode enough for it to emit electrons. These electrons collide and ionize noble gas atoms inside the bulb surrounding the filament to form a plasma by the process of impact ionization.
3. Solid carbon dioxide is a white solid called dry ice and is generally used for deep freezing processes. When dry ice is kept exposed to air, then pressure is reduced to normal atmospheric pressure, its temperature rise, and it starts changing into CO_2 gas. Therefore, it is confirmed that to convert CO_2 gas to solid CO_2 (for reverse reaction), high pressure and low temperate is needed. We have also studied in case 2 that increasing the pressure and lowering the temperature can change the state of matter. Thus, CO_2 gas is also converted into solid ice at high pressure and low temperature.

Case Study-2

1. Burning caused by steam are much more severe than boiling water because steam contains more latent heat of vaporization than boiling water.
2. It means that 3.34×10^5 joules of heat is required to change 1 kg of ice at its melting point (0° C) into water at the same temperature i.e. 0° C.
3. During the melting of ice, ice takes the latent heat from our palm. Our palm loses heat to ice and hence we feel it to be cold.