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

Matter

Matter may be defined as anything that occupies space and possesses mass. All the things which we see or feel around us like air, water, plants, animals, stones, sand, ice, steel, etc. are termed as matter.

• Physical Nature of Matter

- Matter is made up of particles.
- The particles of matter have space between them.
- The particles of matter are continuously moving.
- The particles of matter are very small.
- The particles of matter attract each other.
- The above characteristics can be established by the following activities:



To demonstrate that particles of matter have spaces between them

- Take a beaker and fill it half with water.
- Mark the level of water.
- Dissolve some salt or sugar in it.
- **Observation:** Water level remains the same as earlier.
- Conclusion: When sugar or salt is dissolved in water, the particles of sugar or salt get into the spaces between particles of water.



To demonstrate that the particles of matter are very small

• Take 2-3 crystals of potassium permanganate and dissolve in 100 mL of water.

- Take 10 mL of this purple solution and mix with 90 mL of fresh water in second beaker.
- Take 10 mL of this second solution and mix with 90 mL of fresh water in third beaker.
- Take 10 mL of this third solution and mix with 90 mL of fresh water in fourth beaker.
- Dilute the solution five to six times.
- Observation: The water in the last beaker is still coloured and is light pink now.
- Conclusion: Just 2-3 crystals of potassium permanganate impart colour to a large volume of water. It shows that the particles of matter are very very small.



• Diffusion

- The intermixing of particles of two substances on their own is called diffusion.
- The rate of diffusion increases on heating, since with increase in temperature kinetic energy of the particles increases and they move faster.
- Diffusion occurs in gases, liquids and solids. The diffusion is fastest in gases because the particles in gases move very rapidly. The diffusion is slowest in solids because the particle in solids do not move much. The diffusion in liquids is, however, much faster than that ill solids and slower than that in gases.





To demonstrate that particles of matter are continuously moving

Experiment-I

- Light an agarbatti in one corner of a room.
- **Observation:** The fragrance spreads in the whole room quickly.
- Conclusion: The vapours of agrabatti are mixed with air and move rapidly in the room. Thus particles of matter are in continuous motion (Diffusion).

Experiment-II

- Put a few crystals of copper sulphate in a beaker containing water.
- Do not stir.
- **Observation:** The water of the whole beaker turns blue after sometime.
- **Conclusion:** The spreading of blue colour of copper sulphate is due to the movement of copper sulphate and water particles (Diffusion).

To demonstrate the strength of attractive forces between particles of different kinds of matter

- Take an iron nail, a piece of chalk and a cube of ice.
- Try to break each of them by beating with a hammer.
- Observation: It is very easy to break the piece of chalk into smaller particles. It requires more force to break a cube of ice whereas the iron nail does not break at all.
- Conclusion: The force of attraction between particles of chalk is weaker than ice while the force of attraction between particles of iron is very strong.

ILLUSTRATION

- 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.
- **Sol.** 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.
- 2. Even one or two crystals of potassium permanganate can impart colour to a very large volume of water. Which characteristic of matter is illustrated by this observation?
- **Sol.** From this observation we conclude that each potassium permanganate crystal is made up of millions of small particles which keep on separating and imparting colour to more and more water. Hence we can say that matter is made up of very very small particles.

Classification of Matter

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



States of Matter

On the basis of physical state, matter can be classified into three groups- Solids, Liquids and Gases. In general, this classification arises due to variation in

characteristics of the particles of matter.

• The Solid State

- Solids have fixed shape and fixed volume.
- Solids possess rigidity hence cannot be compressed.
- Solids do not flow or diffuse into each other.
- Solids have high density.

Von

- A rubber band can change its shape by stretching but regains its shape when force is removed.
- A sponge can be compressed due to presence of small holes in it, in which air is trapped, when a sponge is pressed the air is released.

The Liquid State

- Liquids have fixed volume but no fixed shape. -
- Liquids have fixed volume but no fixed shape.
- Liquids cannot be compressed much.
- Liquids flow from a higher to lower level. -
- Liquids have lesser density than solids.
- Solids, liquids and gases can diffuse into liquids.
- **The Gaseous State**
 - Gases are highly compressible. -
 - Gases have very low density.
 - Gases flow easily and diffuse into one another.
 - Gases do not have fixed shape and volume and can thus fill the entire space of the container.



Due to high compressibility large amount of gas can be filled in a small container, e.g.. Liquefied Petroleum Gas (LPG) used for cooking or Compressed Natural Gas (CNG) used as fuel in vehicles are compressed gases. The oxygen gas supplied to hospitals in cylinders is also in compressed form.



Two More States of Matter

Plasma

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

A fluorescent light bulb or a neon sign bulb is an example of plasma state. As electricity flows through helium or neon filled in the bulb or the sign bulb, the atoms of these gases break into charged electrons and ions, consequently plasma is formed which glows with a specific colour.

The sun and the stars glow due to presence of natural plasma created by the high temperature.

Bose-Einstein Condensate

This state is called fifth state of matter and is the main work of the scientists Satyendra Nath Bose and Albert Einstein. But this was actually shown to exist by three American scientists, Eric A. Comell, Wolfgang Ketterle and Carl E. Wieman in 2001 by cooling certain gases of extremely low density to a very low temperature called super low temperature.

Particle Mode of Three States

Particle Mode of Three States

Following properties of particles decide the state of matter:

- Intermolecular distance
- Force of attraction between the particles
- Kinetic energy of the particles

Comparison of the three states in terms of inter particle spaces

		8+ ¥ 8+ ¥
		-8 A
(Solid)	(Liquid)	(Gas)

- Explanation of States of Matter on the Basis of **Molecular Structure**
 - In case of solids, the intermolecular spaces are very large. The molecules can vibrate about their mean position, but cannot change their positions. Hence the solids have definite definite shape, volume and are incompressible.
 - In case of liquids, the intermolecular spaces are somewhat large and intermolecular forces fairly small as compared to the solids. The molecules of liquid have more kinetic energy than the solids. Due to large intermolecular spaces and kinetic energy, the molecules can interchange their position. Hence liquids take the shape of the vessel and flow from higher to lower level, and they require a container to keep.
 - In case of gases, the intermolecular spaces are about 1000 times more than the liquids and intermolecular forces of almost negligible magnitude. The molecules are free to move in any direction hence gases have no definite shape or volume. The kinetic energy of molecules of gases is maximum and they move randomly at a high speed. These moving molecules hit the sides of the vessel and exert pressure on the walls of container.



liquids are only slightly compressible while gases are highly compressible.

- Take three 100 mL glass syringes having pistons.
- Remove the pistons from all the syringes.
- In first syringe (a) fill chalk powder, in second syringe (b) fill water and in third syringe (c) fill nothing (air is already present in it).
- Put the pistons back on all the syringes.
- Try to compress the contents by pushing the piston in each syringe.



- Observations:
- The piston of first syringe does not move.
- The piston of second syringe move in slightly.

- The piston of third syringe move considerably.
- Conclusions:
- Solids cannot be compressed by applying pressure.
- Liquids are slightly compressed by applying pressure.
- Gases can be compressed easily by applying pressure.

Rigidity and Fluidity

- Rigid means inflexible. A solid is a rigid form of matter, hence it does not require a container to keep it.
- Fluid is a material which can flow easily and requires a vessel to keep it. A liquid is a fluid form of matter which takes the shape of container while a gas is a fluid form of matter which fills the container.

	Property	Solid State	Liquid State	Gaseous State
1.	Inter particle space	Very small, particles are	Comparatively large,	Very large, particles are very
		closely packed	particles are loosely	loosely packed
			packed	
2.	Inter particle force	Very strong	Weak	Very weak
3.	Nature	Very hard and rigid	Fluid	Highly fluid
4.	Compressibility	Negligible	Very small	Highly compressible
5.	Shape and Volume	Definite shape and	Indefinite shape but	Indefinite shape as well as
		volume	definite volume	volume
6.	Density (Mass/Volume)	High	Less than the density of	Very low density
			solid state	
7.	Molecular motion or	Low	Comparatively high	Very high
	kinetic energy			
8.	Diffusion	Negligible	Slow	Very fast

Comparison of three states of matter

TLLUSTRATION

- 3. Out of solid, liquid and gas which has
 - (a) maximum inter particle space?
 - (b) maximum particle motion?
 - (c) definite volume but no definite shape?
 - (d) least diffustion of the particles?
- Soln. (a) Gas, (b) Gas, (c) Liquid, (d) Solid.
- **4.** Carbon dioxide gas is heavier than both nitrogen and oxygen. Why does not it form lower layer in the atmosphere?
- **Soln.** The diffusion of a gas is not affected by gravity. This means that carbon dioxide (CO₂) remains uniform ally mixed in air. Therefore,

the carbon dioxide gas does not form the lower layer in the atmosphere.

- 5. Liquids generally have low density as compared to solids, but you must have observed that ice floats on water. Find out why?
- **Soln.** Ice is solid, hence it is supposed to be heavier than water which is liquid. But ice has lesser density than water due to its cage like structure with vacant spaces between the molecules while density of water is more, hence ice floats on water.
- **6.** Why does a gas completely fill the container while liquid or solid does not?
- Soln. The molecules of a gas have large intermolecular spaces and very less

intermolecular forces of attraction. Hence the molecules of gas move away from each other and spread in the entire space available to them.

Volume

- The space coupled by a substance is called volume.
- The SI unit of volume is cubic metre (m³). The common unit is litre (L).

These units are related as: 1 L = 1 dm³; 1L = 1000 mL; 1 mL = 1 cm³, where dm \Rightarrow decimeter = 10⁻¹ m

Density

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

Density = Mass/Volume. Units of density are kg/m^3 or g/cm^3 .

Scales of Measuring Temperature

Three scales are used to measure the temperature.

• Celsius scale (°C)

Freezing point of water is taken as 0°C and boiling point is taken as 100°C.

 Fahrenheit scale (°F) Freezing point of water is taken as 32°F and boiling point is taken as 212°F.

Celsius and Fahrenheit scales are related to each

other by the relation, ${}^{\circ}F = \frac{9}{5}({}^{\circ}C) + 32$

• Kelvin scale (K) or Absolute scale It is SI unit of temperature.

Freezing point of water is taken as 273.15 K or 273 K approx. and boiling point is taken as 373 K. Celsius and kelvin scales are related to each other by the relation, $K = 273 + ^{\circ}C$



Change of State

Inter conversion of states of matter can be achieved

- by changing the temperature.
- by changing the pressure.



(liquid)

(gas)

Solid to Liquid Change: Melting

(solid)

- The process in which a solid changes into a liquid on heating is called melting or fusion.
- The temperature at which a solid changes into liquid at atmospheric pressure is called melting point of the substance.
- Higher the melting point, stronger are the forces of attraction between the particles.
- Liquid to Gas Change: Boiling or Vaporization
 - The process in which a liquid substance changes into a gas on heating is called boiling or vaporization.
 - The temperature at which a liquid boils and changes into gas at atmospheric pressure is called boiling point of the liquid.
 - Impurities increase the boiling point of liquids.
 - If pressure is increased, the boiling point increases. Boiling point of water is taken as 373 K at 1 atm pressure.
 - Higher the boiling point, stronger are the forces of attraction between the particles.

• Gas to Liquid Change : Condensation

- The process of changing a gas to a liquid on cooling is called condensation.
- Condensation is the reverse of vaporization.

Liquid to Solid Change : Freezing

- The process of changing a liquid into solid by cooling is called freezing.
- Freezing is also called solidification and is reverse of melting.
- The temperature at which a liquid freezes to become a solid at atmospheric pressure is called the freezing point.
- Impurities lower the freezing point of liquids.



To demonstrate that the temperature remains constant during the change of state

- Take about 100 g of ice in a beaker.
- Hang a laboratory thermometer in it so that its bulb is in contact with ice.
- Note down the initial temperature and start heating the beaker.
- Note the temperature when ice starts changing to water.
- Note the temperature when the complete ice is converted to water.
- Continue heating and note the temperature when water starts changing to vapours.
- Note the temperature when most of the water has vaporized.



• Observations:

There is no change in temperature till all the ice melts though heating continues. Temperature remains constant at 0°C.

Once the ice is converted to water, the temperature starts rising till the water begins to boil.

Once the ice is converted to water, boiling, the temperature remains constant at 100° C till all the water has changed into vapors.

• **Conclusion:** During the change of state from solid to liquid or from liquid to gas, the temperature remains constant till all the solid has melted or all the liquid has vaporized. The heat energy supplied is used up in overcoming the forces of attraction and hence the thermometer does not show any rise in temperature.

• Sublimation (Solid to Gas or Gas to Solid Change)

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

Solid <u>on heating</u> Vapour

- Few examples of the substances which sublime are camphor, ammonium chloride, naphthalene, iodine, solid carbon dioxide, etc.



• Applications of Sublimation

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

(1) Process of sublimation is very useful in the purification of solids which sublime on heating and contain non-volatile impurities.

(2) Freeze-dried foods prepared by sublimation can be stored for long times.

(3) In very cold places, the snow does not melt but sublimes directly to vapours.



Effect of Change of Pressure

- The process of conversion of a gas into liquid by increasing pressure and decreasing temperature is called liquefaction of gases.
- On applying pressure, the intermolecular space in gases decreases and the molecules come closer.
- On reducing pressure the reverse process takes place.
- Solid carbon dioxide which is also called dry ice is converted directly to carbon dioxide gas by decrease in pressure upto 1 atm without coming into liquid state.
- The pressure exerted by a gas is measured in atmosphere. Atmospheric pressure at sea level is taken as 1 atmosphere which is also normal atmospheric pressure.

1 atm = 1.01×10^5 Pa (Pa = Pascal, SI unit of pressure).

The interchange of states of matter can be shown as below:



Latent Heat

The heat which is given to the system during a phase change and which is not used in raising the temperature -s called latent heat (hidden). The latent heat is used up in changing the state by breaking the intermolecular forces of attraction hence there is no increase in temperature till one state changes to other.

Latent Heat of Fusion

- It is defined as the amount of heat energy required to change 1 kg of a solid into liquid at atmospheric pressure without any change in temperature at its melting point.
- It is observed that latent heat of fusion of ice is 3.34 x 10⁵ J/kg or 80 kcal/kg.
- Ice at 273 K is more effective in cooling than water at 273 K. This is due to the reason that for melting, each kilogram of ice absorbs latent heat of 3.347 x 10⁵ joules from the substance and hence cools the substance more effectively.

Latent Heat of Vaporization

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



7. The burns caused by steam are much more severe than those caused by boiling water though both have same temperature of 100°C.Why?

- Sol. The steam at 100° C has more heat (latent heat of vaporization which is equal to 22.5×10^{5} J/kg) than boiling water at 100° C. Hence steam when comes in contact with skin gives out 22.5×10^{5} J/kg more heat than boiling water and causes more severe burns.
- 8. Convert the temperature of 373°C to Kelvin and 573 K to Celsius scale.
- Sol. $K={}^{\circ}C+273$ Hence, K = 373 + 273 = 646 or $373{}^{\circ}C=646K$. Similarly, $K = {}^{\circ}C+273$ Hence, $573 = {}^{\circ}C+273$ or ${}^{\circ}C=573-273=300$ or $573K=300{}^{\circ}C$.

Evaporation

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

At any given temperature the kinetic energy of some particles on the surface of liquid is high enough to overcome the forces of attraction by other particles, hence they leave the liquid and are converted into vapours.

- Evaporation is an Endothermic Process During evaporation, a liquid absorbs heat energy from any other body in contact with it or from the
 - surroundings. Factors Affecting Evaporation
 - **Surface area**: Greater the surface area, more is the rate of evaporation.

Temperature: - Higher the temperature, faster is the evaporation.

Humidity: - Lesser the humidity (dampness) in air, more is the rate of evaporation.

Wind speed: - Higher is the speed of wind, more is the rate of evaporation.

• Cooling Effect of Evaporation

During evaporation, the liquid particles having high kinetic energy leave the surface of the liquid and are converted to vapours. As a result the average kinetic energy of the remaining system decreases resulting in decrease in temperature. The particles absorb energy from the surroundings to regain the energy lost, making the surroundings cool.



 The air from the fan causes rapid evaporation of sweat. During evaporation the seat takes away heat from the body. As a result, we feel relief under a fan.

- As water vapour molecules present in air, come in contact with the cold glass of water, the molecules loose energy, slow down and get condensed into liquid state which we see as water droplets.
- Evaporation of water from the leaves is called transpiration. Transpiration helps plants/trees to keep cool. During summer, when the temperature is high, a tree must transpire more to keep itself cool. More transpiration requires more leaves. So, tress acquire more leaves during summers.
- Light coloured or white coloured clothes absorb less heat in summer, however dark coloured clothes absorb more heat making the person feel more hot and sweaty, as a result light coloured clothes are preferred in summer as they make the person feel cool and comfortable.

Difference between Boiling and Evaporation

Boiling				Evapo	orati	on		
1. Bo	iling	occur	s only	Evapo	ration	of	а	liquid
when the liquid is heated.			takes	place	on	its	own.	
2. Boili	ng ta	kes pla	ce at a	Evaporation takes place				
specifi	2	temp	erature	at a	all i	temp	bera	atures
known	as	the	boiling	below	the	boili	ng	point
point of the liquid.			of liqu	id.				
3. Boiling occurs from the			Evapo	ration	is a	a si	urface	

surface as well as from	phenomenon and occurs
the bulk of the liquid.	from the surface of the
	liquid.
4. No cooling is caused	Cooling is always caused
during boiling.	during evaporation.

ILUSTRATION -

- **9.** Why do we sprinkle water on the roof or open ground in summer?
- **Sol.** The sprinkling of water on the open ground or roof causes the water molecules to absorb energy from the open ground roof and surroundings and to get evaporated. The evaporation of water causes a cooling effect since it makes use of the very large latent heat of vaporization of water $(22.6 \times 10^5 \text{ J kg}^{-1})$.
- **10.** Why do we perspire more during summer?
- **Sol.** During summer or after a heavy exercise, the temperature of our body rises. Due to increase in temperature the body gives out more sweat.

When the sweat evaporates, it takes large amount of energy (equal to latent heat of vaporization of water) from our body. Due to loss of heat the body feels cool.



ESSENTIAL POINTS For COMPETITIVE EXAMS

Simultaneous Effect of Temperature and Pressure on the Physical State of a Substance

The decrease in temperature brings the particles of a substance closer while increase in pressure can have the same effect. At low temperature and under high pressure a gas can be liquefied easily. The effect of temperature is more important than pressure. For every gas there is a certain temperature above which the gas cannot be liquefied however large be the pressure applied. The temperature above which a gas cannot be liquefied is called critical temperature and the corresponding pressure is called critical pressure.

Difference between Gas and Vapour

A substance is said to be a gas if its boiling point is below room temperature. For example, oxygen, nitrogen, carbon dioxide, etc.

If the normal physical state of a substance is either a solid or a liquid but gets converted into the gaseous state either on its own or by absorbing energy, the gaseous state is called the vapour state. For example, vapours of water in air.

SI units for Some Measurable Quantities					
Quantity	Unit	Symbol			
Length	metre	М			
Mass	kilogram	Kg			
Time	second	S			
Temperature	kelvin	К			
Volume	cubic metre	m ³			
Density	kilogram per cubic	kg m ⁻³			
Droccuro	netre	Do			
Pressure	pascal	Pd			

Some more Units of Mass, Volume, Pressure and Temperature

- Mass: kg or g; $1 \text{ kg} = 10^3 \text{ g}$
- Volume : L, mL, cm³, m³
 - 1 m³ = 10³ dm³ = 10⁶ cm³; 1 L = 10³ cm³ = 10⁻³ m³ = 1 dm³
- **Pressure :** atm, cm of Hg, mm of Hg, Pa, Torr 1 atm = 76 cm of Hg = 760 mm of Hg 760 mm of Hg = 760 Torr

1 Nm- 2 = 1 Pa ; 1 atm = 101.325 x 10 3 Nm^{-2}

- 1 atm = 1.01325 bar = 1.01325 x 10⁵ Pa
- Temperature: K, °C K = °C + 273.15

Sublime and Sublimate

A gaseous state directly formed from a solid on heating is known as sublime. A solid state of matter formed directly from its gaseous state on cooling is known as sublimate.

Gas Laws

• Boyle's Law

At constant temperature, the volume of fixed mass of gas is inversely proportional to the pressure.

Mathematically, $V \propto \frac{1}{P}$ PV = constant or $P_iV_1 = P_2V_2$.

The graph between P and 1/V as shown is a straight line.



• Charles' Law

At constant pressure, the volume of a fixed mass of gas is directly proportional to its temperature.

Mathematically, $V \propto T$ constant or $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

The graph between V and T as shown is a straight line.



Avogadro's Law

Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules. Mathematically $V \propto n$.

• Graham's Law of Diffusion

The rate of diffusion or effusion (the process of diffusion through a small aperture) is inversely proportional to the square root of its density or molar mass at constant temperature and pressure.

Rate of diffusion
$$\propto \sqrt{\frac{1}{d}}$$
 or Rate $\propto \sqrt{\frac{1}{M}}$

For comparison of rates of diffusion the law can

be put as $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$ where two gases with

densities d_1, d_2 and molar masses M_1, M_2 have rate of diffusion as r_1 and r_2 respectively.



The relation can be graphically represented as shown in the graph.

A gas which obeys Boyle's law and Charles' law is called an ideal gas.

• Ideal gas equation

PV = RT (for one mole of gas) = nRT (for n moles of gas)

R is universal gas constant = $8.314 \text{ Jmol}^{-1} \text{ K}^{-1} \approx 2$ calmol⁻¹K⁻¹.

Ideal gas		Real gas			
(a) Obeys gas equation PV = RT	(a)	Obeys	van	der	Waals
	equation.				

(b) Molecules are point	$\left(p + \frac{a}{V^2}\right)(V - b) = RT$ (b) Molecules have finite
particles which do not occupy	size. The free volume
any volume. Free volume	available for molecules is
available to molecules is V.	less than V, it is (V-b).
 (c) No force of interaction between the molecules. (d) Obeys Boyle's and Charles⁷ law for all pressures and 	(c) Intermolecular forces exist. (d) Do not obey Boyle's and Charles' law.
temperatures.	(e) Internal energy depends
(e) Internal energy depends on	on temperature as well as
temperature only.	volume.
(f) Specific heat does not depend on temperature.	(f) Specific heat depends on temperature.

Properties of Liquids

• Vapour Pressure

- When a liquid is heated in a closed vessel, it is converted to vapours and after some time an equilibrium is established between vapours and the liquid.
- The pressure exerted by the vapours on the liquid at equilibrium is called vapour pressure, it increases with increase in temperature. When vapour pressure of a liquid is equal to atmospheric pressure, the liquid starts boiling.

• Viscosity

The internal friction or resistance which resists the relative motion of the layers of liquids or the resistance in the flow of liquids is called viscosity. Glycerine is said to have more viscosity than water since glycerine does not flow as easily as water.

• Surface Tension

Due to unequal forces on the surface of a liquid, the surface feels stretched. This tension on the surface of the liquid is known as surface tension. Due to surface tension, liquids tend to minimize the surface area to reduce tension. Hence a drop of water always acquires a spherical shape and water rises in a capillary.

Types of Solids

• Amorphous Solid

An amorphous solid is a substance in which atoms, molecules or ions have a random and non-uniform arrangement. They melt over a range of temperature. The amorphous solids do not have a fixed geometry or a sharp melting point, e.g., glass, plastic, rubber, etc.

Crystalline Solid

Crystalline solid is a substance in which the atoms, molecules or ions have a characteristic, regular and fixed arrangement. They have a sharp melting point. Crystalline solids have a definite geometric shape such as cube, octahedron, tetrahedron, etc. e.g., sodium chloride, sugar, diamond, copper sulphate, etc.

Types of crystalline solids: On the basis of their structural unit such as atoms, ions or molecules the crystalline solids can be classified as

(i) Ionic solids: They consist of anions and cations held together by electrostatic forces.

e.g., NaCl, KCl, ZnS, etc.

(ii) Molecular solids: They are made up of neutral molecules held by weak van der Waals forces, e.g., ice, solid carbon dioxide, etc.

(iii) **Covalent solids:** They consist of atoms held by strong covalent bonds, e.g., diamond, graphite, etc.

(iv) Metallic solids: They are made up positive metal ions dispersed in sea of electrons, e.g., Cu, Fe, Zn, etc.

SOLVED EXAMPLES

- 1. What Celsius and kelvin temperature correspond to 68°F?
- **Sol.** To convert °F to °C °C = (°F - 32°) x - (68 - 32) x - 20°C K = °C + 273 = 20 + 273 = 293 K.
- 2. Few iodine crystals are kept in a conical flask, it is stoppered and kept undisturbed for a long time. A few crystals are seen near the mouth and sides of the flask. Explain.
- **Sol.** Over a period of time iodine molecules sublime and are converted into gas. Some of these gas molecules condensed back on the surface of the flask and near the mouth of the flask to form iodine crystals.
- 3. Name the process by which a drop of ink spreads in a beaker of water? Soln.: Diffusion
- 4. Ammonia and hydrogen chloride gases are both pungent smelling in nature. Both the gases are released separately from two opposite comers of the room. Which gas will reach first to a person sitting in the centre of the room?
- **Sol.** The particles of lighter gas diffuse faster as compared to the heavier gas. Out of the two gases ammonia (mol. mass 17) is lighter than hydrogen chloride (mol. mass 36.5). Hence

the smell of ammonia will reach first to the person sitting in the centre of the room.

- 5. Ordinary water boils at 100°C. Can it be made to boil at 95°C or 105°C?
- **Sol.** Yes. The boiling point of a liquid depends upon the pressure acting on it. Water boils at 100°C at 1 atm pressure. If the pressure is reduced it can be made to boil at lower temperature and if the pressure is increased it can be made to boil at higher temperature.
- 6. What happens to the heat energy supplied when the solid has already melted?
- **Sol.** The temperature of the molten liquid remains constant till the complete solid melts. The heat energy supplied is converted into latent heat of fusion. The temperature starts rising only after the complete solid is converted to liquid.
- 7. The melting points of two solids X and Y are 300 K and 400 K respectively. Which has more inter particle forces?
- **Sol.** Y. Higher melting point shows more energy is required to break inter particle forces.

8. How do aquatic plants survive?

- **Sol.** The air contains gases like oxygen, nitrogen, carbon dioxide, etc. These gases dissolve in water by the process of diffusion. The oxygen and carbon dioxide are taken up by aquatic animals and plants respectively for their survival,
- 9. What are the factors which are responsible for bringing a change in the physical state of a substance?
- **Sol.** Temperature and pressure are two factors which can bring about the change in physical state. But they have opposing effect. Increase in temperature separate the particles of a substances apart while increase in pressure brings them closer.
- 10. How can the evaporation of a liquid be made faster?
- Sol. (i) By increasing the surface area (ii) By increasing the temperature (iii) By blowing wind

(iv) By decreasing the humidity

- 11. Why is solid carbon dioxide known as dry ice ? Why is it stored under high pressure?
- **Sol.** Solid carbon dioxide is an extremely cold substance. It is used to deep freeze food and ice-creams. Since solid carbon dioxide directly changes into carbon dioxide gas without undergoing the formation of liquid state, it is called dry ice. It is stored under high pressure because on decreasing the pressure, solid carbon dioxide is directly converted to gas.

12. Define the terms condensation and freezing.

- **Sol.** The process in which a gas or vapour is converted into liquid by cooling is called condensation and the process in which a liquid is converted into solid by cooling is called freezing.
- 13. Explain the change of state from liquid to gas on the basis of molecular structure.
- **Sol.** When a liquid is heated, its molecules absorb heat energy and their kinetic energy increases. With increase in kinetic energy, molecules move faster which increases intermolecular spaces and the intermolecular forces, the molecules move apart, leave the liquid and are converted into gas.
- 14. Give an experiment to show that rate of diffusion of solids increases with increase in temperature.
- Sol. Take two beakers fill them with water one at room temperature and other with boiling hot water. Drop one crystal of KMnO₄ in cold water and other in hot water. Observe the beakers after ten minutes, we observe
 (i) In the beaker with cold water, violet colour diffuses slowly and the colour is darker at the

diffuses slowly and the colour is darker at the base of beaker.

(ii) In case of hot water, the violet colour diffuses rapidly and the whole beaker has violet colour spread uniformly.

15. A handful of sand has a mass of 208 g and it displaces a volume of 80 mL of water. What is its density?

Sol. Density $=\frac{Mass}{Volume} = \frac{208}{80} = 2.60 \text{g/mL}$

- 16. Solids are generally very heavy while gases are light. Explain.
- **Sol.** In solids, the particles are very closely packed. As a result the number of particles per unit volume is quite large, hence the solids are normally quite heavy in the gases, the particles are loosely packed. The number of particles per unit volume is comparatively very small, hence gases are light.
- 17. Boiling point of ethyl alcohol is 78.3°C, of benzene is 80.2°C and of water is 100°C. What information do you get?
- **Sol.** Boiling point of a liquid is an indicator of the strength of intermolecular forces between the molecules of the liquid. It shows that the strength of intermolecular forces of water is likely to be maximum and that of alcohol is minimum.
- 18. List few examples of increased rate of evaporation due to increase in surface area,

increase in temperature, decrease in humidity and increase in wind speed.

Sol. (a) Increase in surface area

(i) If hot tea is poured in saucer it gets cooled faster.

(ii) Wet clothes dry faster when spread out.

(b) Increase in temperature

(i) One feels more cold after a hot water bath than a cold water bath.

(ii) Quick drying of clothes in summer as compared to winter.

(c) Decrease in humidity

(i)Desert cooler cools better on a hot dry day.(ii) Water is cool in earthen pitcher during dry hot day.

(d) Increase in wind speed

(i) One feels comfortable under a moving fan in summer.

(ii) The clothes dry faster on windy days.

19. A fixed mass of carbon dioxide occupies a volume of 480 litres at 2 atmospheric pressure the gas is transferred to a container of 12 litre capacity what will be its pressure ?

Sol. Given $P_1 = 2$ atm, $P_2 = ?$

 $V_1 = 480L, V_2 = 12L$ According to Boyle's law, $P_1V_1 = P_2V_2$ or

 $P_2 = \frac{P_1 V_1}{V_2} = \frac{2 \times 480}{12} = 80 \, \text{atm}$

20. What will be the volume of 600 cm³ of a gas when it is cooled from 27°C to 7°C?

Sol. Given
$$V_1 = 600 cm^3$$
, $V_2 = ?$
 $T_1 = 273 + 27^\circ C = 300K$, $T_2 = 273 + 7^\circ C = 280K$
According to Charles' law, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

or
$$V_2 = \frac{V_1 T_2}{T_1} = \frac{600 \times 280}{300} = 560 \,\mathrm{cm}^3$$

21. At what temperature will the volume of a gas at 0°C double itself, pressure remaining constant?

Sol. Given

$$V_{1} = a cm^{3}, V_{2} = 2a cm^{3}, T_{1} = 273, T_{2} = ?$$

$$\frac{V_{1}}{T_{1}} = \frac{V_{2}}{T_{2}}$$

$$\therefore T_{2} = \frac{V_{2} \times T_{1}}{V_{1}} = \frac{2a \times 273}{a} = 546K.$$

22. At a certain temperature the volume of a gas sample is 120 mL at 1 atm pressure. Keeping temperature same, the pressure is raised to 5 atm. What would be the volume of the gas? Sol. Given $P_1 = 1$ atm, $P_2 = 5$ atm $V_1 = 120mL, V_2 = ?$ $P_1V_1 = P_2V_2$ $\therefore V_2 = \frac{P_1V_1}{P_2} = \frac{1 \times 120}{5} = 24mL$

23. 40 mL of a gas is collected at 25°C. If the temperature is raised to 50°C and the pressure remains constant, what would be the new volume of the gas?

Sol. Given
$$V_1 = 40mL$$
,

$$T_{1} = 273 + 25^{\circ}C = 298K$$

$$V_{2} = ?, T_{2} = 273 + 50^{\circ}C = 323K$$

$$\frac{V_{1}}{T_{1}} = \frac{V_{2}}{T_{2}}$$

$$\therefore V_{2} = \frac{V_{1}T_{2}}{T_{1}} = \frac{40 \times 323}{298} = 43.35mL$$

NCERT SECTION

- 1. Which of the following are matter? Chair, air, love, smell, hate, almonds, thought, cold, cold drink, smell of perfume
- Ans. Chair, air, almonds, cold drink and smell of perfume
- Give reasons for the following observation: The smell of hot sizzling food reaches you several metres away, but to get smell from cold food, you have to go close.
- Ans. This happens because rate of diffusion of gas increases with increase in temperature. In case of hot food diffusion of smell is faster whereas in case of cold food, diffusion is slower.
- **3.** A diver is able to cut through water in a swimming pool. Which property of matter does this observation show?
- **Ans.** The particles of water are held together by forces of attraction. It is the reason that the diver is able to cut through water in a swimming pool.
- (a) Tabulate the differences in the characteristics of states of matter.
 (b) Comment upon the following: rigidity, compressibility, fluidity, filling a gas container, shape/kinetic energy and density.

Property	Solid	Liquid	Gas
1. Shape and	They have a definite	They have a definite volume but no	They have neither a definite shape
volume	shape as well as definite	definite shape.	nor a definite volume.
	volume.		
2. Compressibility	Solids are completely	Liquids are almost incompressible.	Gases are highly compressible.
	incompressible.	Liquids can flow, therefore they	
3. Rigidity/Fluidity	Solids possess rigidity.	possess fluidity which is lower than	Gases flow more easily than liquids
		that of gases	and thus have the highest fluidity.
4. Energy	Their particles have	Their particles have energy higher	Their particles have highest energy.
	minimum energy.	than those of solids.	
5. Density	They have high density.	Their density is lower than those of	They generally have very low
		solids but much higher than those	densities.
		of gases.	
6. Diffusion	They normally do not	They show the property of	They diffuse very rapidly. The rate
	show the property of	diffusion. As a result, solids, liquids	of diffusion of a gas is, however,
	diffusion although some	and gases all can diffuse into	inversely proportional to the square
	rare examples of diffusion	liquids.	root of its density. Thus, lighter gas
	of one solid into another		diffuses more rapidly than the
	are known.		heavier one.

(b) (i) Rigidity : It is the property which helps a substance to retain its shape when force is % applied to it. Solids are rigid while gases, and liquids are not.

Δns

(ii) **Compressibility:** The particles of matter can be compressed or reduced in volume by applying force or pressure. Gases are highly compressible.

(iii) Fluidity: It is the tendency of a substance to flow. Liquids and gases possess fluidity while solids are rigid.

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

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

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

Solids have minimum kinetic energy due to least movement of particles.

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

- 5. What are the characteristics of the particles of matter?
- **Ans.** The characteristics of the particles of matter are following:

(a) Matter consists of tiny particles which cannot be seen by an individual with naked eye.

(b) The particles of matter have spaces between them.

(c) The particles of matter attract each other with a force called intermolecular forces of attraction. The forces of attraction are maximum in solids and minimum in gases. Liquid have intermolecular forces in between solids and gases.

(d) The particles of a matter are not stationary but are continuously moving.

(e) The intermolecular forces decrease with the increase in intermolecular spaces and vice- versa.

(f) Kinetic energy of the molecule increases with the rise in temperature.

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

(Density = mass/volume)

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

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

7.

(d) We can easily move our hand in air but to do the same through a solid block of wood we need a karate expert.

Ans. (a) The particles of a gas are constantly moving in all the directions with different speeds.

Therefore they do not have a fixed volume and hence completely fill the vessel in which they are kept.

(b) The molecules of a gas are free to move randomly in all directions. During their motion, they collide with one another and also with the walls of the container. The constant bombardment of the molecules on the walls of the container exerts a steady force. The force acting per unit area on the walls of the container is called pressure. Thus, gases exert pressure.

(c) A wooden table is called solid because it has a definite mass, volume and shape.

(d) In air, there is lot of empty space between the molecules and the forces between the particles are almost negligible. Hence, we can move our hand in air. However we cannot move our hand in a solid block because there are strong forces of attractions between particles in a solid and there is no empty space between them.

- 8. Liquids generally have lower density as compared to solids. But you must have observed that ice floats on water. Find out why?
- Ans. When water freezes to form ice, some empty spaces are created. As a result, volume increases for the same mass of water. In other words, mass per unit volume or density of ice is lower than that of water and hence ice floats over water.
- **9.** Convert the following temperatures to Celsius scale :
 - (a) 300 K (b) 573 K.
- Ans. (a) Temperature in °C = Temperature in kelvin- 273 = 300 - 273 = 27°C

(b) Temperature in °C = 573 - 273 = 300°C

- What is the physical state of water at :(a) 250°C(b) 100°C?
- Ans. (a): Physical state of water at 250°C is gaseous state because the boiling point of water is100°C.Therefore at a temperature higher than its boiling point. It exists as gas.

(b): At 100°C both liquid and gaseous states are present. These are in a state of equilibrium.

So at 100°C both liquid water and vapour are present.

- **11.** For any substance, why does the temperature remain constant during the change of state?
- **Ans.** The temperature remains constant during the change of state because the heat supplied during the change is used up in overcoming the intermolecular forces between the particles of the state.
- **12.** Suggest a method to liquefy atmospheric gases.
- Ans. In order to liquefy a gas, the constituent particles or molecules have to be brought closer. The atmospheric gases can be liquefied either by increasing pressure or by decreasing temperature.
- **13.** Why does a desert cooler cool better on a hot dry day?
- Ans. The cooling in a desert cooler is caused by the evaporation of water. A desert cooler cools better on a hot and dry day because the higher temperature on a hot day increases the rate of evaporation of water and the dryness of air (low humidity of air) also increases the rate of evaporation of water. And due to increased rate of evaporation of water, a desert cooler cools better on a hot and dry day.
- **14.** How does the water kept in an earthen pot (matka) become cool during summer?
- Ans. An earthen pot (matka) has many small pores. Water seeps out through them and evaporates from the surface of the pot. The energy needed for evaporation is taken from the water kept in the earthen pot. As a result, water kept in earthen pot becomes cool.
- **15.** Why does our palm feel cold when we put some acetone or petrol or perfume on it?
- **Ans.** Both acetone and perfume are low boiling liquids. When they are poured on the palm, they evaporate readily and for this change of state they take the energy from the palm and we get a cooling sensation.
- **16.** Why are we able to sip hot tea or milk faster from a saucer rather than a cup?
- Ans. We are able to sip hot tea faster from a saucer rather than a cup because a. saucer has a greater surface area; As a result, rate of evaporation increases.
- **17.** What type of clothes should we wear in summer?
- Ans. We should wear cotton clothes in summer. During summer, we perspire more because of the mechanism of our body which keep us cool. Cotton, being a good absorber of water

helps in absorbing the sweat and exposing it to the atmosphere for easy evaporation.

- **18.** Convert the following temperatures to Celsius scale :
 - (a) 293 K
 - (b) 470 K
- **Ans.** (a) We know that, temperature in °C = K -273, where, C = "Celsius, K = Kelvin = 293 - 273 = 20°C

(b) °C = K - 273 = 470 - 273 = 197°C

- **19.** Convert the following temperatures to the Kelvin scale :
 - (a) 25°C
 - (b) 373°C
- Ans. (a) We know that temperature in K = $^{\circ}C + 273$ K = 25 $^{\circ} + 273 = 298$ K

(b) K = °C + 273 = 373 + 273 = 646 K

20. Give reasons for the following observations :(a) Naphthalene balls disappear with time without leaving any solid,

(b) We can get the smell of perfume sitting several metres away.

Ans. (a) Naphthalene balls disappear with time without leaving any solid because they undergo sublimation i.e., they directly change into vapour without passing through the liquid state.

(b) We can get the smell of perfume sitting several metres away due to diffusion. The perfumes contain solvent which carries pleasant smelling vapour. They diffuse quite fast and can reach a person sitting several metres away.

- **21.** Arrange the following substances in increasing order of forces of attraction between the particles: water, sugar, oxygen.
- Ans: The forces of attraction are the strongest in solids, followed by liquids and the weakest in gases. Oxygen is a gas, water is a liquid and sugar is a crystalline solid. So the increasing order of forces of attraction is Oxygen < Water < Sugar.
- **22.** What is the physical state of water at (a) 25°C (b) 0°C (c) 100°C?
- Ans. (a) 25°C, the physical state of water is a liquid.
 (b) 0°C, the physical state of water can be either a solid or a liquid.

(c) 100°C, the physical state of water can be either a liquid or a gas (steam).

- 23. Give two reasons to justify that:
 (a) Water at room temperature is a liquid.
 (b) An iron almirah is a solid at room temperature.
- Ans. (a) Water is a liquid at room temperature due to following reasons:

(i) Water has not fixed shape but fixed volume. It takes the shape of the container.

(ii) Water can flow easily hence it is not rigid but a fluid.

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

(i) An almirah has a fixed shape and a fixed volume.

(ii) It cannot flow, hence it is rigid.

- **24.** Why is ice at 273 K more effective in cooling than water at the same temperature?
- **Ans.** Cooling takes place when heat is removed from a system. In case of ice at 273 K, it will take latent heat from the medium to convert itself into water at 273 K and then into water at a higher temperature. Thus, in case of ice at 273 K there will be a change in physical state, whereas in case of water at 273 K there will be no change in state. Hence lesser energy will be taken from the medium.
- **25.** Which produces more severe burns, boiling water or steam?
- Ans. Steam contains more heat, in the form of latent heat, than boiling water. So when steam comes in contact with skin it gives out 22.5×10^5 joules per kilogram more heat than boiling water, so steam causes more severe bums.





PROBLEMS-SOLUTIONS

Multiple Choice Questions (MCQs)

 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

🐐 Thinking Process

In compression of gases, molecules come closer and kinetic energy decreases and hence temperature decreases. Solubility of most gases in liquids decreases with increase of temperature.

Ans. (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. 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
- Ans. (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.** 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

🛉 Thinking Process

Fluid means a material which can flow easily and requires a vessel to keep it.

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

👋 Thinking Process

(i) Diffusion is the net spreading out movement of a substance from a region of high concentration to a region of low concentration and mixing of a substance with another substance due to motion of its particles.

(ii) Transpiration is the process of water movement through a plant and its evaporation from aerial parts such as leaves.(iii) Osmosis is the process in which solvent

molecules move from their higher concentration to their lower concentration through semi-permeable membrane.

(iv) Evaporation is the process in which a liquid changes into vapour (or gas) even below its boiling point.

Ans. (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 vaporization from the remaining water. In this way, the remaining water loses heat and gets cooled.

- 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
- Ans. (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. 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

📲 Thinking Process

T° C + 273 =T K

- Ans. (d) 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 $25^{\circ}C+273 = 298 \text{ K} \Rightarrow 38^{\circ}C+273 = 311 \text{ K} \Rightarrow 66^{\circ}C+273 = 339 \text{ K}$ Therefore, the correct sequence of temperature will be 298 K, 311 K and 339 K.
- 7. Choose the correct statement of the following.

(a) Conversion of solid into vapours without passing through the liquid state is called vaporization.

(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.

Ans. (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 vaporization.

The conversion of liquid into solid is called freezing.

The conversion of solid into liquid is called melting.

- 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
- Ans. (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 (:: PC + 273 = TK). Boiling point of diethyl ether=35°C+273=308 K Boiling point of acetone = 56°C + 273 = 329 K Boiling point of n-butyl alcohol = 118°C + 273 = 391 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
- Ans. (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. 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)

Ans. (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 the 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.

Short Answer Type Questions

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.

👻 Thinking Process

(i) The presence of impurities increases the boiling point.

(ii) The presence of impurities decreases the freezing/melting point.

Ans. 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. 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.



Ans. 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 increase 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. Fill in the blanks.

(a) Evaporation of a liquid at room temperature leads to a effect.

(b) At room temperature the forces of attraction between the particles of solid substances are...... than those which exist in the gaseous state.

(c) The arrangement of particles is less ordered in the..... state. However, there is no order in the...... state.

(d) is the change of gaseous state directly to solid state without going through the...... state.

(e) The phenomenon of change of a liquid into the gaseous state at any temperature below its boiling point is called

Ans. (a) Evaporation of a liquid at room temperature leads to a cooling effect.

(b) At room temperature the forces of attraction between the particles of solid substances are stronger than those which exist in the gaseous state.

(c) The arrangement of paritcles is less ordered in the liquid state. However, there is no order in the gaseous state.

(d) Sublimation is the change of gaseous state directly to solid state without going through the liquid state.

(e) The phenomenon of change of a liquid into the gaseous state at any temperature below its boiling point is called evaporation.

 Match the physical quantities given in Column A to their SI units given in Column B.

	Column A		Column B	
(a)	Pressure	1.	Cubic metre	
(b)	Temperature	2.	Kilogram	
(c)	Density	3.	Pascal	
(d)	Mass	4.	Kelvin	
(e)	Volume	5.	Kilogram	per

		cubic metre

Ans. The correct matching is

Column A			Column B	
(a)	Pressure	1.	Pascal	
(b)	Temperature	2.	Kelvin	
(c)	Density	3.	Kilogram pe	er
			cubic metre	
(d)	Mass	4.	Kilogram	
(e)	Volume	5.	Cubic metre	

15. The non-SI and SI units of some physical quantities are given in Column A and Column B respectively. Match the units belonging to the same physical quantity.

Column A				Column B	
(a)	Degree Celsius		1.	Kilogram	
(b)	Centimeter		2.	Pascal	
(c)	Gram pe	r	3.	Metre	
	centimeter				
	cube				
(d)	Bar		4.	Kelvin	
(e)	Milligram		5.	Kilogram	per
				metre cube	

Ans. The correct matching is

(a)	Degree Celsius	Kelvin
(b)	Centimeter	Metre
(c)	Gram per centimeter cube	Kilogram per metre cube
(d)	Bar	Pascal
(e)	Milligram	kilogram

- **16.** 'Osmosis is a special kind of diffusion'. Comment.
- **Ans.** 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.
- **17.** 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 throughout the house.

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

👻 Thinking Process

(i) Osmosis is the process in which solvent molecules, move from the place of their higher concentration to the place of their lower concentration through semi-permeable membrane. (ii) Diffusion is the spreading out and mixing of a substance from the region of its higher concentration with another substance due to motion of its particles. It goes on until a uniform mixture is formed.

Ans. 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.

- Water as ice has a cooling effect, whereas water as steam may cause severe burns. Explain these observations.
- Ans. 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 vaporization) which it has absorbed when water was converted into steam. So, steam produces severe burn.
- **19.** 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.

Ans. The temperature of both boiling water and steam is 100°C, but steam gives out more heat (due to latent heat of vaporization) in comparison to boiling water.

It is because, when water changes into steam, it absorbs latent heat of vaporization, but when steam condenses to form water, an equal amount of latent heat is given out without changing the temperature.

Hence, she felt intense heat from puff of steam gushing out of the spout of the kettle.

20. 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 would correctly represent the change in its temperature as a function of time



- Ans. (a) Figure (a) represents the change of temperature with time correctly. The temperature of water first decreases up to zero degree celcius, then remains constant for some time (till the ice is formed), then again starts decreasing.
- **21.** Look at the figure and suggest in which of the vessels A, B, C or D, the rate of evaporation will be the highest? Explain.



Y Thinking Process

Rate of evaporation increases by increasing surface area (exposed to evaporation) and by increasing wind speed.

Ans. The rate of evaporation will be highest in vessel C as the surface area exposed for evaporation is larger than 6 (smaller size). The moving fan increases the wind speed which also increases the rate of evaporation. Although A and D are also equal in size to that

of C but A is at a greater distance from the fan and D is covered with a lid.

(a) Conversion of solid to vapour is called sublimation. Name the term used to denote the conversion of vapour to solid.
(b) Conversion of solid state to liquid state is called fusion; what is meant by latent heat of fusion?

Mr Thinking Process

Sublimation is the process of converting solids to vapours by heating or by converting vapours to solids by cooling without going into the liquid state.

Ans. (a) It is also called sublimation.

(b) The amount of heat energy required to change 1 kg of a solid into liquid at atmospheric pressure at its melting point is known as the latent heat of fusion.

Long Answer Type Questions

23. You are provided with a mixture of naphthalene and ammonium chloride by your teacher. Suggest an activity to separate them with well labeled diagram.

📲 Thinking Process

(i) First dissolve naphthalene and ammonium chloride into water.

(ii) Filter the solution. Separate the residue from filtrate.

(iii) Heat the filtrate to crystallize the crystals of ammonium chloride.

Ans. Naphthalene is insoluble in water but soluble in benzene (organic solvent). Ammonium chloride is soluble in water but insoluble in benzene. Naphthalene changes into vapours at room temperature whereas ammonium chloride changes into vapours on heating. Method

(a) Add water to the mixture and shake it vigorously to dissolve ammonium chloride.

(b) Filter the mixture. Naphthalene is obtained as residue whereas, filtrate contains ammonium chloride. Crystallize the filtrate by heating till saturated solution of ammonium chloride is obtained.

(c) Cool the hot saturated solution to get crystals of ammonium chloride.



- 24. It is a hot summer day, Priyanshi and all are wearing cotton and nylon clothes respectively. Who do you think would be more comfortable and why?
- **Ans.** Priyanshi would be more comfortable. The reason is that we get a lot of sweat on our body in a hot summer day.

Cotton being a good absorber of water, absorbs sweat from the body and provides larger surface area for evaporation which causes more cooling effect. Nylon does not absorb sweat, so the sweat does not evaporate and Ali would feel uncomfortable.

25. 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?

👋 Thinking Process

The washed wet clothes dry more quickly, if we increase the rate of evaporation.

Ans. This can be done by the following (any one or more) steps

(i) Dry it under the fan under the fan when the speed of wind increases, the particles of water vapour from the shirt move away with the wind, decreasing the amount of water vapour in the surroundings. It increases the rate of evaporation of water and the washed wet shirt dries more guickly.

(ii) Use hanger for exposing its larger surface to air When shirt is spread, it has large surface area. This makes the evaporation of water faster. Due to this, shirt dries up more quickly. (iii) Dry it in Sun On sunny day, temperature of atmosphere is more, therefore, the rate of evaporation increases. It is because, on increasing temperature, more particles of water get enough kinetic energy to go into the vapour state. This increases the rate of evaporation. (iv) Use iron By the use of iron, temperature increases and water converts into vapour state (steam) very quickly Hence, rate of evaporation increases and shirt dries very quickly.

26. 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.

Ans. (a) Evaporation produces cooling. This is based on the fact that when a liquid evaporates, it takes (or draws) the latent heat of vaporization 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.

- **27.** Why does the temperature of a substance remain constant during its melting point or boiling point?
- Ans. The temperature of a substance remains constant during melting and boiling points till the completion of melting and boiling. It is because substance makes use of latent heat of fusion to overcome force of attraction between particles of solid to change into liquid during melting and latent heat of vaporization to overcome force of attraction between particles of liquid to change into vapours during boiling.

Therefore, temperature remains constant.



Multiple Choice Questions

- The density of water is maximum at

 (a) 0°C
 (b) 277K
 (c) 100°C
 (d) 283K
- Addition of impurities to water(a) decreases the freezing point of water(b) increases the boiling point of water

(c) does not affect the freezing or boiling Point of water

(d) both (a) and (b) As the solid melts to form liquid, 3. (a) Interparticle forces of attraction decreases (b) the kinetic energy of the particles increases (c) compressibility increases (d) all of these Which of the following is not a characteristic 4. of solids? (a) high rigidity (b) high fluidity (c) low compressibility (d) high density 5. 300 K temperature may be written in Celsius scale as (a) 300°C (b) 127°C (c) 27°C (d) 573°C The physical state of water at $10^{\circ}C$ is 6. (a) solid (b) liquid (c) gas (d) may be solid orliquid 7. The boiling point of water at normal atmospheric pressure is (a) 273K (b) 373 K (c) 100K (d) 0°C Which of the following has highest 8. intermolecular forces of attraction? (a) Liquid water (b) Liquid ethyl alcohol (c) Gaseous CO₂ (d) Solid CO₂ Which of the following compounds will 9. undergo sublimation? (a) Common salt (b) Camphor (c) Sugar (d) Sand 10. Which one of the following gases undergoes diffusion most readily? (b) Carbon dioxide (a) LPG (c) Hydrogen (d) Nitrogen 11. The standard temperature is taken as (a) 0°C (c) 298 K (d) 20°C (c) 273 K 12. In which of the following substances, the Interparticle forces of attraction are the strongest? (a) Sodium chloride (b) glycerine (c) Ethyl alcohol (d) Carbon Dioxide 13. Which of the following indicates the relative randomness of particles in the three states matter? (a) Solid > liquid > gas (b) Liquid < solid < gas (c) Liquid > gas > solid (d) Gas > liquid > solid 14. The process of evaporation causes (a) heating (b) cooling

(c) increase in temperature (d) none of these 15. The conversion of a gas into liquid is called (a) gasification (b) sublimation (c) condensation (d) freezing The force that binds the particles of matter 16. together is known as (a) intermolecular (b) bond (c) intermolecular force (d) nuclear 17. Ice floats on the surface of water because (a) it is heavier than water (b) the density or both water and ice is the same (c) ice is lighter than water (d) none of these 18. Which of the following statements is not correct? (a) Matter is continuous in nature. (b) Interparticle spaces are maximum in the gaseous state of a substance. (c) Particles which constitute the matter follow zig-zag path. (d) Solid state is the most compact state of substance. 19. 10°C temperature is equal to (a) 163 K (b) 10 K (c) 183 K (d) 283 K 20. During evaporation, particles of a liquid change into vapors only (a) from the surface (b) from the bulk (c) from both surface and bulk (d) neither from surface nor from bulk 21. Solids cannot be compressed because (a) constituent particles are very closely packed (b) interparticle attractive forces are weak (c) movement of constituent particle is resisted (d) constituent particles diffuse very slowly 22. The two major gases present in air are (a) nitrogen and oxygen (b) nitrogen and hydrogen (c) hydrogen and oxygen (d) nitrogen and carbon dioxide Evaporation of a liquid can take place 23. (a) at its boiling point (b) below its boiling point (c) at all temperatures (d) at a fixed temperature

24. A liquid is kept in an open china dish. The evaporation of the liquid can be accelerated (a) by keeping the dish in the open

- (b) by blowing air into the liquid
- (c) by keeping the dish under a running fan
- (d) all are correct

25. The melting point temperature of the solid state and freezing point temperature of the liquid state of the same substance are

(a) both same
(b) both different
(c) can't say
(d) none of these

26. Which one of the following statements is wrong for gases?

(a) Cases do not have a definite shape and

(a) Gases do not have a definite shape and volume.

(b) Volume of the gas is equal to the volume of the container confining the gas.

(c) Confined gas exerts uniform pressure on the walls of container in all directions.

(d) Mass of the gas cannot be determined by weighing a container in which it is enclosed.

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

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

(b) volume always remains constant

(c) pressure always remains constant

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

28. Rate of diffusion of a gas is

(a) directly proportional to its density

(b) directly proportional to its molecular mass

(c) directly proportional to the square root of its molecular mass

(d) inversely proportional to the square root of its molecular mass

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

(a) weight	(b) gram
(c) mass	(d) density

- **30.** 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
- **31.** In which phenomenon water changes into water vapour below its boiling point?
 - (a) Evaporation(b) Condensation
 - (D) Condensat
 - (c) Boiling
 - (d) No such phenomenon exists
- **32.** The liquid which has the highest rate of evaporation is
 - (a) mercury
 - (b) nail polish remover
 - (c) water
 - (d) alcohol-water mixture.
- **33.** When we put some crystals of potassium permanganate in a beaker containing water, we observe that after some time whole water has turned pink. This is due to

(a) boiling

(b) melting of potassium permanganate crystals

(c) sublimation of crystals

- (d) diffusion
- 34. 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 definite volume. (c) It has a definite volume but not a definite shape. (d) It has neither a definite shape nor a definite volume. 35. 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) Energy exchanges Which of these choices is defined as 36. "Standard Pressure"? (a) 14.7 psi (b) 1 atm (c) 760 torr (d) all of the above 37. All liquids have same (a) density (b) viscosity (c) solubility (d) none of these 38. Which has the least energetic molecules? (a) Solids (b) Liquids (d) Plasmas (c) Gases 39. Which of these choices will not change the state of matter? (a) Temperature (b) Crushing a crystal (c) Pressure (d) Electricity 40. Of the following, what is the densest state of matter? (a) Solids (b) Liquids (c) Gases (d) Vapors When ice melts to water, then heat is 41. (a) absorbed (b) evolved (c) no change (d) depends on conditions 42. If we add common salt in water then its freezing point (a) increases (b) decreases (c) remains constant (d) can't be determined 43. Which of the following has more heat content (a) 10 g of ice at 0°C (b) 10 g of water at 0°C (c) both have same heat content
 - (d) their heat content cannot be compared

- **44.** The value of latent heat of vaporization of water in cal/kg is
 - (a) 80 (b) 540 (c) 334 (d) 225
- **45.** Minimum spaces between particles is the characteristic property of
 - (a) liquids (b) solids
 - (c) gases (d) none of these
- **46.** A gas can be best liquefied
 - (a) by increasing the temperature
 - (b) by lowering the pressure
 - (c) by increasing the pressure and reducing the temperature
 - (d) none of these is correct
- **47.** Which of the following statements does not go with the liquid state?

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

- (b) Fluidity is maximum in the liquid state.
- (c) Liquids cannot be compressed much.
- (d) Liquids take up the shape of any container in which they are placed.
- **48.** The large volumes of gases can be put into small volumes of cylinders because of their property known as
 - (a) sublimation (b) compressibility
 - (c) evaporation (d) solidification
- **49.** In summer, we prefer wearing
 - (a) dark nylon clothes
 - (b) white cotton clothes
 - (c) white silk clothes
 - (d) dark silk clothes
- **50.** Which of the following factors, when increased, affect the rate of evaporation adversely?
 - (a) Temperature of liquid
 - (b) Surface area of liquid exposed to surrounding
 - (c) Humidity in air
 - (d) Latent heat of condensation
- **51.** 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
- **52.** 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
- **53.** 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 consist of molecules which are in a state of random motion

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

(d) one mole of each gas occupies 22.4 L at STP.

- **54.** Which of these choices is not an example of a plasma?
 - (a) Aurora borealis
 - (b) Fluorescent light bulb
 - (c) Neon sign bulb
 - (d) Incandescent light bulb
- **55.** Amorphous solids
 - (a) are more flexible at higher temperatures(b) include glasses
 - (c) do not have specific melting point
 - (d) all of the above
- 56. The evaporation of a liquid can be best carried out in a(a) beaker(b) china dish
 - (a) beaker (b) china (c) test-tube (d) flask
- 57. SI unit of temperature is

 (a) Kelvin
 (b) Celsius
 (c) Both (a) and (b)
 (d) None of these

 58. When liquid starts boiling, further heat energy
- 58. When liquid starts boiling, further heat energy which is supplied(a) is last to the surrounding energy
 - (a) is lost to the surrounding as such
 - (b) increases the temperature of the liquid
 - (c) increases the kinetic energy of the particles in the liquid
 - (d) is absorbed as latent heat of vaporization by the liquid
- 59. The forces of attraction between the particles of matter is maximum in(a) iron rod(b) kerosene oil
 - (c) glycerine (d) dry air
- 60. The volume of a gas at constant pressure

 (a) increases with increase in temperature
 (b) decreases with increase in temperature
 (c) remains constant at all temperatures
 (d) increases with decrease in temperature.
- 61. Which of the following substances has the highest density?(a) Water
 - (a) Water (b) Kerosene oil
 - (c) Iron (d) Lead
- 62. The substance having the maximum tendency to flow is(a) water(b) sodium

(c) sodium chloride (d) chlorine

- **63.** Which of the following is not correct regarding gases?
 - (a) Gases exert pressure.
 - (b) Gases have large intermolecular spaces.
 - (c) Gases have weak tendency to diffuse.
 - (d) Gases have weak intermolecular forces of attraction.
- 64. Which of the following does not make sense?(a) Solids have fixed shape and fixed volume.(b) We can easily compress a liquid but not a gas.

(c) Solids have negligible kinetic energy of the particles.

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

- **65.** If a few spoons of salt are dissolved in pure water then
 - (a) its b.pt. becomes less than $100^{\circ}C$
 - (b) its b.pt. becomes more than $100^{\circ}C$
 - (c) no change in b.pt.
 - (d) all may be correct
- **66.** Which is the most favorable condition for liquefaction of ammonia?
 - (a) High pressure, high temperature
 - (b) High pressure, low temperature
 - (c) Low pressure, low temperature
 - (d) Low pressure, high temperature
 - The unit of latent heat is
 - (a) joules per kilogram

67.

- (b) calories per gram per $0^{\circ}C$
- (c) ergs per K (d) all of these
- 68. Latent heat of vaporization is used to(a) overcome the forces of attraction between molecules in solid state.

(b) increase the kinetic energy of molecules mliquid state.

(c) overcome the forces of attraction between molecules in liquid state.

(d) increase the kinetic energy of molecules in vapor state.

- **69.** The rate of diffusion decreases
 - (a) with increase in temperature

(b) with increase in kinetic energy of molecules

- (c) with decrease in temperature
- (d) no effect of temperature.
- 70. Liquefaction of a gas can be caused by(a) increase in kinetic energy of molecules
 - (b) decrease in interparticle separation
 - (c) both (a) and (b) (d) neither (a) nor (b).
- **71.** Dry ice on heating produces (a) liquid CO_2 (b) liquid water
 - (c) gaseous CO₂ (d) water vapor

- 72. What type of a process is evaporation?
 (a) Exothermic
 (b) Endothermic
 (c) Photochemical
 (d) Biochemical
- 73. In summer, white or light colored clothes are preferred to dark colored clothes because
 (a) white colour absorbs less heat
 (b) black colour or dark colours absorb less heat

(c) white clothes look good

(d) dark colored clothes are more comfortable.

74. Which of the following statements best explains why a closed balloon filled with helium gas rises in air?

(a) Helium is a monatomic gas, whereas nearly all the molecules that make up air, such as nitrogen and oxygen, are diatomic

(b) The average speed of helium atoms is higher than the average speeds of air molecules, and the higher speed of collisions with the balloon walls propels the balloon upward

(c) Because the helium has a lower molar mass than the average air molecule, the helium gas is less dense than air

(d) Because helium has a lower molar mass than the average air molecule, the helium atoms are in faster motion. This means that the temperature of the helium is higher than the air temperature. Hot gases tend to rise.

- 75. Boyle's law states that the

 (a) pressure of a gas is directly proportional to the temperature at constant volume
 (b) pressure of a gas is inversely proportional to the volume at constant temperature
 (c) volume is directly proportional to the temperature at constant pressure
 (d) none of the above.
- 76. 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.

FILL IN THE BLANKS

- **1.** Liquids take the shape of the.....
- **2.** Liquids have..... density than gases.
- **3.** The temperature at which a liquid changes into gas/vapour is called.....
- **4.** Intermolecular space in solids is..... than that of liquids.
- 5. Evaporation takes place from the.....of the liquid, while boiling takes place from the.....of the liquid.

- Intermolecular forces of 6. attraction are.....in solids,.... liquids in and..... in gases.
- Gases can be compressed by applying 7.and lowering.....
- 8. Liquid and..... states are fluid states.
- 9. Mass occupied by a solid per unit volume is called..... of solid.
- 10. The smell of perfume gradually spreads across a room due to.....
- Latent heat of fusion is the amount of heat 11. energy required to change 1 kg of solid into liquid at its
- 12. Evaporation causes.....
- 13. is the change of gaseous state into solid without going through liquid state and vies versa.
- 14. Gases at higher temperature have generally..... kinetic energy as compared to lowa temperature.
- 15. solids have sharp melting points.
- As the volume of a specific amount of a gas 16. decreases, the pressure.....
- 17. metal is liquid at room temperature
- 18. Density is measured in.....
- 19. In solid state, particles are packed..... an are unable to
- 20. When a solid is heated, the forces of attraction between the particles are.....by tin increased..... of the particles

TRUE OR FALSE

- The intermolecular forces in the liquid state a 1. substance are stronger than those in solid state
- 2. The volume of a gas expands on heating.
- 3. Boiling is a bulk phenomenon,
- Latent heat of vaporization is the heat energy 4. required to change 1 kg of a liquid to gas at atmospheric pressure at its melting point.
- 5. The molecules of a gas are in constant motion.
- AU materials change from solid to liquid to 6. gas as the temperature increases.
- 7. Evaporation and boiling are the same process because molecules move from a liquid to gas phase.
- 8. CNG is compressed nitrogen gas.
- 9. Fusion is a change of solid state to liquid state.
- A system that changes from a solid state to a 10. liquid state gains energy.

- 11. Gases have highest rate of diffusion among all the three states of matter.
- 12. Solid CO₂ is an example of ionic solid.
- Higher fluidity and high rigidity 13. are characteristics of solids.
- 14. Ammonium chloride sublimes on heating.
- 15. Under normal conditions of temperature and pressure, the matter exists in four states.
- 16. Plasma state of matter exists at low temperature.
- 17. Gas molecules are unevenly distributed in the atmosphere.
- 18. The plasma glows in a special colour depending on the amount of electricity passed through the gas.
- 19. During the phase change, from solid to liquid or from liquid to gas, the temperature remains constant.
- 20. Few substances like calcium carbonate (a solid at room temperature) cannot be melted or vaporized.

MATRIX MATCH TYPE

In this section, each question contains statements

given in a two columns which have to be matched. Statements (A, B, C, and D) in Column-I have to be matched with statements D (p, q, r, s) in Column-II. The answers to these questions have to be



appropriately bubbled as illustrated in the following example. If the correct matches are A-q, A-r, B-p, B-s, C-r, C-s and D-q, then the correctly bubbled matrix will look like as shown.

- 1. Column I
 - (A) Liquid \rightarrow solid (B) Solid \rightarrow gas

(D) Gas \rightarrow solid

(A) Increase in

(B) Decrease in

(C) Evaporation

surface area

temperature

Column I

- (C) Gas \rightarrow liquid
- (p) Condensation

Column II

- (q) Sublimation
- (r) Solidification

Column II

- (p) Evaporation increases
- (q) Evaporation decreases
- (r) Bulk phenomenon
- (s) Surface

Column II

- (p) $-63^{\circ}C$
- (q) 300° C
- (r) $27^{\circ}C$

- (D) Boiling
 - phenomenon Column I

(A) 300 K

(B) 573K

(C) 646*K*

- 3.

2.

	(D) 210 <i>K</i>	(s) 373° <i>C</i>
4.	Column I	Column II
	(A) In liquids, particles are held together	(p) Slightly
	(B) Liquids can be compressed	(q) Less firmly
	(C) In gases, particles are held together	(r) Most firmly
	(D) In solids, particles are held together	(s) Least firmly
5.	Column I	Column II
	(A) Liquid	(p) Definite shape
	(B) Solid	(q) Definite volume
	(C) Plasma	(r) Super low density
	(D) BEC	(s) Super energetic
6.	Column I	Column II
	(A) Particles move randomly	(p) Water
	(B) Layers can slide ove each other	r (q) Sugar
	(C) Becomes solid unde pressure	r (r) Nitrogen
	(D) Particles are not free to move	(s) Carbon dioxide

ASSERTION & REASON QUESTIONS

Directions: In each of the following questions, a statement of Assertion (A) is given followed by a corresponding statement of Reason (R) just below it. Of the statements, mark the correct answer as

(a) If both assertion and reason are true and reason is the correct explanation of assertion

(b) If both assertion and reason are true but reason is not the correct explanation of assertion

(c) If assertion is true but reason is false

(d) If assertion is false but reason is true.

- Assertion: During evaporation of liquids the temperature remains unaffected
 Reason: Kinetic energy of the molecules is directly proportional to absolute temperature.
- 2. Assertion: Camphor disappears without leaving any residue.

Reason: Camphor undergoes sublimation.

- Assertion: The process of diffusion is always followed by effusion,
 Reason: Both diffusion and effusion deal with spreading of gas.
- Assertion: HCl diffuses faster than ammonia.
 Reason: Rate of diffusion of a gas is inversely proportional to the square root of its density.
- 5. Assertion: Liquids diffuse less easily as compared to gases.

Reason: Intermolecular forces are greater in gases.

6. Assertion: A drop of liquid acquires spherical shape.

Reason: It does so because of capillary action.

7. Assertion: Glass is an amorphous solid.

- **Reason:** Glass has irregular, random arrangement of atoms.
- Assertion: Ionic solids conduct electricity in solid state.
 Reason: They are made up of canons and anions.
- 9. Assertion: Ice floats on the surface of water. Reason: The density of both water and ice is same.
- **10. Assertion:** The intermolecular forces in solid state are stronger than those in the liquid state.

Reason: The space between the particles of matter is called intermolecular space.

- Assertion: The rate of evaporation increases with increase in temperature.
 Reason: Increase in temperature increases the kinetic energy of the particles.
- Assertion: Solids do not diffuse in air.
 Reason: The particles are closely packed in solids.
- **13.** Assertion: It is easier to cook food at high altitudes.

Reason: The boiling point of water decreases at high altitudes.

- 14. Assertion: Cohesive forces keep the molecules together.Reason: Evaporation is the escape of the molecules from the liquid state.
- **15. Assertion:** There is no change in the temperature of a substance when it undergoes a change of state though it is still being heated.

Reason: The heat supplied is absorbed either as latent heat of fusion or as latent heat of vaporization.

- Assertion: The conversion of a gas directly into solid is called condensation.
 Reason: Naphthalene does not leave any residue when kept open for some time.
- Assertion: At normal pressure (1atm) the boiling point of water is 100°C or 373.15 K.
 Reason: As the pressure increases, boiling point of water also increases.
- **Assertion:** The melting point of ice is 0°C or 273.15 K.
 Beason: The conversion of a solid into liquid is

Reason: The conversion of a solid into liquid is also called fusion of the solid.

19. Assertion: The term vapors is used to represent the gaseous state of a substance which is otherwise liquid at room temperature.

Reason: It is proper to regard the gaseous state of ammonia as vapors.

- **20. Assertion:** Naphthalene, camphor, iodine, ammonium chloride are some common examples of the substances which undergo sublimation.
- **21. Reason:** All solids are first converted to liquids and then gases on heating.

PASSAGE

PASSAGE 1: The molecules of a gas are free to move about in any direction. Because of large are Intermolecular spaces, the gases easilv compressible. The kinetic energy of the molecules of gases is maximum and they move about randomly at a high speed. The randomly moving high speed molecules hit against the sides of containing vessel. The pressure exerted by any gas is due to the force exerted by its molecules on the sides of containing vessel.

- **1.** A gas fills all the space in a container in which it is kept because
 - (a) the gases have large intermolecular spaces(b) the molecules are not free to move

(c) the randomly moving molecules hit against the walls of container

(d) the molecules have large intermolecular forces of attraction.

2. When pressure is applied on a gas, it is converted to a liquid due to

(a) increase in intermolecular forces of attraction between the particles

(b) increase in intermolecular distances between the particles

(c) decrease in intermolecular forces of attraction between the particles

(d) increase in kinetic energy of particles.

- **3.** The force per unit area exerted by the particles of the gas on the walls of container is called
 - (a) atmospheric pressure
 - (b) pressure of the gas
 - (c) kinetic energy of the gas
 - (d) density of the gas.

PASSAGE 2: The pressure exerted by air is called atmospheric pressure. The pressure is generally measured in atmospheres. The atmospheric pressure at sea level is 1 atmosphere and is taken as normal

atmospheric pressure. 1atm = 760 mm of Hg = 76 cm of mercury At a depth of 33 ft below the sea level, an additional 1 atm pressure is exerted by water. Other units of pressure are torr and bar. S.I. unit of pressure is Pascal (Pa). $(1atm = 1.01 \times 10^5 Pa)$

- When we blow air into a balloon, it inflates because

 (a) air particles diffuse in balloon.
 (b) air particles collide with walls of balloon and exert pressure on them.
 (c) rubber is elastic in nature.
 (d) the temperature of air in the balloon becomes high.
- At a depth of 100 ft below sea level what is the value of total pressure experienced by a diver?
 (a) 1 atm
 (b) 2 atm
- (a) 1 atm
 (b) 2 atm
 (c) 3 atm
 (d) 4 atm
 (d) 4 atm
 (e) 1 atm
 (f) 2 atm
 (f) 2 atm
 (g) 1.5 atm
 (g) 1 atm
 (g) 2 atm

PASSAGE 3: The phenomenon of change of liquid into vapors at any temperature below its boiling point is called evaporation. The rate of evaporation increases with increase in surface area, temperature, speed of wind and decrease in humidity. Evaporation causes cooling due to decrease in average kinetic energy of the remaining liquid after the surface molecules leave. Lower the boiling point of the liquid, higher is its rate of evaporation.

1. Synthetic clothes are uncomfortable in summer because (a) they absorb kinetic energy from the air molecules. (b) they do not let the sweat evaporate (c) they are highly porous (d) they are very thick. 2. Liquids like ether and acetone are kept in cool places because (a) ether and acetone have high boiling points (b) the rate of evaporation increases with surface area (c) ether and acetone are volatile liquids with low boiling points

(d) ether and acetone have lower density than water.

- **3.** The water spilled on the floor evaporates faster than the water in a glass due to
 - (a) increase in surface area(b) increase in temperature
 - (c) increase in humidity

(d) decrease in kinetic energy.

PASSAGE 4: Surface tension of liquids is a molecular phenomenon involving the force of cohesion or attraction among the liquid molecules. It is a scalar quantity. Numerically it is proved that the potential energy of a liquid is maximum on the surface. Surface tension of a liquid is independent of surface area but it depends on the intermolecular force and temperature. It is defined as the force acting on the surface at right angle of unit length. Sparingly soluble salts decrease the surface tension of liquid while fairly soluble solutes increase the surface tension of the liquid.

- 1. Surface tension of a liquid does not depend on
 - (a) temperature
 - (b) intermolecular force
 - (c) surface area
 - (d) solute dissolved in liquid
- 2. Which of the following has highest surface tension?

(a) Water (b) Soap in water

(c) Detergent in water (d) Glycerol in water

- **3.** Which of the following phenomenon is not due to surface tension?
 - (a) Small droplets are spherical in shape
 - (b) Water rises in a capillary
 - (c) Oil rises in a lamp wick
 - (d) Insects cannot walk on water.
 - The unit of surface tension is

4.

(a) dyne cm^{-1}	(b) Joules cm^{-2}
(c) calorie	(d) cm^{3}

PASSAGE 5: When two or more non-reacting gases are kept side by side, they have the tendency to mix with one another to form a homogeneous mixture. This can occur also if two gases have different densities. The heavier gas can move up or a lighter gas can move down against the action of gravity. It shows that gas particles move at random with large intermolecular spaces. This mixing of gases is known as diffusion. According to Graham's law of diffusion, the rate of diffusion of a gas is inversely proportional to the square root of its density or molar mass.

1.	Which of the followin	g gases will have the
	highest rate of diffusion	ו?
	(a) O ₂	(b) CO ₂

- (c) NH₃ (d) N₂
- 2. Non-reacting gases have a tendency to mix with each other. This phenomenon is known as

(a	a) (effus	sior	۱		(b) d	iffusio	n
							-	

(c) chemical reaction (d) explosion

- **3.** The rate of diffusion of hydrogen is about
 - (a) only half of that of helium
 - (b) 1.4 times that of helium
 - (c) twice that of helium
 - (d) four times that of helium.

SUBJECTIVE PROBLEMS

VERY SHORT ANSWER TYPE QUESTIONS

- **1.** Is the melting point temperature of solid and the freezing point temperature of liquid same or different?
- 2. What is the heat absorbed during the change of state of a substance called?
- 3. Name a common substance which can undergo a change in the state upon heating or cooling without any change in its composition?
- **4.** Predict the physical state of a substance which has melting point below room temperature.
- 5. What is the space occupied by matter called?
- **6.** Name the temperature at which a liquid solidifies.
- **7.** Why do solids generally lack the property of diffusion?
- 8. Define gaseous state of a substance.
- **9.** Write an expression to show Charles' law.
- **10.** Which property of gas can explain the characteristic that there is large space between the molecules of a gas?
- **11.** Why a drop of Dettol is evenly distributed in a bucket of water without the need of stirring?
- **12.** What is the term used to describe the phase change of a liquid to gas?
- **13.** What happens when ammonium chloride is heated?
- 14. The water taken from sea freezes at about 2°C and boils at 101°C. Explain the reason.
- **15.** When a solid starts melting, its temperature does not rise till the complete solid has malted. Explain.

SHORT ANSWER TYPE QUESTIONS

- **1.** A given mass of a gas occupies 960 mL at $27^{\circ}C$. What volume will it occupy if the temperature is raised to $177^{\circ}C$ at constant pressure?
- A gas occupies a volume of 8 litres at 2 atm. What will be its pressure if the volume is increased to 10 litres?

- **3.** Define latent heat of fusion of a solid.
- **4.** What is the difference between gas and vapor?
- 5. What is humidity? What is its effect on evaporation?
- 6. What is the effect of pressure on boiling point?
- 7. How will you show that the process of evaporation depends on the nature of me liquid?
- 8. Why does honey diffuse in water at a slower rate than ink?
- **9.** Why are the forces of attraction between the gaseous molecules negligible?
- **10.** Define density.
- 11. Why do solids expand on heating?
- **12.** Why does it take more time for the clothes to dry in monsoon season than in the dry season?
- **13.** Explain the term boiling.
- **14.** What is condensation?
- **15.** How does applying pressure help in liquefaction of a gas?

LONG ANSWER TYPE QUESTIONS

- **1.** State the various factors which affect evaporation.
- 2. Mention the characteristic properties of a gas.
- **3.** What is meant by inter convertibility of the states of matter?
- **4.** What are the main differences between evaporation and vaporization or boiling?
- 5. Why do we rub ice on a burnt part of the body to feel less pain?
- 6. Calculate the temperature at which Fahrenheit and Celsius scales have the same reading.
- 7. What is meant by liquefaction? Discuss different ways by which liquefaction of gases can be achieved?
- **8.** Explain some important characteristics of matter based on its particle nature.
- 9. Why are gases considered as fluid?
- **10.** Why do solids, liquids and gases have different properties?
- **11.** Besides solids, liquids and gases what are the other states of matter and under what conditions do they exist?
- **12.** Explain Kelvin or absolute scale of temperature.
- **13.** Why is the melting point of a substance very important?

14. Define specific latent heat of fusion and specific latent heat of vaporization.

INTEGER ANSWER TYPE

This section contains 5 questions. The answer to each of the questions is a single digit integer, ranging from 0 to 9. If the correct answers to question numbers X, Y, Z and W (say) are 6, 0, 9 and 2 respectively, then the correct darkening of bubbles will look like the following.



- 1. The density of ice is maximum at a temperature (°C) of
- A fixed mass of ammonia occupies a volume of 480 L at a certain pressure X atm. If the gas is transferred to another container of pressure 240 atm and volume 12 L, then the value of X is
- **3.** A pressure of 228 cm Hg is equivalent to X atmosphere. The value of x is
- 4. Mass of 270 g block of iron displaces a volume of 30 mL of a liquid. The density is
- 5. The temperature of a liquid before heating was recorded as 25° C and after heating was recorded as 300 K. The difference in temperature is



1. B	2. D	3. D	4. B	5. C	6. B	7. B
8. D	9. B	10. C	11. B	12. A	13. D	14. B
15. C	16. C	17. C	18. C	19. D	20. A	21. A
22. A	23. B	24. D	25. A	26. D	27. D	28. D
29. C	30. B	31. A	32. B	33. D	34. C	35. A
36. D	37. D	38. A	39. B	40. A	41. A	42. B
43. B	44. B	45. B	46. C	47. B	48. B	49. B
50. C	51. A	52. D	53. C	54. D	55. D	56. B
57. A	58. D	59. A	60. A	61. D	62. D	63. C
64. B	65. B	66. B	67. A	68. C	69. C	70. B
71. C	72. B	73. A	74. C	75. B	76. A	

Fill in the Blanks

1.	container	2.	more
3.	boiling point	4.	less
5.	surface, bulk	6.	maximum, intermediate,
			minimum
7.	pressure, temperature	8.	gaseous
9.	density	10.	diffusion
11.	melting point	12.	cooling
13.	Sublimation	14.	higher

15. Crystalline	16. increases			
17. Mercury				
18. kg per cubic metre or g per cubic centimetre				
19. tightly, move 20. weakened, distance				

True or False

1.	False. Intermolecular forces are strongest in
	solid state.
2.	True
3.	True
4.	False. Latent heat of vaporization is the heat
	energy required to change 1 kg of a liquid to gas
	at atmospheric pressure at its boiling point.
5.	True
6.	False. Few substances undergo sublimation.
7.	False. Evaporation is the process of conversion
	of liquid phase to gaseous phase below the
	boiling point of the liquid. Also evaporation is a
	surface phenomenon whereas boiling is a bulk
	phenomenon.
8.	False. CNG is compressed natural gas.
9.	True
10.	True
	-
11.	Irue

12.	False.	Solid	CO_{2}	is	an	example	of	molecular
	solid.							

13. False. Solids are highly rigid, fluidity is characteristic of gases and liquids.

14. True

15. False. Under normal conditions of temperature and pressure, the matter exists in three states, solid, liquid and gas. Other two states plasma and EEC exist under specific conditions of temperature and pressure.

16. False. Plasma exists only at a very high temperature of about 106 K. This high temperature is found only in the interior of the stars.

17. True

- 18. False. The electricity passed through the gas creates plasma but the colour of the glow depends upon what kind of gas is present inside.19. True
- **20.** True. On heating calcium carbonate decomposes into calcium oxide which is another solid and carbon dioxide which is a gas.

Matrix Match Type

1.	$A \rightarrow r;$	$B \rightarrow q;$	$C \rightarrow p;$	$D \rightarrow q$
2.	$A \rightarrow p;$	$B \rightarrow q;$	$C \rightarrow s;$	$D \rightarrow r$
3.	$A \rightarrow r;$	$B \rightarrow q;$	$C \rightarrow s;$	$D \rightarrow p$

4.	$A \rightarrow q;$	$B \rightarrow p;$	$C \rightarrow s;$	$D \rightarrow r$
5.	$A \rightarrow q;$	$B \rightarrow p, q;$	$C \rightarrow s;$	$D \rightarrow r$
6.	$A \rightarrow r, s;$	$B \rightarrow p;$	$C \rightarrow s;$	$D \rightarrow q$

Assertion and Reason Type

1. D	2. A	3. D	4. D	5. C
6. C	7. A	8. D	9. C	10. B
11. A	12. A	13. D	14. B	15. A
16. D	17. B	18. B	19. C	20. C

3. B

3. B

3. A

3. D

3. B

Passage - 1	

1. A

Passage - 2

2. A

1. B

Passage - 3

2. C

2. D

1. B

1. C

1.

Passage - 4

2. D

1. C

2. B

Passage - 5

integer Answer Type								
4	2.	6	3.	3	4.	9	5.	2