CHAPTER 5

PHYSICAL STATES OF MATTER

MULTIPLE CHOICE QUESTIONS

1. **Which of the following expand or compressed easily**
   (a) liquid (b) gases (c) solids (d) water
2. **Diffusion is faster in:**
   (a) liquid (b) solids (c) gases (d) plasma
3. **Gases exerts pressure in all directions**
   (a)uniformly (b) randomly (c) alternately (d) constantly
4. **Which principle is used in working pressure cooker?**
   (a) Boiling point increased by increasing the external pressure.
   (b) Boiling point decreased by decreasing the external pressure.
   (c) Boiling point increased by increasing the external pressure.
   (d) None of these
5. **Red phosphorus is:**
   (a) less reactive (b) non-poisonous (c) brittle (d) all of above
6. **Which percentage of salt is required to kill the bacteria?**
   (a) 10% (b) 20% (c) 30% (d) 40%
7. **The density of gold is:**
   (a) 2.70 gcm^{-3} (b) 7.86 gcm^{-3} (c) 9.3 gcm^{-3} (d) 2.98 gcm^{-3}
8. **The solids in which particles are arranged in definite three-dimensional pattern are called:**
   (a) solids (b) Crystalline solids (c) Amorphous solids (d) both b & c
9. **The transition temperature of tin is:**
   (a) 96^0C (b) 250^0C (c) 18^0C (d) 100^0C
10. **Oxygen has two allotropic forms:**
   (a) O_2 and O_4 (b) O_2 and O_3 (c) O and O_3 (d) O_2 and O
11. **Plastics, glass rubber, lamp-black etc. are the examples of:**
   (a) Crystalline solids (b) Super cooled liquids
   (c) Amorphous solids (d) ionic solids
12. **The temperature at which the solid and liquid phases of a substance co-exist:**
   (a) freezing point (b) boiling point (c) melting point (d) equilibrium

13. **The existence of solid in different physical forms is called:**
(a) Crystals (b) Allotropy (c) Evaporation (d) Tra

14. **It depends upon the nature of liquid, intermolecular forces and exter**
(a) melting point (b) freezing point (c) boiling point (d) none of

15. **The conversion of a liquid into vapours at all temperature is called.**
(a) Evaporation (b) Boiling (c) Cooling process (d) both a

16. **Density is expressed in:**
(a) $g\ cm^{-3}$ (b) $g\ dm^{-3}$ (c) both a & b (d) none of these

17. Charles described, how gases tend to expand when heated:
(a) 1882 (b) 1802 (c) 1820 (d) 1828

18. **Mass per unit volume is called:**
(a) pressure (b) temperature (c) density (d) solubility

19. **Robert Boyle's was a natural:**
(a) philosopher (b) chemist (c) physicist (d) All of above

20. **Matter exists in three physical states:**
(a) Solid, liquid, plasma (b) Solid, water, vapour
(c) Plasma, liquid, solid (d) Solid, liquid, gas

ANSWER KEY

1	b	4	c	7	c	10	b	13	b	16	c	19	d
2	c	5	d	8	b	11	c	14	c	17	b	20	d
3	a	6	b	9	c	12	a	15	a	18	c	KIPS	

SHORT QUESTIONS

5.1 GASEOUS STATE

Q.1 Why the rate of diffusion of gases is rapid than that of liquids?

Ans. The rate of diffusion of gases is more than that of liquids because, more empty spaces are present between their molecules, as compare to liquid. So, the flow of rate of gas molecules is more as compare to liquid molecules.

Q.2 Why the gases are compressible?

Ans. Gases are highly compressible due to empty spaces between their molecules and the intermolecular forces in gases are vary week. When gases are compressed molecules come closer to one another and occupy less volume as compare to the volume in uncompressed state.

Q.3 What do you mean by Pascal? How many Pascals are equal to 1 atm?

Ans. Pascal: "The pressure equal to one Newton per square meter is called Pascal."

$$1\ atm = 101325\ Pa$$

Q.4 Whether the densities of a gas decrease on cooling?

Ans. No, the density of a gas does not decrease on cooling, it increases on cooling because on cooling their volume decrease and density is inverse to volume.

As $$d = \frac{m}{v}$$

Q.5 Why is the density of gas measured in g dm^{-3} while that of a liquid is expressed in g cm^{-3}?

Ans. The gas molecules are far apart to each other due to very weak intermolecular forces among them. Gases occupy more spaces at normal condition as compare to liquids that is why, a smaller unit of volume measurement is used for liquids.

dm^3 is big unit of volume

cm is smaller unit of volume

So For gases = d = gdm^{-3}

For liquid = d = gcm^{-3}

Convert the following

(a) 70 cm Hg to atm:

$$760\ cm\ Hg = 1\ atm$$

$$1\ cm\ Hg = \frac{1}{760}$$

$$70\ cm\ Hg = \frac{1}{760} \times 70 = 0.0921\ atm$$

Ans. 70 cm Hg = 0.0921 atm

(b) 3.5 atm to torr:

1 atm = 760 torr

3.5 atm = 760 × 3.5

= 2660

Ans. 3.5 atm equal to 2660 torr

(c) 1.5 atm to Pa

1 atm = 101325 Pa

1.5 atm = 101325 × 1.5

= 151987.5

Ans. 1.5 atm is equal to 151987.5 Pa

5.2 LAWS OF RELATED TO GASES

Q.1 Is the Boyle's law applicable to liquids?

Ans. No, Boyle's law is only applicable to gases.

$$PV = \text{constant}$$

Constant is temperature.

Q.2 Is the Boyle's law valid at very high temperature?

Ans. No, the Boyle's law is not valid/applicable at very high constant temperature because at high temperature, the kinetic energy of gas molecules increases, that increases the mobility of molecules, it exerts pressure that may vary the volume of gases.

Q.3 What will happen if the pressure on a sample of gas is raised three times and its temperature is kept constant?

Ans. If the pressure on a sample of gas is raised three times at constant temperature, the volume will also decreases three times of its original (normal)

Q.4 Which parameters are kept constant in Charles' law?

Ans. Pressure is kept constant. While, volume and temperature are variable parameters.

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

Constant is pressure.

Q.5 Why volume of a gas decreases with increase of pressure?

Ans. As according to Boyle's law: " The volume of the given mass of the gas inversely proportional to its pressure provided the temperature constant" So by increases the pressure, the molecules of gas compressed and come closer to each other and occupy less volume. as $d = \frac{m}{v}$

LONG QUESTIONS

Introduction

Matter exists in three physical states i.e. gas, liquid and solid. The simplest form of matter is the gaseous state'. Liquids are less common and most of the matter exists as solid. Matter in gaseous state does not have definite shape and volume. Therefore, gases occupy all the available space. Their intermolecular forces are very weak. Pressure is a significant property of gases. The effect of pressure and temperature on volume of a gas has been studied quite extensively.

The liquid state has strong intermolecular forces hence it has definite volume but it does not have definite shape. It attains the shape of the container in which it is kept. Liquids evaporate and their vapours exert pressure. When vapour pressure of a liquid becomes equal to external pressure, it boils. Liquids are less mobile than gases therefore, they diffuse slowly.
The solid state has definite volume and shape. They are rigid and denser than liquids and gases. They exist in amorphous or crystalline forms.

5.1 GASEOUS STATE

Q.No.1 Write down the general properties of Gaseous state.

Typical Properties

Gases have similar physical properties.
A few typical properties are discussed here.

5.1.1 Diffusion

A spontaneous mixing up of molecules by random motion and collisions to form a homogeneous mixture.

Dependence

Rate of diffusion depends upon the molecular mass of the gases. Lighter gases diffuse rapidly than heavier ones. For example, H_2 diffuses four times faster than O_2 gas.

5.1.2 Effusion

It is escaping of gas molecules through a tiny hole into a space with lesser pressure.

Example

When a tyre gets punctured, air effuses out.

Dependence

Effusion depends upon molecular masses, lighter gases effuse faster than heavier gases.

5.1.3 Pressure

The force (F) exerted per unit surface area(A).

Formula

$$P = \frac{F}{A}$$

Pascal

The SI unit of force is Newton and th·· of area is m^2 Hence pressure has SI unit of N m -2. It is also called Pascal (Pa)

One Pascal (Pa) = 1 Nm^{-2}

Pressure Measure Devices

- Barometer is used to measure atmospheric pressure
- Manometer is used to measure pressure in the laboratory.

Standard Atmospheric Pressure

It is the pressure exerted by the atmosphere at the sea level.

OR

It is defined as the pressure exerted by a mercury column of 760 mm height at sea level.

Different units of Pressure

1 atm =760 mm of Hg = 760 torr

(1 mm of Hg = one torr)

101325 Nm-2 = 101325 Pa

5.1.4 Compressibility

Properties

- Gases are highly compressible due to empty spaces between their molecules.
- When the gases are compressed, the molecules come closer to one another and occupy less volume as compared to the volume in uncompressed state.

5.1.5 Mobility

- Gas molecules are always in state of continuous motion.
- They can move from one place to another because gas molecules possess very high kinetic energy.
- They move through empty spaces that are available for the molecules to move freely.
- The mobility or random motion results in mixing" up of gas molecules to produce a homogeneous mixture.

5.1.6 Density of Gases

- Gases have low density than liquids and solids.
- It is due to light mass and more volume occupied by the gas molecules.
- Gas density is expressed in grams per dm^3.
- Whereas, liquid and solid densities are expressed in grams per cm^3 i.e. liquids and solids are 1000 times denser than gases.
- The density of gases increases by cooling because their volume decreases.

5.2 LAWS RELATED TO GASES

Q.No.2 State Boyle's Law. Give the experimental verification of Boyle's law.

5.2.1 BOYLE'S LAW

Introduction

In 1662 Robert Boyle studied the relationship between the volume and pressure of a gas at constant temperature. Robert Boyle (1627-1691) was natural philosopher, chemist, physicist and inventor it is famous for 'Boyle's law of gases'

Statement 1

The volume of a given mass of a gas is inversely proportional to its pressure provided the temperature remains constant.

Explanation

According to this law the volume (V) of a given mass of a gas decreases with the increase of pressure (P) and vice versa.

Mathematically

It can be written as:

$$V \alpha \frac{1}{P} \qquad PV = \text{constant}$$

As both equations have same constant therefore, their variables are also equal to each other.

$$P_1V_1 = P_2V_2$$

This equation establishes the relationship between pressure and volume of the gas.

Experimental Verification of Boyle's law

The relationship between volume and pressure can be verified experimentally by the following series of experiments. Let us take some mass of a gas in a cylinder having a movable piston and observe the effect of increase of pressure on its volume. The phenomenon is represented when the pressure of 2 atmosphere (atm) is applied, the volume of the gas reads as 1 dm^3. When pressure is increased equivalent to 4 atm, the volume of the gas reduces to 0.5 dm^3. Again when pressure is increased three times i.e. 6 atm, the volume reduces to 0.33 dm^3, Similarly, when pressure is increased up to 8 atm on the piston, volume of the gas decreases to 0.25 dm^3 where 'k' is proportionality constant. The value of k is same for the same amount of a given gas.

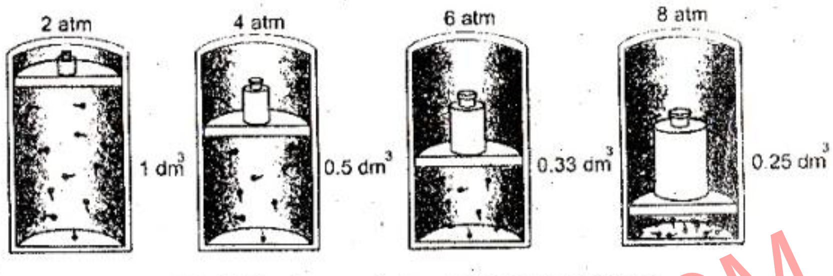


Fig. 5.1 The decrease of volume with increase of pressure.

Statement 2

Therefore, Boyle's law can be stated as the product of pressure and volume of a fixed mass of a gas is constant at a constant temperature.

Result

When we calculate the product of volume and pressure for this experiment, the product of all these experiments is constant i.e 2 atm dm^3. It proves the Boyle's law

Example 5.1

A gas with volume 350 cm^3 has a pressure of 650 mm of Hg. If its pressure is reduced to 325 mm of Hg calculate what will be its new volume?

Given Data

V_1= 350 cm-
P_1=650 mm of Hg
P_2=325 mm of Hg
V_2= ?

Solution

$$P_1V_1=P_2V_2 \quad \text{Or} \quad V_2=\frac{P_1V_1}{P_2}$$

But putting the values:

$$V_2=\frac{650\times350}{325}=700\,cm^3$$

Thus volume of the gas is doubled by reducing its pressure to half.

Example 5.2

785 cm^3 of a gas was enclosed in a container under a pressure of 600 mm Hg. If volumes is reduced to 350 cm^3, what will be the pressure?

Given Data

VI	=	785 cm^3
PI	=	600 mm of Hg
V2	=	350 cm^3
P2	=	?

Solution

By using the Boyle's equation

$$P_1V_1=P_2V_2$$

$$P_2=\frac{P_1V_1}{V_2}$$

By putting the values

$$P_2=\frac{785\times600}{350}=1345.7\text{ mm of Hg}$$

or $$P_2=\frac{1345.7}{760}=1.77\text{ atm}$$

Thus pressure is increased by decreasing volume.

Q.No.3 State Charle's Law. Give the experimental verification of Boyle's law.

CHARLE'S LAW

Introduction

The relationship between volume and temperature keeping the pressure constant was also studied by French scientist J. Charles in 1787. J. Charles (1746-1823) was a French inventor scientist, mathematician and balloonist. He described in 1802 how gases tend to expand when heated.

Statement

"The volume of a given mass of a gas is directly proportional to the absolute temperature if the pressure is kept constant"

Explanation

When pressure P is constant, the volume V of a given mass of a gas is proportional to absolute temperature T.

Mathematically

It is represented as

$$V \propto T$$

$$V = k\,T$$

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

Where *k* is proportionality constant

If temperature of the gas is increased its volume also increases. When temperature is changed from T_1 to T 2, the volume changes from V_1 to V_2. The mathematical form of Charles' Law will be:

Experimental Verification of Charles' Law

Let us take a certain amount of gas enclosed in a cylinder having a movable piston. If the initial volume of the gas V_1 is 50 cm^3 and initial temperature T_1 is 25°C on heating the cylinder up to 100 °C its new volume V_2 is about 62.5 cm^3. The increase in temperature increases the volume that can be observed as elaborated.

Representation of increase of volume with the increase of temperature.

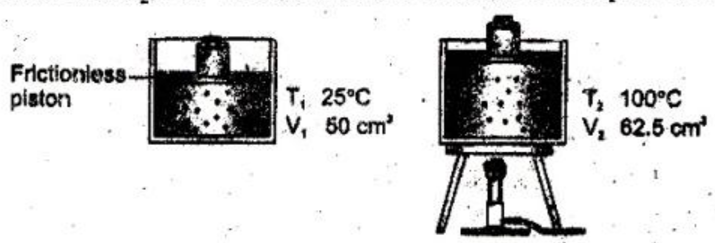


Fig. 5.2: Representation of increase of volume with the increase in temperature.

Q.No.4 Explain the absolute temperature scale with example.

ABSOLUTE TEMPERATURE SCALE

Introduction

Lord Kelvin introduced absolute temperature scale or Kelvin scale. This scale of temperature starts from 0 K or -273.15 °C, which is given the name of absolute zero.

Definition

It is the temperature at which an ideal gas would have zero volume. As both scales have equal degree range, therefore, when 0 K equal to -273°C then 273 K is equal to 0°C as shown in the scales.

Conversion of Kelvin temperature to Celsius temperature and vice versa can be carried out as follows:

Remember

Always convert temperature scale from °C to K scale while solving problems. K = 273 + °C

Example 5.3

A sample of oxygen gas has a volume of 250 cm^3 at -30°C. If gas is allowed to expand up to 700 cm^3 at constant pressure, find out its final temperature.

Given Data

$V_1 = 250\ cm^3$

$T_1 = -30^0C = 243\ K$

$V_2 = 700\ cm^3$

$T_2 = ?$

Solution

By using the equation:

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

or $$T_2 = \frac{V_2 T_1}{V_1}$$

By putting the value in equation

$$T_2 = \frac{700 \times 243}{250} = 680.4\ K$$

Example 5.4

A sample of hydrogen gas occupies a volume 160 cm^3 at 30°C. If its temperature is raised to 100°C, calculate what will be its volume if the pressure remains constant

Given Data

$V_1 = 160\ cm^3$

$T_1 = 30^oC = 303K$ (as $0^oC = 273$ K)

$T_2 = 100^oC = 373$ K

$V_2 = ?$

Solution

By using the equation of Charles' Law

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

or $$V_2 = \frac{V_1 T_2}{T_1}$$

By putting the value in equation

$$T_2 = \frac{160 \times 373}{303} = 196.9\ cm^3$$

Thus volume of the gas has increased by raising the temperature.

Q.No.5 Why Degree sign (o) is used with Celsius scale not with Kelvin scale?

Degree sign (o) is used with Celsius scale not with Kelvin scale.

- Body temperature is measured in Fahrenheit scales. Normal body temperature is 98.6F, it is equivalent to 37°C.
- This temperature is close to average normal atmospheric temperature.
- In winter atmospheric temperature falls lower than that of our body temperature.
- According to principle of heat flow, heat flows out from our body and we feel cold.
- To control this outward flow of heat, we wear black and warm clothes.
- To maintain body temperature we use dry fruits, tea, coffee and meats etc.

Q.No.6 Explain the Physical States of Matter and Role of Intermolecular Forces.

Physical States of Matter and Role of Intermolecular Forces

- Three physical states; gas, liquid and solid.
- In the gaseous state, the molecules are far apart from each other. Therefore, intermolecular forces are very weak in them
- But in the liquid and solid states intermolecular forces play a very important role on their properties. In the liquid state molecules are much closer to each other as compared to gases As a result liquid molecules develop stronger intermolecular forces, which affect their physical properties like diffusion, evaporation, vapour pressure and boiling point.
- Compounds having stronger intermolecular forces have higher boiling points. The intermolecular forces become so dominant in solid state that the molecules look motionless. They arrange in a regular pattern therefore they are denser than molecules of liquids.

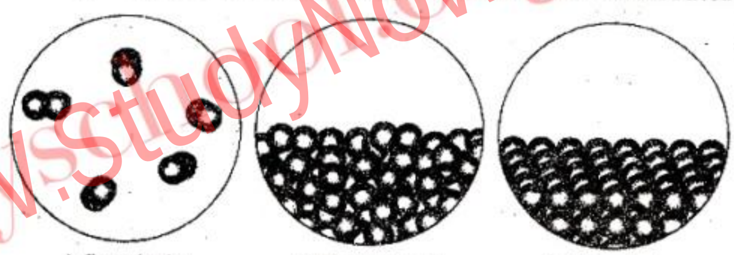


Fig 5.3 Three states of matter showing intermolecular forces.

Liquid State

Liquids have a definite volume but their shape is not definite. A liquid attains shape of the container in which it is put. A few typical properties of the liquids are discussed here.

5.3 TYPICAL PROPERTIES OF LIQUIDS

Q.No.7 Explain the Evaporation. Write down the factor effecting evaporation.

5.3.1 EVAPORATION

Definition

The molecules having more than average kinetic energy over come the attractive forces among the molecules and escape from the surface is called as evaporation.

OR

The molecules having more than average kinetic energy over come the attractive forces among the molecules and escape from the surface is called as evaporation.

OR

The process of changing of a liquid into a gas phase is called evaporation.

Explanation

It is reverse to condensation in which a gas changes into liquid. Evaporation is an endothermic process (heat is absorbed). Such as when one mole of water in liquid state is converted into vapour form, it requires 40.7 kJ of energy.

$$H_2O_{(l)} \longrightarrow H_2O_{(g)} \qquad \Delta H^{\circ}_{vap} = 40.7\ \text{Kj/mol}$$

In the liquid state, molecules are in a continuous state of motion. They possess kinetic energy but all the molecules do not have same kinetic energy. Majority of the molecules have average kinetic energy and a few have more than average kinetic energy.

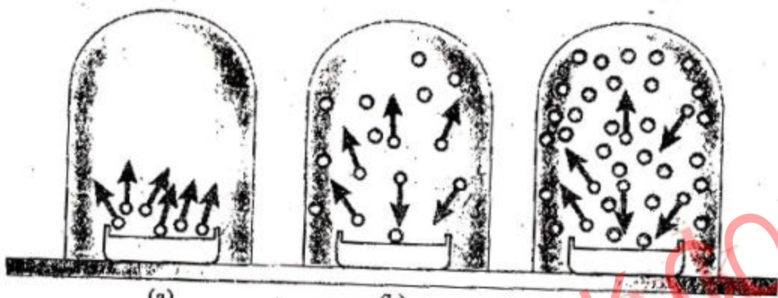


Fig. 5.4 A state of Dynamic Equilibrium between liquid and its vapours

Properties

- Evaporation is a continuous process taking place at all temperatures.
- The rate of evaporation is directly proportional to temperature.
- It increases with the increase in temperature because of increase in kinetic energy of the molecules.
- Evaporation is a cooling process.
- When the high kinetic energy molecules vaporize, the temperature of remaining molecules falls down. To compensate this deficiency of energy, the molecules of liquid absorb energy from the surroundings. As a result the temperature of surroundings decreases and we feel cooling.

Example

- When we put a drop of alcohol on palm.
- The alcohol evaporates and we feel cooling effect.

Evaporation depends upon following factors

(i) **Surface area:** Evaporation is a surface phenomenon. Greater is surface area, greater is evaporation and vice verse. For example, sometimes a saucer is used if tea is to be cooled quickly. This is because evaporation from the larger surface area of saucer is more than that from the smaller surface area of a tea cup.

(ii) **Temperature:** At high temperature, rate of evaporation is high because at high temperature kinetic energy of the molecules increases so high that they over- come the intermolecular forces and evaporate rapidly.

For example, water level in a container with hot water decreases earlier than that of a container with cold water. This is because the hot water evaporates earlier than the cold water.

(iii) **Intermolecular forces:** If intermolecular forces are stronger, molecules face difficulty in evaporation. For example, water has stronger intermolecular forces than alcohol, therefore, alcohol evaporates faster than water.

Q.No.8 Explain the Vapour pressure. Write down the factor effecting vapour pressure.

5.3.2 Vapour Pressure

The pressure exerted by the vapours of a liquid at equilibrium with the liquid at a particular temperature is called vapour pressure of a liquid. **State of equilibrium**

The equilibrium is a state when rate of vaporization and rate of condensation is equal to each other but in opposite directions.

Dynamic Equilibrium

The number of molecules evaporating will be equal to the number of molecules coming back (condensing) to liquid. This state is called dynamic equilibrium.

Explanation

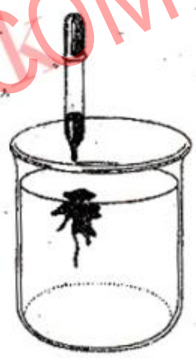
From the open surface of a liquid, molecules evaporate and mix up with the air but when we close a system, evaporated molecules start gathering over the liquid surface. Initially the vapours condense slowly to return to liquid. After sometime condensation process increases and a stage reaches when the rate of evaporation become equal to rate of condensation.

A state of Dynamic Equilibrium between liquid and its vapors

Vapour pressure of a liquid depends upon the following factors.

(i) **Nature of liquid:**

- Vapors pressure depends upon the nature of liquid.
- Polar liquids have low vapour pressure than non-polar liquids at the same temperature.
- This is because of strong intermolecular forces between the polar molecules of liquids.



5.6 Diffusion in liquids

Example

Water has less vapour pressure than that of alcohol at same temperature.

(ii) **Size of molecules**

Small size molecules can easily evaporate than big size molecules hence, small size molecules exert more pressure.

Example

- Hexane (C_6H_{14}) is a small sized molecule as compared to decane ($C_{10}H_{22}$).
- C_6H_{14} evaporates rapidly and exerts more pressure than $C_{10}H_{22}$).

(iii) **Temperature**

At high temperature, vapour pressure is higher than at low temperature. At elevated temperature, the kinetic energy of the molecules increases enough to enable them to vaporize and exert pressure.

Example

Vapour pressure of water at different temperatures

Relationship of Vapour Pressure of Water with Temperature

Q.No.9 Explain the boiling point. Write down the factor effecting boiling point.

5.3.3 Boiling Point

The temperature at which the vapour pressure of a liquid becomes equal to the atmospheric pressure or any external pressure

Explanation

When a liquid is heated, its molecules gain energy. The number of molecules which have more than average kinetic energy increases. More and more molecules become energetic enough to overcome the intermolecular forces. Due to this, rate of evaporation increases that results in increase of vapour pressure until a stage reaches where the vapour pressure of a liquid becomes equal to atmospheric pressure. At this stage the liquid starts boiling

Example

The increase of vapour pressure of diethyl ether, ethyl alcohol and water with the increase of temperature. At O°C the vapour pressure of diethyl ether is 200 mm Hg, of ethyl alcohol 25 mm Hg while that of water is about 5 mm Hg. When they are heated, vapour pressure of diethyl ether increases rapidly and becomes equal to atmospheric pressure at 34.6°C, while vapour pressure of water increases slowly because intermolecular forces of water are stronger.

Boiling point curves of ether alcohol and water boiling point of the liquid depends upon the following factors.

Temp	Vapour Pressure	Temp	Vapour Pressure
°C	mmHg	°C	mmHg
0	4.58	60	149.4
20	17.5	80	355.1
40	55.3	100	760.0

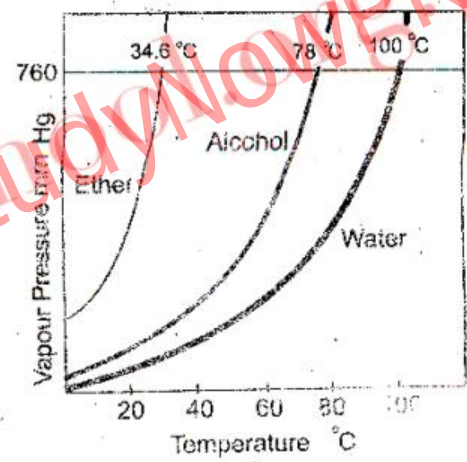


Fig. 5.5 Boiling point curves of Ether Alcohol and Water

(i) **Nature of liquid:**
The polar liquid have high boiling points than that of non-polar liquids because polar liquids have difficulty in evaporation.

Intermolecular forces:

- Intermolecular forces playa very important role on the boiling point of liquids.
- Substances having stronger intermolecular forces have high boiling points, because such liquids attain a level of vapour pressure equal to external pressure at high temperature.

(ii) **External pressure:**
Boiling points of a liquid depends upon external pressure Boiling point of a liquid is controlled by external pressure in such a way, that it can be increased by increasing external pressure and vice versa. This principle is used in the working of 'Pressure Cooker'.

5.3.4 Freezing Point

When liquids are cooled the vapour pressure of liquid decreases and when vapour pressure of a liquid state becomes equal to the vapour pressure of the solid state. At this temperature liquid and solid coexist in dynamic equilibrium with one another and this is called the freezing point of a liquid.

Q.No.9 Explain the diffusion. Write down the factor effecting on diffusion.

5.3.5 Diffusion

The liquid molecules are always in a state of continuous motion. They move from higher concentration to lower concentration. They mix up with the molecules of other liquids, so that they form a homogeneous mixture.

Example

When a few drops of ink are added in a beaker of water, ink molecules move around and after a while spread in whole of the beaker. Thus diffusion has taken place. Liquids diffuse like gases but the rate of diffusion of liquid is very slow. The diffusion of liquid depends upon the following factors.

Intermolecular forces:

Liquids having weak intermolecular forces diffuse faster than those of diffusion in liquids having strong intermolecular forces.

Size of molecules:

Big size molecules diffuse slowly. For example, honey diffuses slowly in water than that of alcohol in water.

Shapes of molecules:

Regular shaped molecules diffuse faster than irregular shaped molecules because they can easily slip over and move faster.

Temperature:

Diffusion increases by increasing temperature because a high temperature the intermolecular forces are weak.

5.3.6 Density

- The density of liquid depends upon its mass and volume.
- Liquids are denser than gases because molecules of liquid are closely packed and the spaces between their molecules are negligible.
- As the liquid molecules have strong intermolecular forces hence they cannot expand freely and have a fixed volume.
- Like gases, they cannot occupy all the available volume of the container that is the reason why densities of liquids are high.

Example:

Density of water is 1.0 g cm^{-3} while that of air is 0.001 g cm^{-3} that is the reason why drops of rain fall downward. The densities of liquids also vary. You can observe kerosene oil floats over water while honey settles down in the water.

Solid State

- It is third state of matter which has definite shape and volume.
- In solid state the molecules are very close to one another and they are closely packed.
- The intermolecular forces are so strong that particles become almost motionless. Hence they cannot diffuse.
- Solid particles possess only vibrational motion.

Q.No.10 What are the general characteristics of solid state?

5.4 TYPICAL PROPERTIES OF SOLID

Solids exhibit typical properties, a few of which are discussed here.

5.4.1 Melting Point

The temperature at which the solid starts melting and coexists in dynamic equilibrium with liquid state is called melting point

Explanation

The solid particles possess only vibrational kinetic energy. When solids are heated, their vibrational energies increase and particles vibrate at their mean position with a higher speed. If the heat is supplied continuously, a stage reaches at which the particles leave their fixed positions and then become mobile. At this temperature solid melts.

Example

The ionic and covalent solids make network structure to form macromolecules. So all such solids have very high melting points.

5.4.3 Density

Solids are denser than liquids and gases because solid particles are closes packed and do not have empty spaces between their particles. Therefore, they have the highest densities among the three states of matter.

Example

Density of aluminum is 2.70 g cm^{-3}, iron is 7.86 g cm^{-3} and gold is 9.3 g cm^{-3}

Q.No.11 Explain the types of solid state?

5.5 TYPES OF SOLIDS

According to their general appearance solids can be classified into two types:

- Amorphous solids
- Crystalline solids.

5.5.1 Amorphous Solids

- Amorphous means shapeless.
- Solids in which the particles are not regular arranged or their regular shapes are destroyed, are called amorphous solids.
- They do not have sharp melting points.

Example

- Plastic
- Rubber
- Glass

5.5.2 Crystalline Solids

Solids in which particles are arranged in a definite three-dimensional pattern are called crystalline solids. They have definite surfaces or faces.

Properties

- Each face has definite angle with the other.
- They have sharp melting points.

Examples

- Diamond
- Sodium chloride

Q.No.12 Define Allotropy. Explain its condition and properties.

5.6 ALLOTROPY

Definition

The existence of an element in more than one forms in same physical state is called allotropy.

Condition

- The existence of two or more kinds of molecules of an element each having different number of atoms such as allotropes of oxygen are oxygen (O_2) and ozone (O_3).
- Different arrangement of two or more atoms or molecules in a crystal of the element. Such as, sulphur shows allotropy due to different arrangement of molecules (S_8) in the crystals.
- They always show different physical properties but may have same or different chemical properties.

Properties

- Allotropes of solids have different arrangement of atoms in space at a given temperature.
- The arrangement of atoms also change with the change of temperature and new allotropic form is produced.
- The temperature at which one allotrope changes into another is called **transition temperature.**

Example

- Transition temperature of sulphur is 96°C. Below this temperature rhombic form is stable.
- If rhombic form is heated up to 96 °C, its molecules rearrange themselves to give monoclinic form.
- Other examples are tin and phosphorus.

EXERCISE

MCQ'S

1. **How many times liquids are denser than gases?**
(a) 100 times (b) 1000 times (c) 10,000 times (d) 100,000 times

2. **Gases are the lightest form of matter and their densities are expressed in terms of:**
(a) mg cm^{-3} (b) g cm^{-3} (c) g dm^{-3} (d) kg dm^{-3}

3. **At freezing point which one of the following coexists in dynamic equilibrium:**
(a) gas and solid (b) liquid and gas (c) liquid and solid (d) all of these.

4. **Solid particles possess which one of the following motions?**
(a) rotational motions (b) vibrational motions
(c) translational motions (d) both translational and vibrational motions

5. **Which one of the following is not amorphous?**
(a) rubber (b) plastic (c) glass (d) glucose.

6. **One atmospheric pressure is equal to how many Pascals:**
(a) 101325 (b) 10325 (c) 106075 (d) 10523

7. **In the evaporation process, liquid molecules which leave the surface of the liquid have:**
(a) very low energy (b) moderate energy (c) very high energy (d) none of these

8. **Which one of the following gas diffuses faster?**
(a) hydrogen (b) helium (c) fluorine (d) chlorine

9. **Which one of the following does not affect the boiling point?**
(a) intermolecular forces (b) external pressure
(c) nature of liquid (d) initial temperature of liquid

10. **Density of a gas increases, when its:**
(a) temperature is increased (b) pressure is increased
(c) volume is kept constant (d) none of these

11. **The vapour pressure of a liquid increases with the:**
(a) increase of pressure (b) increase of temperature
(c) increase of intermolecular forces (d) increase of polarity of molecules

ANSWR KEY

1	a	4	b	7	c	10	b
2	c	5	d	8	a	11	b
3	c	6	a	9	d	KIPS	

SHORT QUESTIONS

Q.1 What is diffusion, explain with an example?

Ans: Diffusion is the movement of solute particles from their higher concentration ot lower concentration in a medium.

For example: When a few drops of ink are added in beaker of water, ink molecules move around and after a while spread in whole of the beaker. Thus diffusion has taken place.

Q.2 Define standard atmospheric pressure. What are its units? How it is related to Pascal?

Ans: **Standard atmospheric pressure:** It is the pressure exerted by the atmosphere at the sea level. It is defined as **the pressure exerted by a mercury column of 760mm height at sea level.** It is sufficient pressure to support a column of mercury 760mm in height at sea level.

One atmosphere (1 atm)

1atm=760 mm = 760torr

1mm Hg = 1torr

One pascal (1 Pa)

$$1\ Pa = \frac{1N}{1m^2} = 1N^{-2}$$

Because $1\ N = 1\ Kgms^{-2}$

Q.3 Why are the densities of gases lower than that of liquids?

Ans: Gases have lower densities than densities of liquids. It is due to the light mass and more volume occupied by the gases. Another reason for lower densities of gases is negligible intermolecular forces among the gases molecules.

Q.4 What do you mean by evaporation how it is affected by surface area?

Ans: **Affect of surface area on evaporation:** Evaporation is a surface phenomenon. Greater is surface area, greater is evaporation and vice versa.

For example: Sometimes, a saucer is used if tea is to be cooled quickly. This is the smaller surface area of a tea cup.

Q.5 Define the term allotropy with examples.

Ans: **Allotropy:**

The existence of an element in more than one forms in same physical state is called allotropy.

Example

Sulphur exists in two allotropic dorms at 96°C below this temperature rhombic form is stable. Above this temperature monoclinic form is stable.

Q.6 In which form sulphur exists at 100°C.

Ans: Sulphur exists in monoclinic form at 100°C

Q.7 What is the relationship between evaporation and boiling point of a liquid?

Ans: **Relationship between evaporation and boiling point:**

If the boiling point of a liquid is high, its evaporations slow. Because intermolecular forces are high in the liquid which have high boiling point. If boiling point is low then evaporation.

LONG QUESTIONS

Q.1 Define Boyle's law and verify it with an example.

Ans: See the topic Boyle's law.

Q.2 Define and explain Charles law of gases.

Ans: See the topic Charles law.

Q.3 What is vapour pressure and how it is affected by intermolecular forces.

Ans: See the topic vapour pressure

Q.4 Define boiling point and also explain, how it is affected by different factors.

Ans: See the topic boiling point.

Q.5 Describe the phenomenon of diffusion in liquids along with factors which influence it.

Ans: See the topic diffusion.

Q.6 Differentiate between crystalline and amorphous solids.

Ans: See the topic types of solids.

NUMERICAL

Q.1 Convert the following units:

(a) 850 mm Hg to atm

(b) 205000 Pa to atm

(c) 560 torr to cm Hg

(d) 1.25 atm to Pa

Solution

(a)

Pressure $= P = 850$ mm Hg

P (atm) $= ?$

P (atm) $= \frac{850 \text{ mm Hg}}{760 \text{ mm Hg}}$ (atm)

P $= 1.11$ atm

(b)

Pressure $= P = 205000$ Pa

P (atm) $= ?$

P (atm) $= \frac{205000 \text{ Pa}}{101325 \text{ Pa}}$

$= 2{,}02$ atm

(c)

Pressure $= P = 560$ torr

P (cm Hg) $= ?$

P (cm Hg) $= 560$ mm Hg

$= \frac{560}{10}$ cm Hg

$= 56$ cm Hg

(d)

Pressure = P = 1.25 atm

Pressure (Pa) = ?

P (Pa) = ?

P = 126656.25 Pa

Q.2 Convert the following units:

(a) 750°C to K **(b) 150°C to K**

(c) 100 K to °C **(d) 172 K to °C.**

Solution

(a)

Tc = 750 °C

Tk = ?

Tk = Tc + 273.15 °C

Tk = 750 + 273.15 °C

Tk = 1023.5 °C

(b)

Tc = 150 °C

Tk = ?

Tk = Tc + 273.15 °C

Tk = 150+273, 15 °C

Tk = 423.15 °C

(c)

Tk = 100 K

Tc = ?

Tc = Tk + 273.15 K

Tc = 100 – 273, 15 K

Tc = –173.15 °C

(d)

Tk = 172 K

Tc = ?

Tc = Tk – 273.15 °C

Tc = 172 – 273, 15 °C

Tc = - 101.15 °C

Q. 3 A gas at pressure 912 mm of Hg has volume $450 cm^3$. What will be its volume at 0.4 atm.

Given Data:

Initial pressure of gas $= P_1 = 912 \text{ mm Hg} = \dfrac{912 \text{ mm Hg}}{760 \text{ mm Hg}}$

$= 1.2$ atm

Initial volume of gas $= V_1 = 450 \text{ cm}^3$

Final volume of gas $= P_2 = 0.4$ atm

Required Data

First volume of gas $= V_2 = ?$

Formula

$$P_1V_1 = P_2V_2$$

Solution:

$$1.2 \text{ atm} \times 450 \text{ cm}^3 = 0.4 \text{ atm} \times V_2$$

$$V_2 = \frac{1.2 \text{ atm} \times 450 \text{ cm}^3}{04 \text{ atm}}$$

$$V_2 = \frac{12}{4} \times 450 \text{ cm}^3$$

$$V_2 = 3 \times 450 \text{ cm}^3$$

Result $\mathbf{V2 = 1350\ cm^3}$

Q.4 A gas occupies a volume of 800 cm^3 at 1 atm, when it is allowed to expand up to 1200 cm^3 what will be its pressure in mm of Hg.

Given Data:

Initial Pressure of gas $= P_1 = 1$ atm
Initial volume of gas $= V_1 = 800 \text{ cm}^3$
Expanded volume of gas $= V_2 = 1200 \text{ cm}^3$

Required Data

First pressure of gas $= P_2 = ?$

Formula

$$P_1V_1 = P_2V_2$$

Solution

$$1 \text{ atm} \times 800 \text{ cm}^3 = P_2 \times 1200 \text{ cm}^3$$

$$P_2 = \frac{1 \text{ atm} \times 800 \text{ cm}^3}{1200 \text{ cm}^3}$$

$$P_2 = \frac{2}{3} \text{ cm}^3$$

$$P_2 = 0.667 \text{ atm}$$

$$P_2 = 0.667 \times 760 \text{ mm Hg}$$

Result $\mathbf{P_2 = 506.7\ mm\ Hg}$

Q.5 It is desired to increase the volume of a fixed amount of gas from 87.5 to 118 cm^3 while holding the pressure constant. What would be the final temperature if the "initial temperature is 23°C.

Given Data:

Initial volume of gas $= V_1 = 87.5 \text{ cm}^3$
Final volume of gas $= V_2 = 118 \text{ cm}^3$
Pressure $= P =$ Constant
Final potential of gas $= P_2 = (\text{mm Hg}) = ?$

Required Data

Final temperature $= T_2 = ?$

Formula

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

Solution

$$T_2 = \frac{V_2 'T_1}{V_1}$$

By putting the values

$$T_2 = \frac{118cm^3 \times 296K}{87.5\ cm^3}$$

Result $T_2 = 399$

Note: T_2 can be converted into Celsius scale as:

$$T_2 = 299 - 273 = 126^oC$$

Q.6 A sample of gas is cooled at constant pressure from 30°C to 10°C. Comment:

(a) Will the volume of the gas decrease to one third of its original volume?

(b) If not, then by what ratio will the volume decrease?

(a)

Solution

Initial temperature = $T_1 = 30^oC$

$T_1 = 273 + 30 = 303\ K$

Final temperature = $T_2 = 10^oC$

$= 273 + 10 = 283\ K$

Initial volume $= V_1 = V$

Final volume $= V_2 = V/3$

Pressure $= P =$ Constant

$$\frac{V_2}{V_1} = ?$$

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

Result $= \frac{\mathbf{V}}{\mathbf{303\ K}}$

(b) Solution

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

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

$$\frac{V_2}{V_1} = \frac{283\ K}{303\ K}$$

Result $\frac{V_2}{V_1} = 0.93$

Q.7 A balloon that contains 1.6 dm^3 of air at standard temperature and pressure is taken under water to a depth at which its pressure increases to 3.0 atm. Suppose that temperature remain unchanged, what would be the new volume of the balloon. Does it contract or expand?

Given Data:

Initial temperature = T_1 = 298 K
Initial pressure = P_1 = 1 atm
Initial volume = V_1 = 1.6 dm^3
Final temperature = T_2 = 298 K
Final pressure = P_2 = 3.0 atm
Pressure = P = constant

Required Data

Final volume = V_2 = ?

Formula

$$P_1V_1 = P_2V_2$$

Solution

$$1 \text{ atm} \times 1.6 \text{ dm} = 3 \text{ atm} \times V_2$$

$$V_2 = \frac{1 \text{ atm} \times 1.6 \text{ dm}^3}{3 \text{ atm}}$$

Result $\mathbf{V_2 = 0.53\ dm^3}$

Q.8 A sample of neon gas occupies 75.0 cm^3 at very low pressure of 0.4 atm. Assuming temperature remain constant what would be the volume at 1.0 atm pressure?

Given Data:

Initial pressure = P_1 = 0.4 atm
Initial volume = V_1 = 75.0 cm^3
Temperature = $T_1 = T_2$ = constant
Final pressure = P_2 = 1 atm

Required Data

Final volume = V_2 = ?

Formula

$$P_1V_1 = P_2V_2$$

Solution

$$0.4 \text{ atm} \times 75 \text{ cm}^3 = 1 \text{ atm} \times V_2$$

$$V_2 = \frac{0.4 \text{ atm} \times 75 \text{ cm}^3}{1 \text{ atm}}$$

Result $\mathbf{V_2 = 30\ cm^3}$

Q.9 A gas occupies a volume of 35.0 dm^3 at 17°C. If the gas temperature rises to 34°C at constant pressure, would you expect the volume to double? If not calculate the new volume.

Given Data:

Initial temperature = T_1 = 17 °C
= 273 + 17 = 290 K
Initial volume = V_1 = 35 dm^3
Pressure = P = P_1 = P_2 = Constant
Final temperature = T_2 = 34 °C
= 273 + 34 = 307 K

Required Data

Final volume $= V_2 = ?$

Formula

Volume will not be doubled because the absolute temperature is not doubled.

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

Solution:

$$\frac{35\ dm^3}{290\ K} = \frac{V_2}{307\ K} \text{ or } V_2 = \frac{35\ dm^3 \times 307\ K}{290\ K}$$

Result $37\ dm^3 = V_2$

Q.10 The largest moon of Saturn, is Titan. It has atmospheric pressure of 1.6×10^5 Pa. What is the atmospheric pressure in atm? Is it higher than earth's atmospheric pressure?

Solution:

Pressure of Titan $= P = 1.6 \times 10^5$ Pa

$$P\ (atm) = \frac{1.6 \times 10^5\ Pa}{101325}$$

$$P\ (atm) = 1.57\ atm$$

Result

It will be cleared that the atmospheric [pressure of Titan is greater than the atmospheric pressure of earth.

CHAPTER 5

PHYSICAL STATES OF MATTER

MULTIPLE CHOICE QUESTIONS

1. **Which of the following expand or compressed easily**
   (a) liquid (b) gases (c) solids (d) water
2. **Diffusion is faster in:**
   (a) liquid (b) solids (c) gases (d) plasma
3. **Gases exerts pressure in all directions**
   (a)uniformly (b) randomly (c) alternately (d) constantly
4. **Which principle is used in working pressure cooker?**
   (a) Boiling point increased by increasing the external pressure.
   (b) Boiling point decreased by decreasing the external pressure.
   (c) Boiling point increased by increasing the external pressure.
   (d) None of these
5. **Red phosphorus is:**
   (a) less reactive (b) non-poisonous (c) brittle (d) all of above
6. **Which percentage of salt is required to kill the bacteria?**
   (a) 10% (b) 20% (c) 30% (d) 40%
7. **The density of gold is:**
   (a) 2.70 gcm^{-3} (b) 7.86 gcm^{-3} (c) 9.3 gcm^{-3} (d) 2.98 gcm^{-3}
8. **The solids in which particles are arranged in definite three-dimensional pattern are called:**
   (a) solids (b) Crystalline solids (c) Amorphous solids (d) both b & c
9. **The transition temperature of tin is:**
   (a) 96^0C (b) 250^0C (c) 18^0C (d) 100^0C
10. **Oxygen has two allotropic forms:**
    (a) O_2 and O_4 (b) O_2 and O_3 (c) O and O_3 (d) O_2 and O
11. **Plastics, glass rubber, lamp-black etc. are the examples of:**
    (a) Crystalline solids (b) Super cooled liquids
    (c) Amorphous solids (d) ionic solids
12. **The temperature at which the solid and liquid phases of a substance co-exist:**
    (a) freezing point (b) boiling point (c) melting point (d) equilibrium

13. The existence of solid in different physical forms is called:
(a) Crystals (b) Allotropy (c) Evaporation (d) Tear

14. It depends upon the nature of liquid, intermolecular forces and exter
(a) melting point (b) freezing point (c) boiling point (d) none of

15. The conversion of a liquid into vapours at all temperature is called.
(a) Evaporation (b) Boiling (c) Cooling process (d) both a

16. Density is expressed in:
(a) g cm^{-3} (b) g dm^{-3} (c) both a & b (d) none of these

17. Charles described, how gases tend to expand when heated:
(a) 1882 (b) 1802 (c) 1820 (d) 1828

18. Mass per unit volume is called:
(a) pressure (b) temperature (c) density (d) solubility

19. Robert Boyle's was a natural:
(a) philosopher (b) chemist (c) physicist (d) All of above

20. Matter exists in three physical states:
(a) Solid, liquid, plasma (b) Solid, water, vapour
(c) Plasma, liquid, solid (d) Solid, liquid, gas

ANSWER KEY

1	b	4	c	7	c	10	b	13	b	16	c	19	d
2	c	5	d	8	b	11	c	14	c	17	b	20	d
3	a	6	b	9	c	12	a	15	a	18	c	KIPS	

SHORT QUESTIONS

5.1 GASEOUS STATE

Q.1 Why the rate of diffusion of gases is rapid than that of liquids?

Ans. The rate of diffusion of gases is more than that of liquids because, more empty spaces are present between their molecules, as compare to liquid. So, the flow of rate of gas molecules is more as compare to liquid molecules.

Q.2 Why the gases are compressible?

Ans. Gases are highly compressible due to empty spaces between their molecules and the intermolecular forces in gases are vary week. When gases are compressed molecules come closer to one another and occupy less volume as compare to the volume in uncompressed state.

Q.3 What do you mean by Pascal? How many Pascals are equal to 1 atm?

Ans. Pascal: "The pressure equal to one Newton per square meter is called Pascal."

$$1 \text{ atm} = 101325 \text{ Pa}$$

Q.4 Whether the densities of a gas decrease on cooling?

Ans. No, the density of a gas does not decrease on cooling, it increases on cooling because on cooling their volume decrease and density is inverse to volume.

As $$d = \frac{m}{v}$$

Q.5 Why is the density of gas measured in g dm^{-3} while that of a liquid is expressed in g cm^{-3}?

Ans. The gas molecules are far apart to each other due to very weak intermolecular forces among them. Gases occupy more spaces at normal condition as compare to liquids that is why, a smaller unit of volume measurement is used for liquids.

dm^3 is big unit of volume

cm is smaller unit of volume

So For gases $= d = gdm^{-3}$

For liquid $= d = gcm^{-3}$

Convert the following

(a) 70 cm Hg to atm:

$$760 \text{ cm Hg} = 1 \text{ atm}$$

$$1 \text{ cm Hg} = \frac{1}{760}$$

$$70 \text{ cm Hg} = \frac{1}{760} \times 70 = 0.0921 \text{ atm}$$

Ans. $70 \text{ cm Hg} = 0.0921 \text{ atm}$

(b) 3.5 atm to torr:

1 atm = 760 torr

3.5 atm = 760 × 3.5

= 2660

Ans. 3.5 atm equal to 2660 torr

(c) 1.5 atm to Pa

1 atm = 101325 Pa

1.5 atm = 101325 × 1.5

= 151987.5

Ans. 1.5 atm is equal to 151987.5 Pa

5.2 LAWS OF RELATED TO GASES

Q.1 Is the Boyle's law applicable to liquids?

Ans. No, Boyle's law is only applicable to gases.

$$PV = \text{constant}$$

Constant is temperature.

Q.2 Is the Boyle's law valid at very high temperature?

Ans. No, the Boyle's law is not valid/applicable at very high constant temperature because at high temperature, the kinetic energy of gas molecules increases, that increases the mobility of molecules, it exerts pressure that may vary the volume of gases.

Q.3 What will happen if the pressure on a sample of gas is raised three times and its temperature is kept constant?

Ans. If the pressure on a sample of gas is raised three times at constant temperature, the volume will also decreases three times of its original (normal)

Q.4 Which parameters are kept constant in Charles' law?

Ans. Pressure is kept constant. While, volume and temperature are variable parameters.

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

Constant is pressure.

Q.5 Why volume of a gas decreases with increase of pressure?

Ans. As according to Boyle's law: " The volume of the given mass of the gas inversely proportional to its pressure provided the temperature constant" So by increases the pressure, the molecules of gas compressed and come closer to each other and occupy less volume. as $d = \frac{m}{v}$

Q.6 What is absolute zero?

Ans. It is the temperature at which an ideal gas would have zero volume.

So, 0K or –73.15 C is the theoretical value of absolute zero temperature.

Q.7 Does Kelvin scale show a negative temperature?

Ans. Yes at 0^oC, the Kelvin scale show negative value, as

$$0^oC = 273\ K$$

Q.8 When a gas is allowed to expand, what will be its effect on its temperature?

Ans. When a gas is allowed to expand, it will cause the cooling effect. Because sudden increase in volume of gas gives cooling effect according to joule Thomson effect.

Q.9 Can you cool a gas by increasing its volume?

Ans. Yes, by sudden increase the volume of a gas, it gives the cooling effect according to joule Thomson effect.

5.3 LIQUID STATE

Q.1 Why does evaporation increase with the increase of temperature?

Ans. With increase in temperature rate of evaporation also increases. Because at high temperature kinetic energy of the molecules increases so high that they overcome the intermolecular forces and rapidly evaporates.

Q.2 What do you mean by condensation?

Ans. This is a reverse process of evaporation. Condensation is that process in which a gas (vapours) changes into liquid.

Q.3 Why is vapour pressure higher at high temperature?

Ans. At high temperature, vapour pressure is higher than at low temperature.

At elevated temperature, the kinetic energy of the molecules increases enough to enable them vapourize.

Q.4 Why is the boiling point of water higher than that of alcohol?

Ans. Boiling point of water is higher than that of alcohol because water is a polar liquid and it also have high intermolecular forces i.e. Hydrogen bonding. Because of these reasons water high boiling point than alcohol.

Q.5 What do you mean by dynamic equilibrium?

Ans. It is that stage at which the number of molecules evaporating will be equal to the number of molecules coming back (condensing) to liquid. This state is called dynamic equilibrium.

Q.6 Why are the rates of diffusion in liquids slower than that of gases?

Ans. Liquids diffuse like gases but the rate of diffusion of liquid is slower than gases because liquids have stronger intermolecular forces than gases. The size of liquid molecules is large than gases that is why, they diffuse slowly.

Q.7 Why does rate of diffusion increase with increase of temperature?

Ans. The rate of diffusion increase with increase because at high temperature increase, kinetic energy of molecules also increase and overcome the intermolecular forces which increase diffusion.

Q.8 Why are the liquids mobile?

Ans. The liquid molecules are always in a state of continuous motion. They move form higher concentration to lower concentration. Because liquid molecules have empty spaces among their molecules and also have weak intermolecular forces. Hence, they remain in a continuous state of motion.

5.4 SOLID STATE

Q.1 Which form of sulphur exists at room temperature?

Ans. Sulphur exists in rhombic form at room temperature.

Q.2 Why is white tin available at room temperature?

Ans. At room temperature white tin is available because its transition temperature is 18 C. Above this temperature tin always present in white tin and below this it converts into grey tin. But the room temperature is usually considered above the 20 C.

Q.3 Why is the melting point of a solid considered its identification characteristic?

Ans. The solid particles posses only vibrational kinetic energy. Melting point is the temperature at which the solid starts melting and co-exists in dynamic equilibrium with liquid state is called melting point.

Example: Melting point of NaCl is 800°C

Q.4 Why amorphous solids do not have sharp melting points while crystalline solids do have?

Ans. Amorphous solids are shapeless. Their particles are not arranged regularly or their shapes are destroyed. Because of this reason amorphous solids do not have sharp melting points.

Q.5 Which is lighter one aluminum or gold?

Ans. Aluminium is lighter than gold because the density of aluminium is 2.70 g cm^{-3} and that of gold is 9.3 gcm^{-3}.

Q.6 Write the molecular formula of a sulphur molecule?

Ans. Molecular formula of sulphur molecule is S_8.

Q.7 Which allotropic form of carbon is stable at room temperature (25 °C)?

Ans. Three allotropic forms of carbon are:

(a) Diamond

(b) Graphite

(c) Bucky Balls

Among these allotropic forms graphite is energetically slightly more stable than diamond.

Q.8 State whether allotropy is shown by elements or compounds or both?

Ans. Allotropy is shown by elements not by compounds.

For example: Allotropic forms of carbon are diamond, bucky balls, graphite. And allotropes of oxygen are O_2 and O_3.

EXERCISE

MCQ'S

1. **How many times liquids are denser than gases?**
(a) 100 times (b) 1000 times (c) 10,000 times (d) 100,000 times

2. **Gases are the lightest form of matter and their densities are expressed in terms of:**
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3. **At freezing point which one of the following coexists in dynamic equilibrium:**
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4. **Solid particles possess which one of the following motions?**
(a) rotational motions (b) vibrational motions
(c) translational motions (d) both translational and vibrational motions

5. **Which one of the following is not amorphous?**
(a) rubber (b) plastic (c) glass (d) glucose.

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(a) 101325 (b) 10325 (c) 106075 (d) 10523

7. **In the evaporation process, liquid molecules which leave the surface of the liquid have:**
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8. **Which one of the following gas diffuses faster?**
(a) hydrogen (b) helium (c) fluorine (d) chlorine

9. **Which one of the following does not affect the boiling point?**
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(c) nature of liquid (d) initial temperature of liquid

10. **Density of a gas increases, when its:**
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(c) volume is kept constant (d) none of these

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For example: When a few drops of ink are added in beaker of water, ink molecules move around and after a while spread in whole of the beaker. Thus diffusion has taken place.

Q.2 Define standard atmospheric pressure. What are its units? How it is related to Pascal?

Ans: **Standard atmospheric pressure:** It is the pressure exerted by the atmosphere at the sea level. It is defined as **the pressure exerted by a mercury column of 760mm height at sea level.** It is sufficient pressure to support a column of mercury 760mm in height at sea level.

One atmosphere (1 atm)

1atm=760 mm = 760torr

1mm Hg = 1torr

One pascal (1 Pa)

$$1\ Pa = \frac{1\ N}{1\ m^2} = 1\ N^{-2}$$

Because 1 N = 1 $Kgms^{-2}$

Q.3 Why are the densities of gases lower than that of liquids?

Ans: Gases have lower densities than densities of liquids. It is due to the light mass and more volume occupied by the gases. Another reason for lower densities of gases is negligible intermolecular forces among the gases molecules.

Q.4 What do you mean by evaporation how it is affected by surface area?

Ans: **Affect of surface area on evaporation:** Evaporation is a surface phenomenon. Greater is surface area, greater is evaporation and vice versa.

For example: Sometimes, a saucer is used if tea is to be cooled quickly. This is the smaller surface area of a tea cup.

Q.5 Define the term allotropy with examples.

Ans: **Allotropy:**

The existence of an element in more than one forms in same physical state is called allotropy.

Example

Sulphur exists in two allotropic dorms at 96°C below this temperature rhombic form is stable. Above this temperature monoclinic form is stable.

Q.6 In which form sulphur exists at 100°C.

Ans: Sulphur exists in monoclinic form at 100°C

Q.7 What is the relationship between evaporation and boiling point of a liquid?

Ans: **Relationship between evaporation and boiling point:**

If the boiling point of a liquid is high, its evaporations slow. Because intermolecular forces are high in the liquid which have high boiling point. If boiling point is low then evaporation.

LONG QUESTIONS

Q.1 Define Boyle's law and verify it with an example.
Ans: See the topic Boyle's law.

Q.2 Define and explain Charles law of gases.
Ans: See the topic Charles law.

Q.3 What is vapour pressure and how it is affected by intermolecular forces.
Ans: See the topic vapour pressure

Q.4 Define boiling point and also explain, how it is affected by different factors.
Ans: See the topic boiling point.

Q.5 Describe the phenomenon of diffusion in liquids along with factors which influence it.
Ans: See the topic diffusion.

Q.6 Differentiate between crystalline and amorphous solids.
Ans: See the topic types of solids.

NUMERICAL

Q.1 Convert the following units:
(a) 850 mm Hg to atm
(b) 205000 Pa to atm
(c) 560 torr to cm Hg
(d) 1.25 atm to Pa

Solution

(a)

Pressure = P = 850 mm Hg
P (atm) = ?

$$P\ (atm) = \frac{850\ mm\ Hg}{760\ mm\ Hg}\ (atm)$$

P = 1.11 atm

(b)

Pressure = P = 205000 Pa
P (atm) = ?

$$P\ (atm) = \frac{205000\ Pa}{101325\ Pa}$$

= 2,02 atm

(c)

Pressure = P = 560 torr
P (cm Hg) = ?
P (cm Hg) = 560 mm Hg

$$= \frac{560}{10}\ cm\ Hg$$

= 56 cm Hg

(d)

Pressure = P = 1.25 atm

Pressure (Pa) = ?

P (Pa) = ?

P = 126656.25 Pa

Q.2 Convert the following units:

(a) 750°C to K **(b) 150°C to K**

(c) 100 K to °C **(d) 172 K to °C.**

Solution

(a)

Tc = 750 °C

Tk = ?

Tk = Tc + 273.15 °C

Tk = 750 + 273.15 °C

Tk = 1023.5 °C

(b)

Tc = 150 °C

Tk = ?

Tk = Tc + 273.15 °C

Tk = 150+273, 15 °C

Tk = 423.15 °C

(c)

Tk = 100 K

Tc = ?

Tc = Tk + 273.15 K

Tc = 100 – 273, 15 K

Tc = –173.15 °C

(d)

Tk = 172 K

Tc = ?

Tc = Tk – 273.15 °C

Tc = 172 – 273, 15 °C

Tc = - 101.15 °C

Q.3 A gas at pressure 912 mm of Hg has volume 450cm^3. What will be its volume at 0.4 atm.

Given Data:

Initial pressure of gas $= P_1 = 912 \text{ mm Hg} = \dfrac{912 \text{ mm Hg}}{760 \text{ mm Hg}}$

$= 1.2$ atm

Initial volume of gas $= V_1 = 450 \text{ cm}^3$

Final volume of gas $= P_2 = 0.4$ atm

Required Data

First volume of gas $= V_2 = ?$

Formula

$$P_1V_1 = P_2V_2$$

Solution:

$$1.2\text{ atm} \times 450\text{ cm}^3 = 0.4\text{ atm} \times V_2$$

$$V_2 = \frac{1.2\text{ atm} \times 450\text{ cm}^3}{04\text{ atm}}$$

$$V_2 = \frac{12}{4} \times 450\text{ cm}^3$$

$$V_2 = 3 \times 450\text{ cm}^3$$

Result $\mathbf{V2 = 1350\ cm^3}$

Q.4 A gas occupies a volume of 800 cm^3 at 1 atm, when it is allowed to expand up to 1200 cm^3 what will be its pressure in mm of Hg.

Given Data:

Initial Pressure of gas $= P_1 = 1$ atm
Initial volume of gas $= V_1 = 800\text{ cm}^3$
Expanded volume of gas $= V_2 = 1200\text{ cm}^3$

Required Data

First pressure of gas $= P_2 = ?$

Formula

$$P_1V_1 = P_2V_2$$

Solution

$$1\text{ atm} \times 800\text{ cm}^3 = P_2 \times 1200\text{ cm}^3$$

$$P_2 = \frac{1\text{ atm} \times 800\text{ cm}^3}{1200\text{ cm}^3}$$

$$P_2 = \frac{2}{3}\text{ cm}^3$$

$$P_2 = 0.667\text{ atm}$$

$$P_2 = 0.667 \times 760\text{ mm Hg}$$

Result $\mathbf{P_2 = 506.7\ mm\ Hg}$

Q.5 It is desired to increase the volume of a fixed amount of gas from 87.5 to 118 cm^3 while holding the pressure constant. What would be the final temperature if the "initial temperature is 23°C.

Given Data:

Initial volume of gas $= V_1 = 87.5\text{ cm}^3$
Final volume of gas $= V_2 = 118\text{ cm}^3$
Pressure $= P =$ Constant
Final potential of gas $= P_2 = (\text{mm Hg}) = ?$

Required Data

Final temperature $= T_2 = ?$

Formula

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

Solution

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

By putting the values

$$T_2 = \frac{118 cm^3 \times 296 K}{87.5\ cm^3}$$

Result $T_2 = 399$

Note: **T_2 can be converted into Celsius scale as:**

$$T_2 = 299 - 273 = 126^\circ C$$

Q.6 A sample of gas is cooled at constant pressure from 30°C to 10°C. Comment:

(a) Will the volume of the gas decrease to one third of its original volume?

(b) If not, then by what ratio will the volume decrease?

(a)

Solution

Initial temperature = $T_1 = 30^\circ C$

$T_1 = 273 + 30 = 303\ K$

Final temperature = $T_2 = 10^\circ C$

$= 273 + 10 = 283\ K$

Initial volume $= V_1 = V$

Final volume $= V_2 = V/3$

Pressure $= P = \text{Constant}$

$$\frac{V_2}{V_1} = ?$$

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

Result $$= \frac{V}{303\ K}$$

(b) Solution

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

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

$$\frac{V_2}{V_1} = \frac{283\ K}{303\ K}$$

Result $$\frac{V_2}{V_1} = 0.93$$

Q.7 A balloon that contains 1.6 dm^3 of air at standard temperature and pressure is taken under water to a depth at which its pressure increases to 3.0 atm. Suppose that temperature remain unchanged, what would be the new volume of the balloon. Does it contract or expand?

Given Data:

Initial temperature = T_1 = 298 K
Initial pressure = P_1 = 1 atm
Initial volume = V_1 = 1.6 dm^3
Final temperature = T_2 = 298 K
Final pressure = P_2 = 3.0 atm
Pressure = P = constant

Required Data

Final volume = V_2 = ?

Formula

$$P_1V_1 = P_2V_2$$

Solution

$$1 \text{ atm} \times 1.6 \text{ dm} = 3 \text{ atm} \times V_2$$

$$V_2 = \frac{1 \text{ atm} \times 1.6 \text{ dm}^3}{3 \text{ atm}}$$

Result $\mathbf{V_2 = 0.53\ dm^3}$

Q.8 A sample of neon gas occupies 75.0 cm^3 at very low pressure of 0.4 atm. Assuming temperature remain constant what would be the volume at 1.0 atm pressure?

Given Data:

Initial pressure = P_1 = 0.4 atm
Initial volume = V_1 = 75.0 cm^3
Temperature = T_1 = T_2 = constant
Final pressure = P_2 = 1 atm

Required Data

Final volume = V_2 = ?

Formula

$$P_1V_1 = P_2V_2$$

Solution

$$0.4 \text{ atm} \times 75 \text{ cm}^3 = 1 \text{ atm} \times V_2$$

$$V_2 = \frac{0.4 \text{ atm} \times 75 \text{ cm}^3}{1 \text{ atm}}$$

Result $\mathbf{V_2 = 30\ cm^3}$

Q.9 A gas occupies a volume of 35.0 dm^3 at 17°C. If the gas temperature rises to 34°C at constant pressure, would you expect the volume to double? If not calculate the new volume.

Given Data:

Initial temperature = T_1 = 17 °C
= 273 + 17 = 290 K
Initial volume = V_1 = 35 dm^3
Pressure = P = P_1 = P_2 = Constant
Final temperature = T_2 = 34 °C
= 273 + 34 = 307 K

Required Data

Final volume $= V_2 = ?$

Formula

Volume will not be doubled because the absolute temperature is not doubled.

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

Solution:

$$\frac{35\ dm^3}{290\ K} = \frac{V_2}{307\ K} \text{ or } V_2 = \frac{35\ dm^3 \times 307\ K}{290\ K}$$

Result $37\ dm^3 = V_2$

Q.10 The largest moon of Saturn, is Titan. It has atmospheric pressure of $1.6x10^5$ Pa. What is the atmospheric pressure in atm? Is it higher than earth's atmospheric pressure?

Solution:

Pressure of Titan = P = 1.6×10^5 Pa

$$P\ (atm) = \frac{1.6 \times 10^5\ Pa}{101325}$$

$$P\ (atm) = 1.57\ atm$$

Result

It will be cleared that the atmospheric [pressure of Titan is greater than the atmospheric pressure of earth.