CHEMISTRY (XI)
Chapter 3
Gases
Short Questions

1. Name the states of matter. Which state is the simplest one?

Ans: Matter exists in four states i.e., solid, liquid, gas and plasma. The simplest form of matter is the gaseous state.

2. What are the properties of gases?(Write any four properties as an answer to short question)

Ans: Following are the properties of gases:

1. Gases don't have a definite volume and occupy all the available space. The volume of a gas is the volume of the container.
2. They don't have a definite shape and take the shape of the container just like liquids.
3. Due to low densities of gases, as compared to those of liquids and solids, the gases bubble through liquids and tend to rise up.
4. Gases can diffuse and effuse. This property is negligible in solids but operates in liquids as well.
5. Gases can be compressed by applying a pressure because there are large empty spaces between their molecules.
6. Gases can expand on heating or by increasing the available volume. Liquids and solids, on the other hand, do not show an appreciable increase in volume when they are heated.
7. When sudden expansion of gases occurs cooling takes place. It is called Joule-Thomson effect.
8. Molecules of gases are in a constant state of random motion They can exert a certain pressure on the walls of the container and this pressure is due to the number of collisions.
9. The intermolecular forces in gases are very weak.

3. What are the properties of liquids? (Write any four properties as an answer to short question)

Ans: Following are the properties of liquids:

1. Liquids don't have a definite shape but have a definite volume. Unlike solids they adopt the shape of the container.

2. Molecules of liquids are in a constant state of motion. The evaporation and diffusion of liquid molecules is due to this motion.

3. The densities of liquids are much greater than those of gases but are close to those of solids.

4. The spaces among the molecules of liquids are negligible just like solids.

5. The intermolecular attractive forces in liquids are intermediate between gases and solids. The melting and boiling points of gases, liquids and solids depend upon the strength of such forces.

6. Molecules of liquids possess kinetic energy due to their motion. Liquids can be converted into solids on cooling i.e., by decreasing their kinetic energy. Molecules of liquids collide among themselves and exchange energy but those of solids cannot do so.

4. What are the properties of solids?

Ans: Following are the properties of solids:

1. The particles present in solid substances are very close to each other and they are tightly packed. Due to this reason solids are non-compressible and they cannot diffuse into each other.

2. There are strong attractive forces in solids which hold the particles together firmly and for this reason solids have definite shape and volume.

3. The solid particles possess only vibrational motion.

5. What are the various units of pressure?

Ans: The S.I. unit of pressure is expressed in Nm^{-2}. One atmospheric pressure i.e 760 torr is equal to 101325 Nm-2. 1pascal=1 Nm^{-2}. So, 760 torr = 101325Pa = 101.325 kilopascals (kpa is another unit of pressure) The unit pounds per square inch (psi) is used most commonly in engineering work, and 1 atm = 760 torr=14.7 pounds $inch^{-2}$. The unit millibar is commonly used by meteorologists.

6. Define one atmospheric pressure.

Ans: The pressure of air that can support 760 mmHg column at sea level, is called one atmosphere. It is the force exerted by 760mm or 76cm long column of mercury on an area of $1cm^2$ at 0 °C. It is the average pressure of atmosphere at sea level 1mmHg=1torr.

7. Define gas laws.

Ans: The relationships between volume of a given amount of gas and the prevailing conditions of temperature and pressure are called the gas laws. Different scientists, like Boyle, Charles, Graham and Dalton have given their laws relating to the properties of gases.

8. State Boyle's law.

Ans: The volume of a given mass of a gas at constant temperature is inversely proportional to the pressure applied to the gas.

$V \alpha 1/P$ (when the temperature and number of moles are constant)

or $V = k/p$

$PV = k$ (when T and n are constant) (1)

'k' is proportionality constant. The value of k is different for the different amounts of the same gas. According to the equation (1), Boyle's law can also be defined as

"The product of pressure and volume of a fixed amount of a gas at constant temperature is a constant quantity"

So $P_1V_1 = k$ and $P_2V_2 = k$

Hence $P_1V_1 = P_2V_2$

P_1V_1 are the initial values of pressure and volume while P_2V_2 are the final values of pressure and volume.

9. State Charles's law.

Ans: The volume of the given mass of a gas is directly proportional to the absolute temperature when the pressure is kept constant.

V α T (when pressure and number of moles are constant)

$$V = kT$$

$$V/T = k$$

If the temperature is changed from T_1 to T_2 and volume changes from V_1 to V_2, then

$$V_1/T_1 = k \text{ and } V_2/T_2 = k$$

$$V_1/T_1 = V_2/T_2$$

The ratio of volume to temperature remains constant for same amount of gas at same pressure.

10. Give quantitative definition of Charles's law. Throw some light on the factor 1/273 in Charles's law.

Ans: At constant pressure, the volume of the given mass of a gas increases or decreases by 1/273 of its original volume at 0 ºC for every 1 ºC rise or fall in temperature respectively.

$$V_t = V_o\left(1 + \frac{t}{273}\right) \ldots\ldots\ldots (3)$$

Where V_t = volume of gas at temperature T

V_o = Volume of gas at 0ºC

t = Temperature on centigrade or celsius scale

11. Why Celsius scale of temperature does not justify Charles's law.

Ans: The increase in temperature from 10 ºC to 100 ºC, increases the volume from 566 cm^3 to 746 cm^3. Applying Charles's law:

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

$$\frac{566}{10} \neq \frac{746}{100}$$

The two sides of equation are not equal. So, Charles's law is not being obeyed when temperature is measured on the Celsius scale.

12. Why Kelvin scale of temperature justifies Charles's law?

Ans: Charles's law is obeyed when the temperature is taken on the Kelvin scale. For example, at 283 K (10 ºC) the volume is 566 cm^3, while at 373 K (100 ºC) the volume is 746 cm^3.

According to Charles's law:

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

$$\frac{566}{283} = \frac{746}{373} = 2 = K$$

13. Tell about Celsius scale of temperature.

Ans: It has a zero mark for the temperature of ice at one atmospheric pressure. The mark 100 °C indicates the temperature of boiling water at 1 atmospheric pressure. The space between these temperature marks is divided into 100 equal parts and each part is 1°C.

14. Tell about Fahrenheit scale of temperature.

Ans: The melting point of ice at 1 atmospheric pressure has a mark 32°F and that of boiling water is 212 ºF. The space between these temperature marks is divided into 180 equal parts and each part is 1 ºF.

15. Tell about absolute or Kelvin scale of temperature.

Ans: The melting point of ice at 1 atmospheric pressure is 273K. The water boils at 373K or more precisely at 373.16 K.

$$K = °C + 273.16$$

16. Calculate the value of ideal gas constant according to STP.

Ans: The volume of one mole of an ideal gas at STP (one atmospheric pressure and 273.16 K) is 22.414 dm^3.

Putting these values in the general gas equation will give the value of R.

$$R = \frac{PV}{nT}$$

Putting their values, alongwith units

$$R = \frac{1\ atm \times 22.414\ dm^3}{1\ mole \times 273.16\ K}$$

$$R = 0.0821\ dm^3\, atm\, K^{-1}\, mol^{-1}$$

When the pressure is in atmospheres, volume in dm^3 then the value of R used should be 0.0821 dm^3 atm K^{-1} mol^{-1}

Physical meaning

The physical meanings of this value is that, if we have one mole of an ideal gas at 273.16 K and one atmospheric pressure and its temperature is increased by 1 K, then it will absorb 0.0821 dm^3-atm of energy, dm^3-atm is the unit of energy in this situation. Hence, the value of R is a universal parameter for all the gases. It tells us that the Avogadro's number of molecules of all the ideal gases have the same demand of energy.

17. Calculate the value of gas constant in SI units.

Ans: Using SI units of pressure, volume and temperature in the general equation, the value of R is calculated as follows. The SI units of pressure are Nm^{-2} and of volume are m^3. By using Avogadro's principle

1 atm = 760 torr = 101 325 Nm^{-2}

$lm^3 = 1000\ dm^3$

n = 1 mole

T = 273.16 K

P = 1 atm = 101325 Nm^{-2}

V = 22.414 dm^3 = 0.022414 m^3

Putting their values, alongwith units.

$$R = \frac{PV}{nT} = \frac{101325\ N\ m^{-2} \times 0.02241\ m^3}{1\ mol \times 273.16\ K}$$

$$R = 8.3143\ Nm\ K^{-1}\ mol^{-1} = 8.3143\ J\ K^{-1}\ mol^{-1}\ (1\ Nm = 1J)$$

Since 1cal. = 4.18 J

$$so\ R = \frac{8.3143}{4.18} = 1.989 cal\ K^{-1}\ mol^{-1}$$

18. Calculate density of an ideal gas.

Ans: For calculating the density of an ideal gas, we substitute the value of number of moles (n) of the gas in terms of the mass (m), and the molar mass (M) of the gas.

$$n = \frac{m}{M}$$

$$PV = \frac{m}{M} RT$$

The equation is another form of general gas equation that may be employed to calculate the mass of a gas whose P, T, V and molar mass are known.

$$PM = \frac{m}{V} RT$$

$$PM = d\ RT \qquad (d = \frac{m}{V})$$

$$d = \frac{PM}{RT}$$

Hence, the density of an ideal gas is directly proportional to its molar mass. Greater the pressure onthe gas, closer will be the molecules and greater the density. Higher temperature makes the gases to expand hence density falls with the increase in temperature. With the help of equation one can calculate the relative molar mass (M) of an ideal gas if its temperature, pressure and density are known.

19. State Avogadro's law.

Ans: Equal volumes of all the ideal gases at the same temperature and pressure contain equal number of molecules.

$$V \propto n$$

$$V = kn$$

For example,

$$22.414 dm^3 \text{ of an ideal gas at STP} = 1 \text{ mole of gas} = 6.02 \times 10^{23} \text{ molecules}$$

20. State Dalton's law of partial pressures.

Ans: The total pressure exerted by a mixture of non-reacting gases is equal to the sum of their individual partial pressures. Let the gases are designated as 1,2,3 and their partial pressures are p_1, p_2, p_3.The total pressure (P) of the mixture of gases is given by:

$$P_t = p_1 + p_2 + p_3$$

21. How Dalton's law of partial pressures is applicable to the collection of gases under water?

Ans: Some gases are collected over water in the laboratory. The gas during collection gathers water vapours and becomes moist. The pressure exerted by this moist gas is, therefore, the sum of the partial pressures of the dry gas and that of water vapours.

$$P_{moist} = p_{dry} + p_{w.vap}$$

$$P_{moist} = p_{dry} + \text{aqueous tension}$$

$$p_{dry} = P_{moist} - \text{aqueous tension}$$

The partial pressure exerted by the water vapours is called aqueous tension.

22. How Dalton's law of partial pressure finds application in breathing process?

Ans: Dalton's law finds its applications during the process of respiration. The process of respiration depends upon the difference in partial pressures. When animals inhale air then oxygen moves into lungs as the partial pressure of oxygen in the air is 159 torr, while the partial pressure of oxygen in the lungs is 116 torr. CO_2 produced during respiration moves out in the opposite direction, as its partial pressure is more in the lungs than that in air.

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23. Why pilots feel uncomfortable breathing at high altitudes?

Ans: At higher altitudes, the pilots feel uncomfortable breathing because the partial pressure of oxygen in the un-pressurized cabin is low, as compared to 159 torr, where one feels comfortable breathing.

24. Why deep sea divers take oxygen mixed with an inert gas?

Ans: Deep sea divers take oxygen mixed with an inert gas say He and adjust the partial pressure of oxygen according to the requirement. Actually, in sea after every 100 feet depth, the diver experiences approximately 3 atm pressure, so normal air cannot be breathed in depth of sea. Moreover, the pressure of N_2 increases in depth of sea and it diffuses in the blood.

25. Mention main postulates of kinetic molecular theory.

Ans: Following are the fundamental postulates of this kinetic theory of gases:

1. Every gas consists of a large number of very small particles called molecules. Gases like He, Ne, Ar have mono-atomic molecules.

2. The molecules of a gas move haphazardly, colliding among themselves and with the walls of the container and change their directions.

3. The pressure exerted by a gas is due to the collisions of its molecules with the walls of a container. The collisions among the molecules are perfectly elastic.

4. The molecules of a gas are widely separated from one another and there are sufficient empty spaces among them.

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5. The molecules of a gas have no forces of attraction for each other.

6. The actual volume of molecules of a gas is negligible as compared to the volume of the gas.

7. The motion imparted to the molecules by gravity is negligible as compared to the effect of the continued collisions between them.

8. The average kinetic energy of the gas molecules varies directly as the absolute temperature of the gas.

26. What is mean square velocity?

Ans: All the molecules of a gas under the given conditions don't have the same velocities. Rather different velocities are distributed among the molecules. According to Maxwell's law of distribution of velocities if there are n_1 molecules with velocity c_1, n_2 molecules with velocity c_2, and so on then,

$$\overline{c^2} = \frac{c_1^2 + c_2^2 + c_3^2 + \ldots\ldots}{n_1 + n_2 + n_3 + \ldots\ldots}$$

In this reference $n_1+n_2+n_3 \ldots\ldots\ldots\ldots = N$

27. What is root mean square velocity?

Ans: When we take the square root of mean square velocity then it is called root mean square velocity

$$C_{rms} = \sqrt{\frac{3RT}{M}}$$

Where, C_{rms} = root mean square velocity
M = molar mass of the gas
T = temperature

28. Prove Charles's law according to KMT/Prove Boyle's law according to KMT/Prove Avogadro's law according to KMT/Prove Graham's law according to KMT. (Any one can be

asked)

Ans:

Boyle's Law

(a) Boyle's Law

According to one of the postulates of kinetic theory of gases, the kinetic energy is directly proportional to the absolute temperature of the gas. The kinetic energy of N molecules is

$$1/2\ mN\overline{c^2}$$

$$1/2\ mN\overline{c^2}\ \alpha\ T$$

$$½\ mN\overline{c^2} = kT\ \ ......(1)$$

Where k is the proportionality constant. According to the kinetic equation of gases:

$$PV=1/3\ mN\overline{c^2}$$

Multiplying and dividing 2 on right hand side

$$PV = 2/3\ (1/2\ mN\overline{c^2})......(2)$$

Putting equation (1) in equation (2)

$$PV=2/3\ kT......(3)$$

If the temperature (T) is constant then right hand side of equation (3) 2/3 kT is constant. Let that constant be k.

So, PV=k (which is Boyle's law)

Hence at constant temperature and number of moles the product PV is a constant quantity.

(b) Charles's Law

Consider the following equation:

$$PV = \frac{2}{3}\text{kT}$$

$$V = \frac{2}{3P} \mathrm{kT}$$

At constant pressure,

Therefore,

$$k'' = \frac{2}{3P} \mathrm{k}$$

$$V = k''T$$

$$V/T = k''$$ (which is Charles's Law)

(c) Avogadro's Law

Consider two gases 1 and 2 at the same pressure P and having the same volume V. Their number of molecules are N_1 and N_2, masses of molecules are m_1 and m_2 and mean square velocities are $\overline{c_1^2}$ and $\overline{c_2^2}$ respectively.

Their kinetic equations can be written as follows:

$$PV = \frac{1}{3} m_1 N_1 \overline{c_1^2} \quad \text{for gas(1)}$$

$$PV = \frac{1}{3} m_2 N_2 \overline{c_2^2} \quad \text{for gas(2)}$$

$$\text{Equalizing } \frac{1}{3} m_1 N_1 \overline{c_1^2} = \frac{1}{3} m_2 N_2 \overline{c_2^2}$$

$$\text{Hence, } m_1 N_1 \overline{c_1^2} = m_2 N_2 \overline{c_2^2} \quad (1)$$

When the temperature of both gases is the same, their mean kinetic energies per molecule will also be same, so

$$\frac{1}{2} m_1 \overline{c_1^2} = \frac{1}{2} m_2 \overline{c_2^2}$$

$$m_1 \overline{c_1^2} = m_2 \overline{c_2^2} \quad (2)$$

Dividing eq (1) by (2)

$$N_1 = N_2$$

Hence equal volumes of all the gases at the same temperature and pressure contain equal number of molecules which is Avogadro's law.

(d) Graham's Law of Diffusion

$$PV=1/3\ mN\overline{c^2} \qquad (1)$$

Applying the kinetic equation

$$PV= 1/3\ mN_A\overline{c^2} \quad (1)$$

If we take one mole of a gas having Avogadro's number of molecules (N=NA) then the equation (1) can be written as:

$$PV= 1/3\ M\overline{c^2} \quad (M=mN_A) \quad (2)$$

If we take one mole of a gas having Avogadro's number of molecules ($N=N_A$) then the equation (1) can be written as:

$$PV= 1/3\ M\overline{c^2}\ (M=mN_A)\ (3)$$

$$\overline{c^2} = 3PV/M$$

Where M is the molecular mass of the gas

Taking square root

$$\sqrt{\overline{c^2}} = \sqrt{\frac{3PV}{M}}$$

$$\sqrt{\overline{c^2}} = \sqrt{\frac{3P}{M/V}} = \sqrt{\frac{3P}{d}} \quad (\frac{M}{V} = d)$$

'V' is the molar volume of gas at given conditions. Since the root mean square velocity of the gas is proportional to the rate of diffusion of the gas.

$$\sqrt{\overline{c^2}} \propto r$$

$$r \propto \sqrt{\frac{3P}{d}}$$

At constant pressure

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

Which is Graham's law.

29. Define plasma.

Ans: Plasma is the fourth state of matter. Plasma is a distinct state of matter containing a significant number of electrically charged particles a number sufficient to affect its electrical properties and behaviour.

30. How is plasma formed?

Ans: An electron may gain enough energy to escape its atom. This atom loses one electron and develops a net positive charge. It becomes an ion. In a sufficiently heated gas, ionization happens many times, creating clouds of free electrons and ions. All the atoms are not necessarily ionized and some of them may remain completely intact with no net charge. This ionized gas mixture, consisting of ions, electrons and neutral atoms is called plasma.

31. Differentiate between natural and artificial plasma.

Ans: Artificial plasma can be created by ionization of a gas as in neon signs. Plasma at low temperatures is hard to maintain because outside a vacuum low temperature plasma reacts rapidly with any molecule it encounters. This aspect makes this material, both very useful and hard to use. Natural plasma exists only at very high temperatures, or low temperature vacuums.

Natural plasma, on the other hand, does not breakdown or react rapidly, but is extremely hot (over 20,000°C minimum). Its energy is so high that it vaporizes any material it touches.

32. What are the characteristics of plasma?

Ans: Following are the characteristics of plasma:

1. A plasma must have sufficient number of charged particles so as a whole it exhibits a collective response to electric and magnetic fields. The motion of the particles in the plasma generate fields

and electric currents from within plasma density. It refers to the density of the charged particles. This complex set of interactions makes plasma a unique, fascinating, and complex state of matter.

2. Although plasma includes electrons and ions and conducts electricity, it is macroscopically neutral. In measurable quantities the number of electrons and ions are equal.

33. Where is plasma found?

Ans: Entire universe is almost of plasma. It existed before any other forms of matter came into being. Plasmas are found in everything from the sun to quarks, the smallest particles in the universe. Plasma is the most abundant form of matter in the universe. It is the stuff of stars. A majority of the matter in inner-stellar space is plasma. All the stars that shine are all plasma. The sun is a 1.5 million kilometer ball of plasma, heated by nuclear fusion.

On earth it only occurs in a few limited places, like lightning bolts, flames, auroras, and fluorescent lights. When an electric current is passed through neon gas, it produces both plasma and light.

34. What are the applications of plasma? (Mention any four applications as an answer to short question)

Ans: Following are the applications of plasma:

1. A fluorescent light bulb is not like regular light bulbs. Inside the long tube is a gas. When the light is turned on, electricity flows through the tube. This electricity acts as that special energy and charges up the gas. This charging and exciting of the atoms creates glowing plasma inside the bulb.

2. Neon signs are glass tubes filled with gas. When they are turned on then the electricity flows through the tube. The electricity charges the gas, possibly neon, and creates plasma inside the tube. The plasma glows with a special colour depending on what kind of gas is inside.

3. They find applications such as plasma processing of semiconductors, sterilization of some medical products, lamps, lasers, diamond coated films, high power microwave sources and pulsed power switches.

4. They also provide the foundation for important potential applications such as the generation of electrical energy from fusion pollution control and removal of hazardous chemicals.

5. Plasma light up our offices and homes, make our computers and electronic equipment work.

6. They drive lasers and particle accelerators, help to clean up the environment, pasteurize foods and make tools corrosion-resistant.

35. Why is the Boyle's law applicable only to the ideal gases?

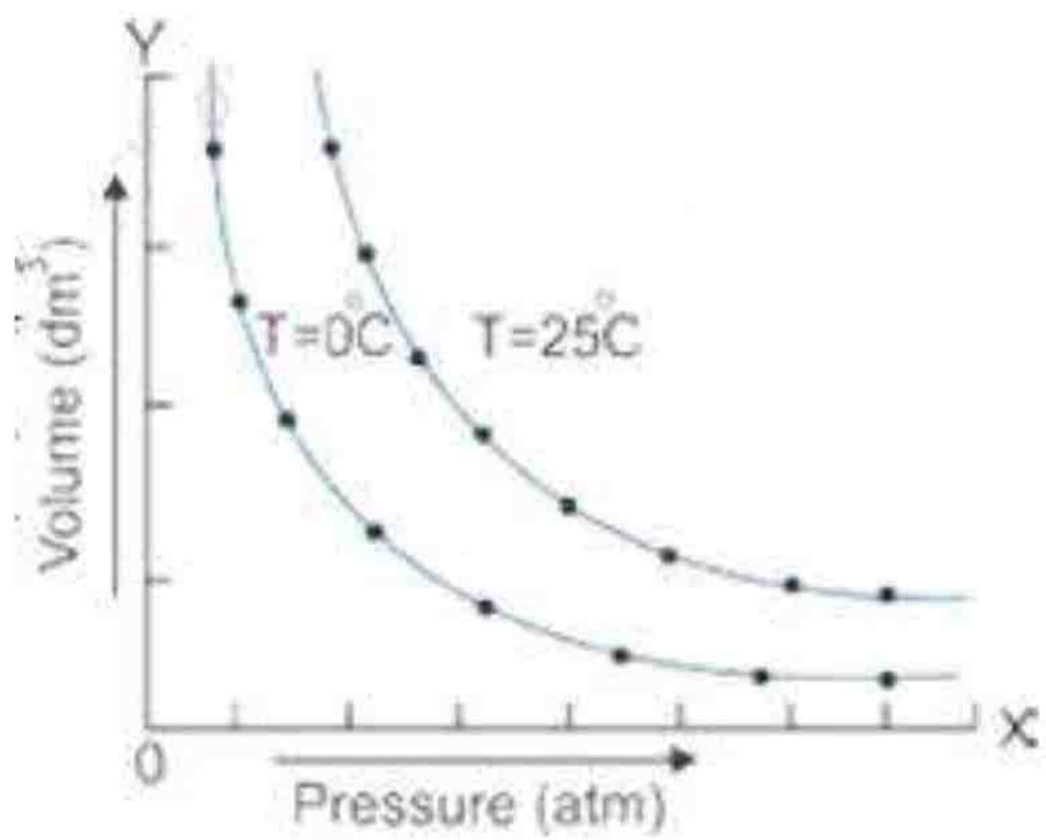
Ans: Boyle's law is applicable only to the ideal gases because in ideal gases there are no forces of attraction among the gas molecules.

36. When a gas obeys the Boyle's law, the isotherms for the gas can be plotted. How is it true?

Ans: Isotherms are the graphs between pressure and volume at constant temperature and number of moles. This condition is fulfilled by Boyle's law. The word isotherm means "same temperature". They are curves. At higher temperature the curves go away from the axis.

37. What are isotherms? What happens to the positions of isotherms when they are plotted at high temperature for a particular gas?

Ans: Isotherms are the graphs between pressure and volume by keeping the temperature constant. Plot a graph at two different temperatures and keeping them constant at different pressure and volume and plot the isotherm. It goes away from both the axes. The reason is that at higher temperature, the volume of the gas has increased. Similarly, if we increase the temperature further, make it constant and plot another isotherm, it further goes away from the axis.



38. The plot of PV versus P is a straight line. Justify.

Ans: Plot a graph between pressure on x-axis and the product PV on Y-axis. A straight line parallel to the pressure axis is obtained. This straight line indicates that 'k' is a constant quantity. At higher constant temperature, the volume increase and value of product PV should increase due to increase of volume at same pressure, but PV remains constant at this new temperature and a straight line parallel to the pressure axis is obtained. This type of straight line will help us to understand the non-ideal behaviour of gases. Boyle's law is applicable only to ideal gases.

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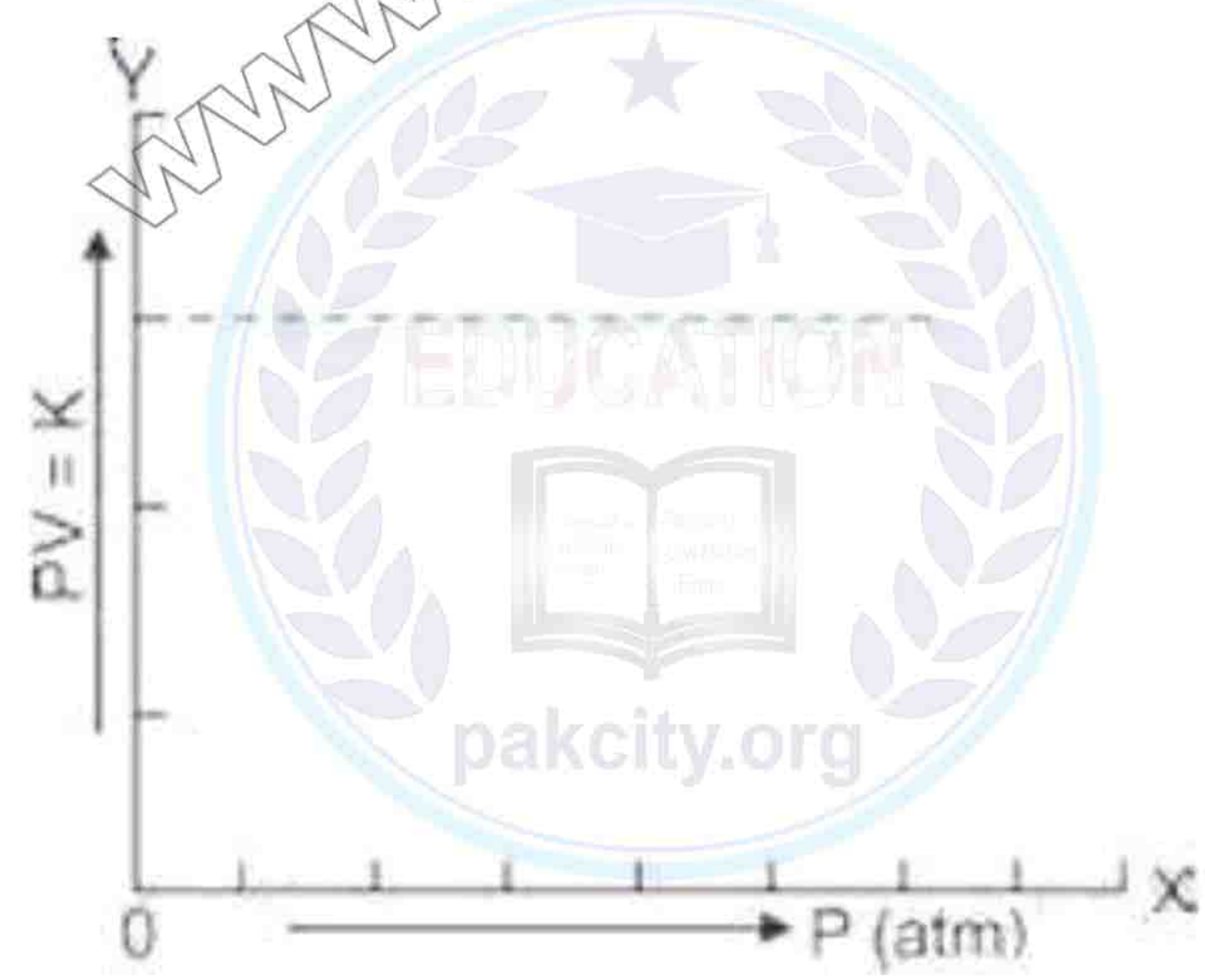
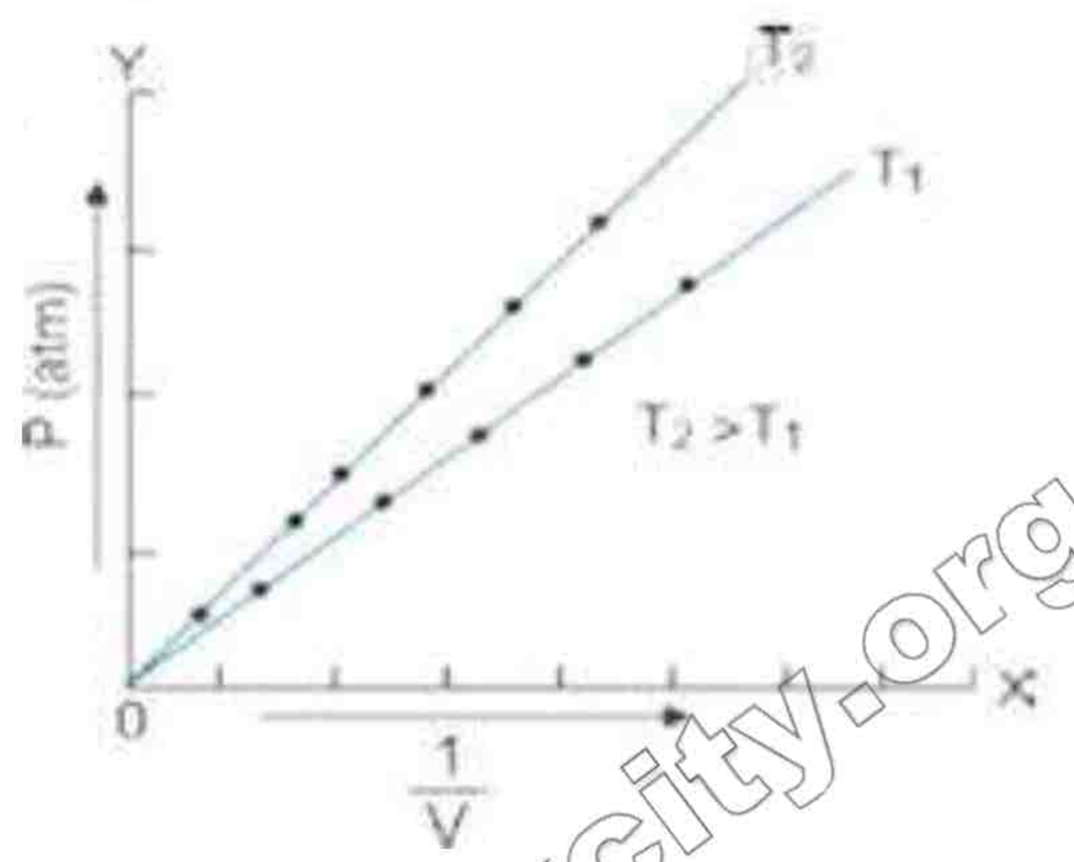


39. Greater the temperature closer the straight line of P versus 1/V to the pressure axis, Justify.

Ans: If a graph is plotted between 1/V on x-axis and the pressure P on the y-axis then a straight line is obtained. This shows that the pressure and inverse of volume are directly proportional to each other. This straight line will meet at the origin which means that when the pressure is very close to zero, then the volume is so high that its inverse is very close to zero. By increasing the temperature of the same gas from T_1 to T_2 and keeping it constant, one can vary pressure and volume. The graph of this data between P and 1/V will give another straight line. This straight line at T_2 will be closer to the pressure-axis.

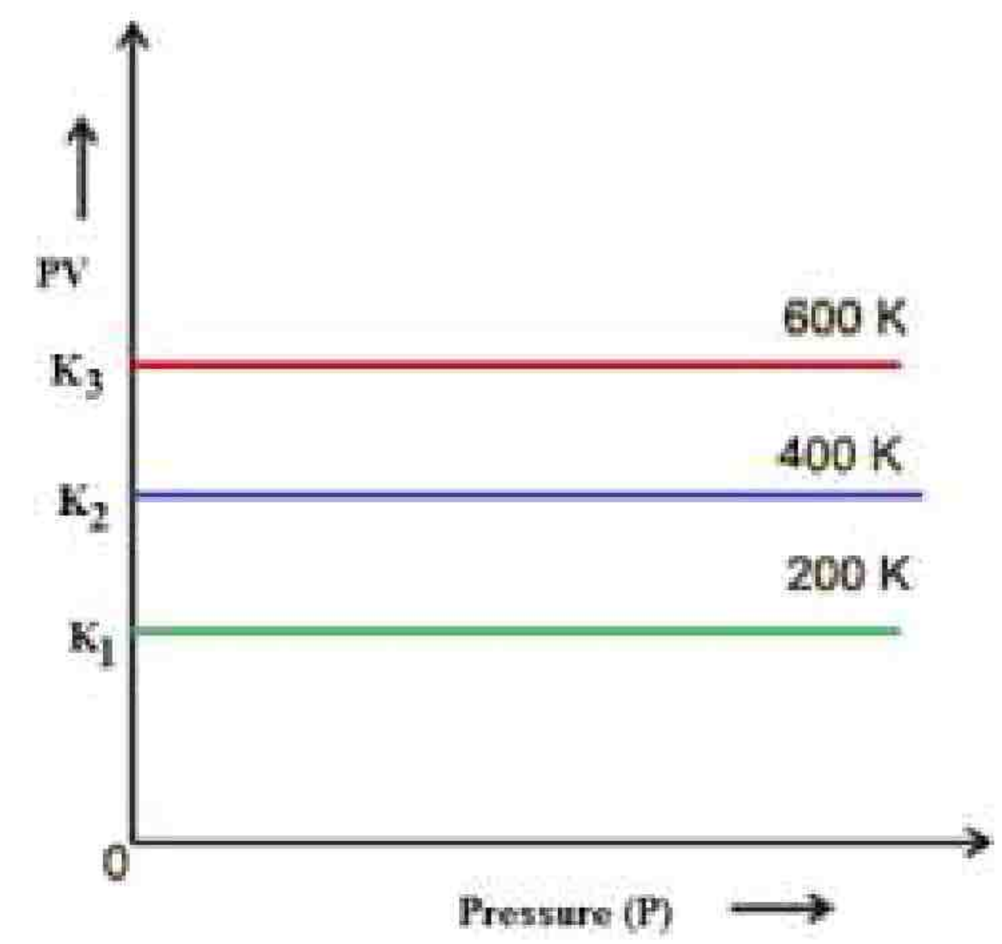


40. What is absolute zero? What happens to real gases while approaching it?

Ans: It is the lowest possible temperature which a gas would attain while remaining in the gaseous state. Its value is -273.16 ^{o} C or 0 K. It is a hypothetical and unattainable temperature. In fact all gases especially real gases are converted to liquid before reaching this temperature.

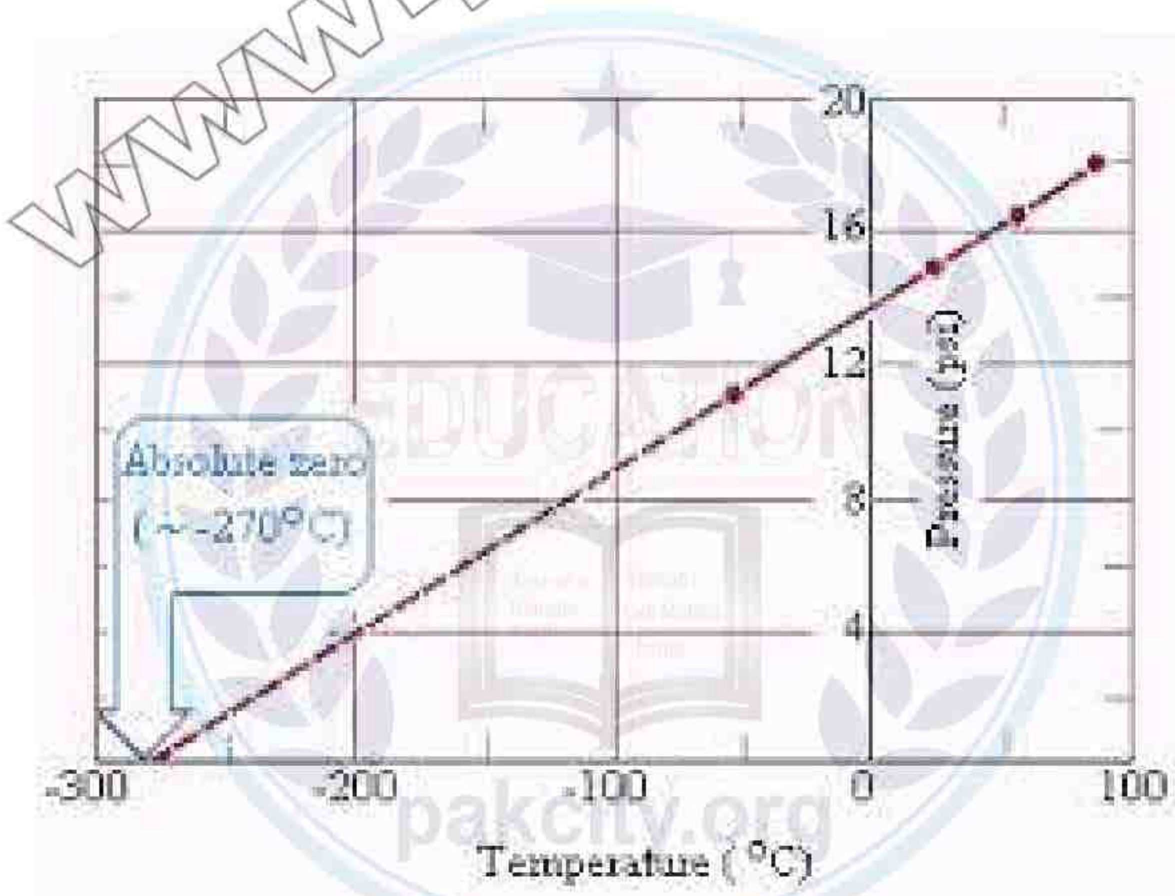
41. The plot of PV vs P is a straight line at constant temperature and with a fixed number of moles of an ideal gas. Justify.

Ans: The plot of PV vs P is a straight line at constant temperature and with a fixed number of moles of an ideal gas showing that 'k' is a constant quantity. At higher constant temperature, the volume increases and value of product PV should increase due to increase of volume at same pressure, but PV remains constant at this new temperature and a straight line parallel to the pressure axis is obtained.



42. Justify that volume of gas becomes theoretically zero at -273 ^{o}C.

Ans: If we plot a graph between temperature on x-axis and the volume of one mole of an ideal gas on y- axis, we get a straight line which cuts the temperature axis at -273.16 ^{0}C. This can be possible only if we extrapolate the graph up to -273.16 ^{0}C. This temperature is the lowest possible temperature which would have been achieved if the substance remains in the gaseous state. Actually, all the gases are converted into liquids even before reaching this temperature.



43. Why lighter gases diffuse more rapidly than heavier gases?

Ans: Lighter gases diffuse more rapidly than heavier gases following Graham's law of diffusion or effusion. In fact, lighter gases have greater velocities and thus greater rates of diffusion.

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

r1 = rate of diffusion of gas 1
r2= rate of diffusion of gas 2
M1= Molar mass of gas 1
M2= Molar mass of gas 2

44. Calculate the density of methane at

STP.

Ans: **Given data:-**

Temperature of gas = 0ºC or

273 K

Pressure of gas = 1 atm

Molecular mass of CH_4 = 16

gmol^{-1}Density of CH_4 = ?

Solution

$$d = PM/RT$$

$$= 1 \times 16/ 0.0821 \times 273$$

$$= 0.7138 \text{ g dm}^{-3}$$

45. Calculate number of molecules and number of atoms in 20 cm^3 of CH_4 at 0ºCand 700mm of Hg.

Ans:

Volume of CH_4 = 20 cm^3
Temperature= 0ºC or 273K
Pressure= 700 mm of Hg = 0.921atm
No. of moles of CH_4 =?
Molecules of CH_4 =?
Atoms of CH_4= ?

Solution

PV=nRT
n=PV/RT
n = 0.921 x 20/ 0.082 x 273
n = 18.42 / 22.386
n = 0.823 mol
No. of molecules of CH_4 = 0.823 x 6.02 10^{23} = 4.95 x 10^{23} molecules
No. of atoms = 5 x 4.95 x 10^{23} = 24.77 x 10^{23} = 2.477 x 10^{24} atoms

46. State Joule-Thomson Effect. Write its application OR Define Joule-Thomson Effect.

Ans: When a highly compressed gas is allowed to expand into the region of low pressure it gets cooled. Nitrogen and oxygen are liquefied on industrial scale by Linde's method of liquefaction which uses the phenomenon of Joule-Thomson effect.

47. Hydrogen and Helium are ideal at room temperature but SO_2 and Cl_2 are non-ideal.

Ans: Gases are non-ideal at high pressure and low temperature because then intermolecular forces become stronger. In helium and hydrogen, already there are weaker Van der Waal's forces because these are non-polar and their particle size is very small so they behave ideally at room temperature. On the other hand, SO_2 and Cl_2 are either polar (SO_2) or having bigger molecules so there are strong intermolecular forces in them which make them non-ideal at room temperature.

48. Some of the postulates of Kinetic Molecular Theory are faulty. Justify OR Write down two faulty assumptions of KMT of gases.

Ans:

Following are the faulty assumptions of KMT:

1. There are no forces of attraction among the molecules of a gas.
2. The actual volume of gas molecules is negligible as compared to the volume of the gas.

49. Derive expression for the molecular mass of the gas using general gas equation.

Ans: According to the general gas equation:

$$PV = nRT$$

But n = m/M, putting in above equation

$$PV = \frac{m}{M}RT$$

$$M = \frac{mRT}{PV}$$

50. Prove that $p_A=P_t.x_A$

Ans: Let us suppose that we have a mixture of gas A and gas B. This mixture is enclosed in a container having volume (V). The total pressure is one atm. The number of moles of the gases A and B are n_A and n_B respectively. If they are maintained at temperature T, then

$P_tV = n_t RT$ (equation for the mixture of gases)

$p_AV = n_A RT$ (equation for gas A)

$P_BV = n_B RT$ (equation for gas B)

$p_AV/P_tV = n_A RT/ n_t RT$

$p_A/P_t = n_A/n_t$

$p_A = \frac{n_A / n_t}{P_t}$

Hence $p_A = x_A P_t$ (xA is a mole fraction of gas A)

51. Define critical temperature (Tc).

Ans: The highest temperature at which a substance can exist as a liquid, is called its critical temperature (Tc). For example, O_2 has a critical temperature 154.4 K (-118.75 °C).

52. SO_2 is comparatively non-ideal at 273K but behave ideally at 373K.

Ans: Low temperature decreases the kinetic energies of molecules resulting in more intermolecular forces. At 273K intermolecular forces are more and that creates non- ideality but 373K breaks intermolecular forces and creates ideality.

53. Rate of diffusion of ammonia is more than that of HCl. Why?

Ans: According to Graham's law, lighter gases diffuse more rapidly than heavier gases. As ammonia is lighter (17 g/mol) than HCl (36.5 g/mol) its rate of diffusion is more than HCl.

54. Pressure of ammonia gas at given conditions is less as calculated by Vander Waal equation than that calculated by general gas equation. Why?

Ans: Van der Waal’s equation tells about intermolecular forces which decrease the observed pressure of a gas. So, pressure of NH_3 gas calculated with this equation shall be mathematically lesser as compared to the value of pressure calculated from ideal gas equation:

$$PV = nRT$$

Vander Waal’s equation is as follows:

$$(P + n^2a/V^2)\ (V - nb) = nRT$$

55. What is physical significance of Vander Waal’s constants ‘a’ and ‘b’?

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Ans:

'a' is the attraction per unit volume and is called co-efficient of attraction for one mole of a gas.Its value depends directly upon the strength of intermolecular forces among gas particles. 'b' is effective volume or excluded or incompressible volume per mole. Its value depends on the size of the gas molecules.

56. Justify that 1 cm ^{3} of H_2 and 1 cm ^{3} of CH_4 at STP will have same number of molecules, when one molecule of CH_4 is 8 times heavier than that hydrogen.

Ans: According to Avogadro's law 1 cm^3 of H_2 and 1 cm^3 of CH_4 at STP will have same number of molecules and it does not depend on mass of molecules. The distances between the gas molecules is 300 times greater than the diameter so sizes and masses do not affect the volume and number of molecules are equal.

22414 cm^3 of 1 mole gas contains molecules= 6.02×10^{23}

1 cm^3 of 1 mole gas contains molecules= $6.02 \times 10^{23}/22414 = 2.68 \times 10^{19}$

Molar mass of H_2 is 2 g mol^{-1} while that of CH_4 is16 g mol^{-1} which shows that the molecule of methane is 8 times heavier than that of hydrogen (H_2).

57. Do you think that the volume of any quantity of gas becomes zero at -273.16 ^oC? Is it not against the law of conservation of mass? How do you deduce the idea of absolute zero from this information?

Ans: The volume of any quantity of a gas does not become zero at -273.16 $^\circ$C because gases are liquefied before reaching this temperature. In fact, -273.16 ^{o}C or zero Kelvin is the lowest possible temperature which has not been achieved by any gas remaining in the gaseous state. It is against the law of conservation of mass. Practically we cannot attain this temperature.

This 0 K is called absolute zero.

58. Why do we feel comfortable in expressing the densities of gases in units of g dm^{-3} rather than g cm^{-3}, a unit which is used to express the densities of liquids and solids?

Ans: We feel comfortable in expressing the densities of gases in the units of g dm^{-3} rather than g cm^{-3} because the gases have high volumes as compared to liquids and solids. So larger units of volume must be preferred. For example, 0.00071 g/cm^3 is the density of methane at 0 ºC. It can also be expressed as 0.71 g/dm^3 which is a more appropriate value.

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59. Do you think that 1 mole of H_2 and 1 mole of NH_3 at 0 •C and 1 atm pressurewill have Avogadro's number of particles?

Ans: It is true because Avogadro's law states that one mole of any substance has 6.02×10^{23} particles in it. So, one mole of any gas shall also follow the same principle.

1 mole of $H_2 = 6.02 \times 10^{23}$ molecules of H_2

1 mole of $NH_3 = 6.02 \times 10^{23}$ molecules of NH_3

60. Dalton's law of partial pressures is only obeyed by those gases which don't have attractive forces among their molecules. Explain it.

Ans: If there are attractive forces among the gas molecules then their pressures against the walls of the container may reduce and observed total pressure of the gaseous mixture may not be equal to expected total pressure. In such cases Dalton's law is not obeyed.

61. Define pressure.

Ans: The force applied per unit area is called pressure. Its SI units are Nm^{-2}.

62. Define diffusion and effusion. Give examples.

Ans:
The spontaneous intermingling of molecules of one gas with another at a given temperature and pressure is called diffusion. For example, the spreading of fragrance of a rose or a scent is due to diffusion.

The effusion of a gas is its movement through an extremely small opening into a region of low pressure. For example, the escape of gas molecules one by one through a punctured tyre.

63. Under which conditions gases behave ideally?

Ans:

(i) Gases are ideal at low pressure and non-ideal at high pressure.

(ii) Gases are ideal at high temperature and non-ideal at low temperature.