Chapter – 6

Gaseous State

I. Choose the best Answer:

Question 1.
Gases deviate from ideal behavior at high pressure. Which of the following statement (s) is correct for non – ideality?
(a) at high pressure the collision between the gas molecule become enormous
(b) at high pressure the gas molecules move only in one direction
(c) at high pressure, the volume of gas become insignificant
(d) at high pressure the inter molecular interactions become significant

Answer:
(d) at high pressure the inter molecular interactions become significant

Question 2.
Rate of diffusion of a gas is …………
(a) directly proportional to its density
(b) directly proportional to its molecular weight
(c) directly proportional to its square root of its molecular weight
(d) inversely proportional to the square root of its molecular weight

Answer:
(d) inversely proportional to the square root of its molecular weight

Question 3.
Which of the following is the correct expression for the equation of state of van der Waals gas?

(a) $\left(P + \frac{a}{n^2V^2}\right)(V - nb) = nRT$

(b) $\left(P + \frac{na}{n^2V^2}\right)(V - nb) = nRT$

(c) $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$

(d) $\left(P + \frac{n^2a^2}{V^2}\right)(V - nb) = nRT$

Answer:
(c) $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$

Question 4.
When an ideal gas undergoes unrestrained expansion, no cooling occurs because the molecules …………
(a) are above inversion temperature
(b) exert no attractive forces on each other
(c) do work equal to the loss in kinetic energy
(d) colide without loss of energy

Answer:
(b) exert no attractive forces on each other

Question 5.
Equal weights of methane and oxygen is mixed in an empty container at 298 K. The fraction of total pressure exerted by oxygen ………..
(a) 1/3
(b) 1/2
(c) 2/3
(d) 1/3 × 273 × 298

Answer:
(a) 1/3
Hint:
mass of methane = mass of oxygen = a

number of moles of methane = $\frac{a}{16}$

number of moles of Oxygen = $\frac{a}{32}$

$$\text{mole fraction of Oxygen} = \frac{\frac{a}{32}}{\frac{a}{16}+\frac{a}{32}} = \frac{\frac{a}{32}}{\frac{3a}{32}} = \frac{1}{3}$$

Partial pressure of oxygen = mole fraction x Total Pressure = $\frac{1}{3}P$

Question 6.
The temperatures at which real gases obey the ideal gas laws over a wide range of pressure is called ………..
(a) Critical temperature
(b) Boyle temperature
(c) Inversion temperature
(d) Reduced temperature

Answer:
(b) Boyle temperature
Hint:
The temperature at which real gases obey the ideal gas laws over a wide range of pressure is called Boyle temperature

Question 7.
In a closed room of 1000 m^3 a perfume bottle is opened up. The room develops a smell. This is due to which property of gases?
(a) Viscosity
(b) Density
(c) Diffusion
(d) None

Answer:
(c) Diffusion

Question 8.
A bottle of ammonia and a bottle of HCl connected through a long tube are opened simultaneously at both ends. The white ammonium chloride ring first formed will be ………...
(a) At the center of the tube

(b) Near the hydrogen chloride bottle
(c) Near the ammonia bottle
(d) Throughout the length of the tube

Answer:
(b) Near the hydrogen chloride bottle
Hint:
Rate of diffusion $\alpha\ 1/\sqrt{m}$
$m_{NH3} = 17$
$m_{HCl} = 36.5$
$\gamma_{NH3} > \gamma_{HCl}$
Hence white fumes first formed near hydrogen chloride.

Question 9.
The value of universal gas constant depends upon ………..
(a) Temperature of the gas
(b) Volume of the gas
(c) Number of moles of the gas
(d) units of Pressure and volume

Answer:
(d) units of Pressure and volume

Question 10.
The value of the gas constant R is …………
(a) 0.082 dm^3 atm.
(b) 0.987 cal mol^{-1} K^{-1}
(c) 8.3 J $mol^{-1}K^{-1}$
(d) 8 erg $mol^{-1}K^{-1}$

Answer:
(c) 8.3 J $mol^{-1}K^{-1}$

Question 11.
Use of hot air balloon in sports at meteorological observation is an application of
(a) Boyle's law
(b) Newton's law
(c) Kelvin's law

(d) Brown's law

Answer:
(a) Boyle's law

Question 12.
The table indicates the value of van der Waals constant 'a' in $(dm^3)^2$ atm. mol^{-2}

Gas	O_2	N_2	NH_3	CH_4
a	1.360	1.390	4.170	2.253

The gas which can be most easily liquefied is …………
(a) O_2
(b) N_2
(c) NH_3
(d) CH_4

Answer:
(c) NH_3

Hint:
Higher the value of 'a', greater the intermolecular force of attraction, easier the liquefaction. Option (c) is correct

Question 13.
Consider the following statements.
(i) Atmospheric pressure is less at the top of a mountain than at sea level
(ii) Gases are much more compressible than solids or liquids
(iii) When the atmospheric pressure increases the height of the mercury column rises Select the correct statement.
(a) (i) and (ii)
(b) (ii) and (iii)
(c) (i) and (iii)
(d) (i), (ii) and (iii)

Answer:
(d) (i), (ii) and (iii)

Question 14.
Compressibility factor for CO_2 at 400 K and 71.0 bar is 0.8697. The molar volume of CO_2 under these conditions is ………..
(a) 22.04 dm^3
(b) 2.24 dm^3
(c) 0.41 dm^3
(d) 19.5 dm^3

Answer:
(c) 0.41 dm^3

Compressibility factor (z) = $\frac{Pv}{nRT}$

$V = \frac{zxnRT}{p}$

$$V = \frac{z \times nRT}{P} = \frac{0.8697 \times 1 \times 8.314 \times 10^{-2} \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1} \times 400 \text{ K}}{71 \text{ bar}}$$

$V = 0.41 \text{ dm}^3$

Question 15.
If temperature and volume of an ideal gas is increased to twice its values, the initial pressure P becomes ………….
(a) 4P
(b) 2P
(c) P
(d) 3P

Answer:
(c) P

Hint:

T_1	$T_2 = 2T_1$
V_1	$V_2 = 2V_1$
P_1	$P2 = ?$

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

$$P_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{V_2} = \frac{P_1V_1}{T_1} \times \frac{2T_1}{2V_1}$$

$P_2 = P_2$ Option (c)

Question 16.
At identical temperature and pressure, the rate of diffusion of hydrogen gas is $3\sqrt{3}$ times that of a hydrocarbon having molecular formula What is the value of n?
(a) 8
(b) 4
(c) 3
(d) 1

Answer:
(b) 4.

Hint:
$$\frac{\gamma_{H_2}}{\gamma_{C_nH_{2n+2}}} = \sqrt{\frac{m_{C_nH_{2n+2}}}{m_{H_2}}}$$
$$3\sqrt{3} = \sqrt{\frac{m_{C_nH_{2n+2}}}{2}}$$
Squaring on both sides and rearranging
$27 \times 2 = m_{C_nH_{2n-2}}$
$54 = n(12) + (2n-2)(l)$
$54 = 12n+2n - 2$
$54 = 14n - 2$
$n = (54 + 2)/14 = 56/14 = 4$

Question 17.
Equal moles of hydrogen and oxygen gases are placed in a container, with a pin-hole through which both can escape what fraction of oxygen escapes in the time required for one-half of the hydrogen to escape. (NEET phase 1)
(a) 3/8
(b) 1/2
(c) 1/8
(d) 1/4

Answer:
(c) 1/8

Hint:

$$\frac{\gamma_{O_2}}{\gamma_{H_2}} = \sqrt{\frac{m_{H_2}}{m_{O_2}}} = \sqrt{\frac{2}{32}} = \frac{1}{4}$$

$$\gamma_{O_2} = \frac{1}{4}\,\gamma_{H_2}$$

The fraction of oxygen that escapes in the time required for one half of the hydrogen to escape is 1/8

Question 18.
The variation of volume V, with temperature T, keeping pressure constant is called the coefficient of thermal expansion ie $\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$ For an ideal gas α is equal to ....
(a) T
(b) 1/T
(c) P
(d) none of these

Answer:
(b) 1/T

Hint:

$$\frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P \text{ [For ani deal gas PV = nRT]}$$

$$= \frac{1}{V}\left(\frac{\partial\left(\frac{nRT}{P}\right)}{\partial T}\right)_P = \frac{nR}{PV}\left(\frac{\partial T}{\partial T}\right) = \frac{nR}{nRT} = \frac{1}{T}$$

Question 19.
Four gases P, Q, R and S have almost same values of 'b' but their 'a' values (a, b are Van der Waals Constants) are in the order Q < R < S < P. At a particular temperature, among the four gases the most easily liquefiable one is ....
(a) P
(b) Q

(c) R
(d) S

Answer:
(a) P
Hint:
Greater the ‘a’ value, casier the liquefaction

Question 20.
Maximum deviation from ideal gas is expected from (NEET)
(a) $CH_{4(g)}$
(b) $NH_{3(g)}$
(c) $H_{2(g)}$
(d) $N_{2(g)}$

Answer:
(b) $NH_{3(g)}$

Question 21.
The units of Van der Waals constants ‘b’ and ‘a’ respectively
(a) mol L^{-1} and L atm^2 mol^{-1}
(b) mol L and L atm mol^2
(c) mol^{-1} L and L^2 atm mol^{-1}
(d) none of these

Answer:
(c) mol^{-1} L and L^2 atm mol^{-1}

Hint:
an^2/V^2 atm
a = atm L^2/mol^2 = L^2 mol^{-2} atm
nb = L
b = L /mol = L mol^{-1}

Question 22.
Assertion : Critical temperature of CO_2 is 304 K, it can be liquefied above 304 K.
Reason : For a given mass of gas, volume is to directly proportional to pressure at constant temperature.

(a) both assertion and reason arc true and reason is the correct explanation of assertion
(b) both assertion and reason are true but reason is not the correct explanation of assertion
(c) assertion is true but reason is false
(d) both assertion and reason are false

Answer:
(d) both assertion and reason are false

Hint:
Correct Statement: Critical temperature of CO_2 is 304 K. It means that CO_2 cannot be liquefied above 304 K, whatever the pressure may applied. Pressure is inversely proportional to volume.

Question 23.
What is the density of N, gas at 227°C and 5.00 atm pressure? (R = 0.082 L atm K^{-1} mol^{-1})
(a) 1.40 g/L
(b) 2.81 g/L
(c) 3.41 g/L
(d) 0.29 g/L

Answer:
(c) 3.41 g/L

Hint:

Density = $\frac{Mass}{Volume}$

$$= \frac{m}{\left(\frac{nRT}{P}\right)} = \left(\frac{m}{n}\right)\frac{P}{RT}$$

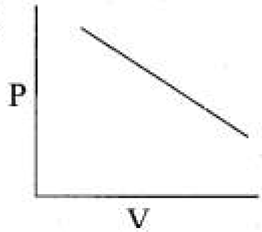
$$= \text{Molar mass} \times \frac{P}{RT}$$

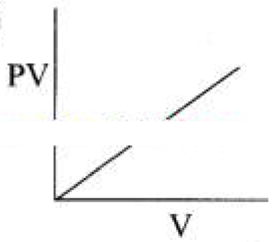
$$= 14 \text{ g mol}^{-1}$$

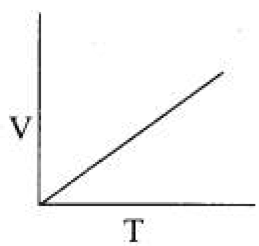
$$= \frac{5 \text{ atm}}{0.082 \text{ L atm K}^{-1} \text{ mol}^{-1} \times 500 \text{ K}}$$

$$= 3.41 \text{g L}^{-1}$$

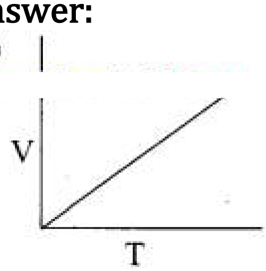
Question 24.
Which of the following diagrams correctly describes the behaviour of a fixed mass of an ideal gas ? (T is measured in K)

(a)


(b)


(c)


(d) All of these

Answer:
(c)


For a fixed mass of an ideal gas V α T
P α 1/V
and PV = Constant

Question 25.
25 g of each of the following gases are taken at 27°C and 600 mm Hg pressure. Which of these will have the least volume?
(a) HBr
(b) HCl
(c) HF

(d) HI

Answer:
(d) HI

Hint:
At a given temperature and pressure
Volume α number of moles
Volume α Mass / Molar mass
Volume α 28 / Molar mass
i.e. if molar mass is more, volume is less. Hence Hl has the least volume.

II. Write brief answer to the following questions:

Question 26.
State Boyle's law.

Answer:
At a given temperature the volume occupied by a fixed mass of a gas is inversely proportional to its pressure.
Mathematically, Boyle's law can be written as
$V \propto 1/P$ …………..(1)
(T and n are fixed, T-temperature, n-number of moles)
$V = k \times 1/P$ …………(2)
k – proportionality constant
$PV = k$ (at constant temperature and mass)

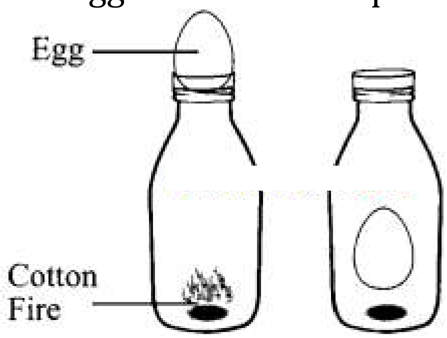
Question 27.
Name two items that can serve as a model for Gay Lussac's law and explain.

Answer:
Gay Lussac's law:

1. P α T at constant volume (or) = V/T
2. Example – 1:
You fill the car type completely full of air on the hottest day of summer. The type cannot change it shape and volume. But when winter comes, the pressure

inside the lyre is reduced and the shape is also reduced. This confirms that pressure and temperature are direct related to each other.

3. Example – 2:
The egg in the bottle experiment.



A glass bottle is taken, inside the bottle put some pieces of cotton with fire. Then place a boiled egg (shell removed) at the top of the bottle. The temperature inside the bottle increases from the fire, rising (he pressure. By scaling the bottle with egg, the fire goes on, dropping the temperature and pressure. This causes the egg to be sucked into the bottle.

P α T is proved (or) = $\frac{P_1}{V_1} = \frac{P_2}{V_2}$

Question 28.
Give the mathematical expression that relates gas volume and moles. Describe in words what the mathematical expression means.

Answer:
The mathematical expression that relates gas volume and moles is Avogadro's hypothesis. It may be expressed as
$V \propto n$,

$\frac{V_1}{n_1} = \frac{V_2}{n_2}$ = constant

where V_1 and n_1 are the volume and number of moles of a gas and V_2 and n_2 are a different set of values of volume and number of moles of the same gas at the same temperature and pressure.

Question 29.
What are ideal gases? In what way real gases differ from ideal gases.

Answer:

1. Ideal gases are the gases that obey gas laws or gas equation PV = nRT.
2. Real gases do not obey gas equation. PV = nRT.
3. The deviation of real gases from ideal behaviour is measure in terms of a ratio of PV to nRT. This is termed as compression factor (Z). Z = PV/nRT
4. For ideal gases Z = 1.
5. For real gases Z > 1 or Z < 1. For example, at high pressure real gases have Z >1 and at intermediate pressure Z < 1.
6. Above the Boyle point Z> 1 for real gases and below the Boyle point, the real gases first show a decrease for Z, reaches a minimum and then increases with the increase in pressure.
7. So, it is clear that at low pressure and high temperature, the real gases behave as ideal gases.

Question 30.
Can a Van der Waals gas with a = 0 be liquefied? Explain.

Answer:
If the van der Waals constant (a) = 0 for gas, then it behaves ideally, (i.e.,) there is no intermolecular forces of attraction. So it cannot be liquefied.
Moreover,

$$P_C = \frac{a}{27b^2}$$

If a = 0, then P_c = 0; therefore it cannot he liquefied.

Question 32.
Suppose there ¡s a tiny sticky area on the wan of a container of gas. Molecules hitting this area stick there permanently. Is the pressure greater or less than on the ordinary area of walls?

Answer:

- Molecules hitting the tiny sticky area on the wall of the container of gas moves faster as they get closer to adhesive surface, but this effect is not permanent.

- The pressure on the sticky wall is greater than on the ordinary area of walls.

Question 32.
Explain the following observations?
(a) Aerated water bottles are kept under water during summer
(b) Liquid ammonia bottle is cooled before opening the seal
(c) The type of an automobile is inflated to slightly lesser pressure in summer than in winter
(d) The size of a weather balloon becomes larger and larger as it ascends up into larger altitude

Answer:
(a) Aerated water bottles contains excess dissolved oxygen and minerals which dissolved under certain pressure and if this pressure suddenly decrease due to change in atmospheric pressure, the bottle will certainly burst with decrease the amount of dissolved oxygen in water, this tends to change the aerated water into normal water.

(b) The vapour pressure of ammonia at room temperature is very high and hence the ammonia will evaporate unless the vapour pressure is decreased. On cooling the vapour pressure decreases so that the liquid remains in the same state. Hence, the bottle is cooled ’ before opening.

(c) In Summer due to hot weather conditions, the air inside the tyre expands to large volumes due to heat as compared to winter, therefore, inflated to lesser pressure in summer.

(d) As we move to higher altitude, the atmospheric pressure decreases, therefore the balloon can J easily expand to large volume.

Question 33.
Give suitable explanation for the following facts about gases.
(a) Gases don’t settle at the bottom of a container
(b) Gases diffuse through all the space available to them and
(c) Explain with an increase in temperature

Answer:
(a) Gases by definition are the least dense state of matter. They have negligible intermolecular forces of attraction. So they are all free to roam separately. So the least dense gas particles will not sink at the bottom of a container.

(b) When a sample of a gas introduced to one part of a closed container, its molecules very quickly disperse throughout the container, this process by which molecules disperse in space in response to differences in concentration is called diffusion. For e.g., you can smell perfume in a room, because it difluses into the air totally inside the room.

(c) Diffusion is faster at higher temperature because the gas molecules have greater kinetic energy. Since heat increase the motion, then diffusion happens faster.

Question 34.
Suggest why there ¡s no hydrogen (H_2) in our atmosphere. Why does the moon have no atmosphere?

Answer:
Hydrogen has a tendency to combine with oxygen from water vapour. Hence, the presence of hydrogen is negligible in the atmosphere. The gravitational pull in the moon is very less and hence, there is no atmosphere in the moon.

Question 35.
Explain whether a gas approaches ideal behaviour or deviates from ideal behaviour if –
(a) it is compressed to a smaller volume at constant temperature
(b) the temperature is raised while keeping the volume constant
(c) more gas is introduced into the same volume and at the same temperature

Answer:
(a) it a gas is compressed to a smaller volume at constant temperature, pressure is increased. At high pressure with a smaller volume, the gas deviates from ideal behaviour.

(b) If a gas temperature is raised keeping the volume constant, the pressure of the gas will increase. At high pressure, the gas deviates from ideal behaviour.

(c) if more gas is introduced into the same volume and at the same temperature, the number of moles are increasing. if the volume remains same, the increased number of moles collide with each other and kinetic energy increases and pressure decreases. At increased pressure, the gas deviates from ideal behaviour.

Question 36.
Which of the following gases would you expect to deviate from ¡deal behaviour under conditions of low-temperature FCl_2, or Br_2? Explain.

Answer:
Bromine has a greater tendency to deviate from ideal behavior at low temperatures. The compressibility factor tends to deviate from unity for bromine.

Question 37.
Distinguish between diffusion and effusion.

Answer:

Diffusion:

- Diffusion is the spreading of molecules of a substance throughout a space or a second substance.
- Diffusion refers to the ability of the gases to mix with each other.
- E.g.. Spreading of something such as brown tea liquid spreading through the water in a tea cup.

Effusion:

- Effusion is the escape of gas molecules through a very small hole in a membrane into an evacuated area.
- Effusion is a ability of a gas to travel through a small pin-hole.
- E.g., pouring out something like the soap studs bubbling out from a bucket of water.

Question 38.
Aerosol cans carry clear warning of heating of the can. Why?

Answer:
Aerosol cans carry clear warning of heating of the can. As the temperature rises, pressure in the can will increase and ambient temperatures about 120°F may lead to explosions. So aerosol cans should always be stored in dry areas where they will not be exposed to excessive temperatures. You should never throw an aerosol can onto a fire or leave it in the direct sunlight. even it is empty. This is because the pressure will build up so much that the can will burst. It is due to 2 reasons.

- The gas pressure increases.
- More of the liquefied propellant turns into a gas.

Question 39.
Would it be easier to drink water with a straw on the top of Mount Everest?

Answer:
It is difficult to drink water with a straw on the top of Mount Everest. This is because the reduced atmospheric pressure is less effective in pushing water into the straw at the top of the mountain because gravity falls off gradually with height. The air pressure falls off, there isn't enough atmospheric pressure to push the water up in the straw all the way to the mouth.

Question 40.
Write the Van der Waals equation for a real gas. Explain the correction term for pressure and volume.

Answer:
Van der Waals equation of state for real gases is
$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Correction term for pressure:
$\frac{an^2}{V^2}$ is the pressure correction. It represents the intermolecular interaction that causes the non-ideal behaviour.

Correction term for Volume:
V – nb is the volume correction. it is the effective volume occupied by real gas.

Question 41.
Derive the values of critical constants from the Van der Waals constants.

Answer:
Derivation of critical constants from the Van der Waals constants:
Van der Waals equation is,
$$\left(P+\frac{an^2}{V^2}\right)(V-nb) = nRT \text{ for 1 mole}$$

From this equation, the values of critical constant $P_C V_C$ and T_C arc derived in terms of a and b the Van der Waals constants.

$$\left(P+\frac{an^2}{V^2}\right)(V-b) = RT \;\ldots\ldots\ldots\ldots(1)$$

On expanding the equestion (1)

$$PV + \frac{a}{V} - pb - \frac{ab}{V^2} - RT = 0 \;\ldots\ldots\ldots(2)$$

Multiplying eqestion (2) by $\frac{V^2}{P}$,

$$\frac{V^2}{P}\left(PV + \frac{a}{V} - Pb - \frac{ab}{V^2} - RT\right) = 0$$

$$V^3 + \frac{aV}{P} - bV^2 - \frac{ab}{P} - \frac{RTV^2}{P} = 0 \quad \ldots\ldots(3)$$

equation (3) is rearranged in the powers of V

$$V^3 - \left[\frac{RT}{P} + b\right] V^2 + \frac{aV}{P} -$$

$$= 0 \;\ldots\ldots\ldots\ldots(4)$$

The above equation (4) is an cubic equation of V, which can have three roots. At the critical point. all the three values of V are equal to the critical volume V_C.
i.e. $V = V_C$.
$V - V_C = 0$ ……….(5)
$(V - V_C)^3 = 0$ ………(6)
$(V^3 - 3V_CV^2 + 3V_C{}^3V - V_C{}^3 = 0$ ………(7)

As the equation (4) is identical with equation (7), comparing the 'V' ternis in (4) and (7),

$$-3V_CV^2 = -\left[\frac{RT_C}{P_C} + b\right]V^2 \quad ......(8)$$

$$3V_C = b + \frac{RT_C}{P_C} \quad ......(9)$$

$$3V_C^{\;2} = \frac{a}{P_C} \quad ......(10)$$

$$V_C^{\;3} = \frac{ab}{P_C} \quad ....(11)$$

Divide equation (11) by (10)

$$\frac{V_C^{\;3}}{3V_C^{\;2}} = \frac{ab/P_C}{a/P_C}$$

$$\frac{V_C}{3} = b$$

$$\therefore V_C = 3b \quad ....(12)$$

When equation (12) is substituted in (10)

$$3V_C^{\;2} = \frac{a}{P_C}$$

$$P_C = \frac{a}{3V_C^{\;2}} = \frac{a}{3(3b)^2} = \frac{a}{3\times 9b^2} = \frac{a}{27b}$$

$$\therefore P_C = \frac{a}{27b^2} \quad ....(13)$$

substituting the values of Vc and Pc in equation (9)

$$3V_C = b + \frac{RT_C}{P_C}$$

$$3\times 3b = b + \frac{RT_C}{a/27b^2}$$

$$9b - b = \frac{RT_C}{a}\times 27b^2$$

$$8b = \frac{T_C.R27b^2}{a}$$

$$\therefore T_C = \frac{8ab}{27Rb^2} = \frac{8a}{27Rb}$$

$$T_C = \frac{8a}{27Rb} \quad ....(14)$$

Critical constant a and b can be calculated using Van der Waals Constant as follows:

$$a = 3V_C^2 P_C$$
$$b = \frac{V_C}{3} \quad ....(15)$$

Question 42.
Why do astronauts have to wear protective suits when they are on the surface of moon?

Answer:
Astronauts must wear spacesuits whenever they leave a spacecraft and are exposed to the environment of the moon. On the moon, there is no air to breathe and no air pressure. Moon is extremely cold and filled with dangerous radiation. Without protection, an astronaut would quickly die in space. Spacesuits are specially designed to protect astronauts from the cold, radiation, and low pressure in space. They also provide air to breathe. Wearing a spacesuit allows an astronaut to survive and work on the moon.

Question 43.
When ammonia combines with HCl, NH_4 Cl is formed as white dense fumes. Why do more funies appear near HCl?

Answer:

1. When ammonia combines with HCl, NH_4 Cl is formed as white dense fumes. The reaction takes place in neutralization between a weak base and a strong acid.
2. The property of the gas is diffusion.
3. Diffusion of gases Ammonia and hydrogen chloride. Concentrated ammonia solution is placed on a pad in one end of a tube and concentrated HCl on the pad at the other.
4. After about a minute, the gases diffuses far enough to meet and a ring of solid ammonium chloride is formed near the HCl end.

Question 44.
A sample of gas at 15°C at 1 atm has a volume of 2.58 dm³. Vhen the temperature is raised to 38°C at I atm does the volume of the gas increase? if so, calculate the final volume.

Answer:

$T_1 = 15°C + 273 \qquad T_2 = 38°C + 273$

$T_1 = 288\ K \qquad T_2 = 311\ K$

$V_1 = 2.58\ dm^3 \qquad V_2 = ?$

(P = 1 atom constant)

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

$$V_2 = \left(\frac{V_1}{T_1}\right) \times T_2$$

$$= \frac{2.58\ dm^3}{288\ \cancel{K}} \times 311\ \cancel{K}$$

$V_2 = 2.78\ dm^3$ i.e. volume increased from $2.58\ dm^3$ to $2.78\ dm^3$.

Question 45.
A sample of gas has a volume of 8.5 dm³ at an unknown temperature. When the sample is submerged in ice water at 0°C, its volume gets reduced to 6.37 dm³. What ¡s its initial temperature?

Answer:

$V_1 = 8.5\ dm^3 \qquad V_2 = 6.37\ dm^3$

$T_1 = ? \qquad T_2 = 0°C = 273\ K$

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

$$V_1 \times \left(\frac{T_2}{V_2}\right) = T_1$$

$$T_1 = 8.5\ \cancel{dm^3} \times \frac{273\ K}{6.37\ \cancel{dm^3}}$$

$T_1 = 364.28\ K$

Question 46.
Of two samples of nitrogen gas, sample A contains 1.5 moles of nitrogen in a vessel of volume of 37.6 dm^3 at 298K, and the sample B is in a vessel of volume 16.5 dm^3 at 298 K. Calculate the number of moles in sample B.

Answer:
$n_A = 1.5$ mol $n_B = ?$
$V_A = 37.6\ dm^3$ $V_B = 16.5\ dm^3$
(T = 298 K constant)

$$\frac{V_A}{n_A} = \frac{V_B}{n_B}$$

$$n_A = \left(\frac{n_A}{V_A}\right)V_B$$

$$= \frac{1.5\ \text{mol}}{37.6\ \cancel{dm^3}} \times 16.5\ \cancel{dm^3}$$

Question 47.
Sulphur hexafluoride is a colourless, odourless gas; calculate the pressure exerted by 1.82 moles of the gas in a steel vessel of volume 5.43 dm^3 at 69.5°C, assuming ¡deal gas behaviour.

Answer:
n = 1.82 mole
$V = 5.43\ dm^3$
T = 69.5 + 273 = 342.5
P = ?
PV = nRT
P = nRT/V

$$P = \frac{1.82\ \text{mol} \times 0.821\ dm^3\ \text{atm mol}^{-1}K^{-1} \times 342.5\ K}{5.43\ dm^3}$$

P = 94.25 atm.

Question 48.
Argon is an inert gas used in light bulbs to retard the vapourlzation of the tungsten filament. A certain light bulb containing argon at 1.2 atm and 18°C is heated to 85°C at constant volume. Calculate its final pressure in atm.

Answer:
$P_1 = 1.2$ atm
$T_1 = 18°C + 273 = 291$ K
$T_2 = 85°C + 273 = 358$ K
$P_2 = ?$

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

$$P_2 = \left(\frac{P_1}{T_1}\right) \times T_2$$

$$= \frac{1.2 \text{ atm}}{291 \not{K}} \times 358 \not{K}$$

Question 49.
A small bubble rises from the bottom of a lake, where the temperature and pressure are 6°C and 4 atm. to the water surface, where the temperature is 25°C and pressure is 1 atm. Calculate the final volume in (mL) of the bubble, if its initial volume is 1.5 mL.

Answer:
$T_1 = 6°C + 273 = 279$ K
$P_1 = 4$ atm $V_1 = 1.5$m
$T_2 = 25°C + 273 = 298$ K
$P_2 = 1$ atm $V_1 = ?$

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

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

$$= \frac{4 \not{atm} \times 1.5 \text{ ml} \times 298 \not{K}}{279 \not{K} \times 1 \not{atm}}$$

$V_2 = 6.41$ mol.

Question 50.
Hydrochloric acid is treated with a metal to produce hydrogen gas. Suppose a student carries out this reaction and collects a volume of 154.4×10^{-3} dm^3 of a gas at a pressure of 742 mm of Hg at a temperature of 298 K. What mass of hydrogen gas (in mg) did the student collect?

Answer:
$V = 154.4 \times 10^{-3} dm^3$
P = 742 mm of Hg
T = 298 K m = ?

$$n = \frac{PV}{RT} = = \frac{742 \text{ mm Hg} \times 154.4 \times 10^{-3} \text{L}}{62 \text{ mm Hg L K}^{-1}\text{mol}^{-1} \times 298 \text{ K}}$$

= 0.006 mol

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

$$n = \frac{Mass}{MolarMass}$$

Mass = n x Molar mass

= 0.006 x 2.016

= 0.0121 g = 12.1 mg.

Question 51.
It takes 192 sec for an unknown gas to diffuse through a porous wall and 84 sec for N2 gas to effuse at the same temperature and pressure. What is the molar mass of the unknown gas?

Answer:

$$\frac{\gamma_{unknown}}{\gamma_{N_2}} = \frac{t_{N_2}}{t_{unknown}} = \sqrt{\frac{m_{N_2}}{m_{unknown}}}$$

$$\frac{84 \sec}{192 \sec} = \sqrt{\frac{14 \text{g mol}^{-1}}{m_{unknown}}}$$

$$= \frac{14 \text{g mol}^{-1}}{m_{unknown}}$$

$$m_{unknown} = 14 \text{g mol}^{-1} \times \left(\frac{192 \sec}{84 \sec}\right)^2$$

$$m_{unknown} = 73.14 \text{ g mol}^{-1}$$

Question 52.
A tank contains a mixture of 52.5 g of oxygen and 65.1 g of CO2 at 300 K the total pressure in the tank ¡s 9.21 atm. Calculate the partial pressure (in atm.) of each gas in the mixture.

Answer:
m_{O2} = 52.5 g
P_{O2} = ?
m_{CO2} = 65.1 g
P_{CO2} = ?
T = 300 K P = 9.21 atm
P_{O2} = X_{O2} x total pressure

$$X_{O_2} = \frac{n_{O_2}}{n_{O_2} + n_{CO_2}}$$

$$n_{O_2} = \frac{\text{Mass of } O_2}{\text{Molar mass of } O_2}$$

$$= \frac{52.5 \text{ g}}{32 \text{ g mol}^{-1}} = 1.64 \text{ mol}$$

$$n_{CO_2} = \frac{\text{Mass of } CO_2}{\text{Molar mass of } CO_2}$$

$$= \frac{65.1 \text{ g}}{44 \text{ g mol}^{-1}} = 1.48 \text{ mol}$$

$$X_{O_2} = \frac{n_{O_2}}{n_{O_2} + n_{CO_2}} = \frac{1.64}{3.12} = 0.53$$

$$X_{CO_2} = \frac{n_{CO_2}}{n_{O_2} + n_{CO_2}} = \frac{1.48}{3.12} = 0.47$$

P_{O2} = X_{O2} x Total pressure
= 0.53 x 9.21 atm = 4.88 atm
P_{CO2} = X_{CO2} x Total pressure
= 0.47 x 9.21 atm = 4.33 atm

Question 53.
A combustible gas Is stored in a metal tank at a pressure of 2.98 atm at 25 °C. The tank can withstand a maximum pressure of 12 atm after which it will explode. The building in which the tank has been stored catches fire. Now predict whether the tank will blow up first or start melting? (Melting point of the metal = 1100 K).

Answer:

$T_1 = 298$ K;

$P_1 = 2.98$ atm;

$T_2 = 1100$K;

$P_2 = ?$

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

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

$$= \frac{2.98\text{atm}}{298\text{K}} \times 1100\text{K} = 11 \text{ atm}$$

At 1100 K, the pressure of the gas inside the tank will become 11 atm. Given that tank can withstand a maximum pressure of 12 atm, the tank will start melting first.