Level-II

Chapter 5

States of Matter

Solutions

SECTION - A

Objective Type Questions (One option is correct)

1. A gaseous mixture of CO, C_2H_6 and C_2H_4 contains 40% by volume of CO. When 250 mL of this mixture is burnt completely in presence of excess supply of oxygen. The total volume of CO_2 formed is

   (1) 250 mL (2) 300 mL (3) 400 mL (4) Can't be calculated

Sol. Answer (3)

$$CO + \frac{1}{2}O_2 \longrightarrow CO_2(g)$$

100 mL 100 mL

$$C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2(g) + 3H_2O$$

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2(g) + 2H_2O$$

$$V_{C_2H_6} + V_{C_2H_4} = 150 \text{ mL}$$

$\therefore$ Total volume of CO_2 produced

= 100 + 2 × 150

= 400 mL

2. A 2.4 L fixed volume container have only N_2 and H_2 at 300 K and 7 atm pressure. At 300 K, N_2 and H_2 completely react a to form NH_3 and N_2H_4. The pressure of final mixture (Final mixture contain only N_2H_4 and NH_3) is 3 atm at 300 K. Reaction are (assume $R = 0.08 \frac{\text{atm L}}{\text{mol K}}$)

   Reaction I

   $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

   Reaction II

   $N_2(g) + 2H_2(g) \rightarrow N_2H_4(g)$

Consider the following statements

I : Mass of NH_3 and N_2H_4 in final mixture are x and y g respectively. Then x is more than y

II : Equal mass of N_2 react (used) in Both reaction I and reaction II

III : Initial mixture of H_2 and N_2 contain 5.6 g N_2 and 1 g H_2.

IV : 0.6 g of H_2 react according to reaction I

V : 50% mol of H_2 react according to reaction II

VI : More mass of H_2 and N_2 react according to reaction I than reaction II

The correct statement(s) is/are

(1) Only I, II, III, V

(2) Only II, III, IV, V and VI

(3) Only I, III, V

(4) Only I, II, III, IV and VI

Sol. Answer (4)

PV = nRT

n = 0.7 mol

Let mol of N_2 = x

mol of H_2 = 0.7 – x

$$\begin{array}{ccc} x-a & 3(x-a) & 2(x-a) \\ N_2 \;+ & 3H_2 \longrightarrow & 2\,NH_3 \end{array}$$

$$\begin{array}{ccc} a & 2a & a \\ N_2 \;+ & 2H_2 \longrightarrow & N_2H_4 \end{array}$$

Total final mol = 0.3

2x – 2a + a = 0.3

2x – a = 0.3

3(x – a) + 2a = 0.7 – x

3x + x – a = 0.7

2x – a = 0.3

a = 0.1

x = 0.2 = mol of N_2

0.5 = mol of H_2 = 0.7 – x

Mol of N_2 react in reaction I = 0.1

Mol of H_2 react in reaction I = 0.3

Mol of H_2 react in reaction II = 0.2

Mol of N_2 react in reaction II = 0.1

Mol of NH_3 = 0.2

Mol of N_2H_4 = 0.1

3. At certain conditions of temperature and pressure 1 L of CH_4 gas contains 12 $\times 10^{24}$ atoms. The volume occupied by SO_3 gas at same conditions of temperature and pressure containing same no. of atoms as that of $CH_4(g)$ sample is

(1) 1 L (2) 1.25 L (3) 3 L (4) 0.8 L

Sol. Answer (2)

At same condition of T and P

V $\propto$ Number of molecules

$\therefore$ Volume occupied by $SO_3(g)$ = 1.25

4. A mixture containing $SO_2(g)$ and $O_2(g)$ in equal mass in a vessel of 10 L at 27°C are made to react to produce maximum quantity (yield) of $SO_3(g)$ as per following reaction (not balanced)

$SO_2(g) + O_2(g) \longrightarrow SO_3(g)$

The % change in pressure at the end of reaction is (assume temperature remains constant)

(1) 33.33% (2) 20% (3) 16.67% (4) 40%

Sol. Answer (3)

$$SO_2 + \frac{1}{2}O_2 \longrightarrow SO_3$$

Molar ratio in mixture : $n_{SO_2} : n_{O_2}$ = 1 : 2

At constant T and V

% change in pressure = % change in mol

$$= \frac{(3-2.5)}{3} \times 100$$

$$= \frac{100}{6}\%$$

5. A compound of sulphur and nitrogen having formula $S_xN_4(g)$ decomposed at high temperature into $N_2(g)$ and $S_8(g)$. If all measurements are made under the same conditions of temperature and pressure, it is found that for 1 litre of $S_xN_4(g)$ is completely decomposed and 2.5 litre of gaseous product are formed. The value of x is

(1) 1 (2) 2 (3) 3 (4) 4

Sol. Answer (4)

$$S_xN_4 \longrightarrow \frac{x}{8}S_8 + 2N_2(g)$$

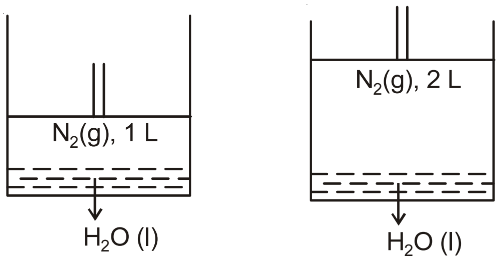
1 L $\quad \frac{x}{8}$L $\quad$ 2L

$$2 + \frac{x}{8} = 2.5$$

$$\frac{x}{8} = 0.5$$

x = 4

6. Consider the following diagrams



(i) (ii)

If pressure measured over liquid surface in container (i) is 100 cm of Hg, then the pressure measured over liquid surface in container (ii) is (Assume same temperature for both the containers and aqueous tension of water at that temperature is equal to 20 cm of Hg. Also neglect the volume of H_2O(l) and mixing of N_2 in H_2O(l))

(1) 50 cm of Hg (2) 100 cm of Hg (3) 80 cm of Hg (4) 60 cm of Hg

Sol. Answer (4)

$$P_{ii} = \frac{(P_{N_2})_1}{2} + \text{Aqueous tension}$$

7. A mixture of methane, carbon monoxide, Ammonia, NO and oxygen. The initial volume of gaseous mixture is 130 c.c and volume of product gases at similar condition are 60 c.c. Equal volume of carbon dioxide is produced by combustion of methane and carbon monoxide. Volume of O_2 required for combustion of NH_3 is 3.5 times O_2 require for NO and 7 times of CO,

Reactions are (Not balanced)

$NH_3(g) + O_2(g) \longrightarrow NO_2(g) + H_2O(l)$

$NO(g) + O_2(g) \longrightarrow NO_2(g)$

$CH_4(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(l)$

Select incorrect statement.

(1) Volume of NO and NH_3 are same and 20 c.c each

(2) Volume of CH_4 is half of NH_3

(3) Volume of CO is equal to methane

(4) Volume of CH_4 is 20 c.c

Sol. Answer (4)

$CH_4 + 2O_2 \rightarrow CO_2(g) + 2H_2O(l)$

$2NO + O_2 \rightarrow 2NO_2(g)$

$CO + \frac{1}{2}O_2 \rightarrow CO_2(g)$

$2NH_3(g) + 3.5O_2 \rightarrow 2NO_2 + 3H_2O$

Let volume of CH_4 = x

Volume of CO = y

Volume of NO = z

Volume of NH_3 = w

Volume of O_2 = p

x + y + z + w + p = 130

x + y + z + w = 60

p = 70

x = y

w = z

w = 2x

So x = 10

y = 10

z = 20

w = 20

8. The following condition is satisfied by two different gases A and B

$T_A M_B = T_B M_A$

Where M_A and M_B represents molar mass of A and B respectively and $M_A \neq M_B$.

T_A and T_B are temperatures of A and B respectively and $T_A \neq T_B$.

The property which can never have same magnitude for both gases. (V $\rightarrow$ velocity)

(1) V_{rms} (2) V_{mp} (3) Density (4) K.E. per mole

Sol. Answer (4)

$\because \frac{T_A}{M_A} = \frac{T_B}{M_B}$

$\therefore$ U_{rms} and U_{MP} for A and B will be same

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

$\therefore$ If $P_A = P_B$, then density can be same

9. Which of the following expression correctly represents the change in root mean square velocity of a gas (mol. mass = M) if the temperature of gas changes by ΔT?

(1) $\frac{3R\Delta T}{v_{rms}}$ (2) $\frac{3R\Delta T}{2Mv_{rms}}$ (3) $\frac{2R\Delta T}{M\,v_{rms}}$ (4) $\sqrt{\frac{3R\Delta T}{4M\,v_{rms}}}$

Sol. Answer (2)

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

$dv_{rms} = \sqrt{\frac{3R}{M}} \cdot \frac{1}{2\sqrt{T}}$

10. The root mean square speed of a gas at a particular temperature is 10^3 m/s. The pressure exerted by 10^{24} gas molecules present in 1 L container at the same temperature is (mass of a gas molecule = 10^{-23} g)

(1) $\frac{1}{3} \times 10^7$ kPa (2) $\frac{1}{3} \times 10^6$ kPa (3) $\frac{1}{3} \times 10^3$ kPa (4) $\frac{1}{3} \times 10^4$ kPa

Sol. Answer (4)

$$PV = \frac{1}{3}mNv_{rms}^2$$

$$P = \frac{1}{3} \times \frac{10^{-26} \times 10^{24} \times 10^6}{10^{-3}}$$

$$= \frac{1}{3}10^7 \text{ Pa}$$

11. Consider the following statements:

    I. Chemical properties of a substance do not change with the change of its physical state.

    II. Gases have maximum thermal energy and minimum force of attraction out of three states *i.e.*, Solid, Liquid and Gas.

    III. Intermolecular forces are attractive as well as repulsive in nature.

    The correct statement(s) is/are

    (1) Only III (2) Only I and II (3) Only II and III (4) I, II and III

Sol. Answer (4)

All the given statements are correct.

12. Select the incorrect statement about dispersion forces.

    (1) It is always attractive in nature

    (2) It is a type of force between instantaneous dipole and induced dipole

    (3) Their interaction energy $\propto \frac{1}{r^6}$ (r = distance between two particles)

    (4) Their magnitude is inversely related on the polarisability of the particle.

Sol. Answer (4)

More the polarisibility more will be the magnitude of dispersion forces.

13. A real gas obey Berthelot equation of gas that is $\left(P + \frac{a}{TV_m^2}\right)(V_m - b) = RT$

    The Boyle's temperature for this is (a and b are constant)

    (1) $\frac{a}{Rb}$ (2) $\sqrt{\frac{a}{Rb}}$ (3) $\frac{2a}{Rb}$ (4) $\sqrt{\frac{2a}{Rb}}$

Sol. Answer (2)

$$P = \frac{RT}{V_m - b} - \frac{a}{TV_m^2}$$

$$\Rightarrow Z = \frac{V_m}{V_m - b} - \frac{a}{RT^2V_m}$$

$$Z = \frac{1}{1 - b/V_m} - \frac{a}{RT^2 V_m}$$

$$= \left(1 - \frac{b}{V_m}\right)^{-1} - \left(\frac{a}{RT^2 V_m}\right)$$

$$= 1 + \frac{b}{V_m} + \frac{b^2}{V_m^2} + \frac{b^3}{V_m^3} \cdots - \frac{a}{RT^2 V_m}$$

$$Z = 1 + \left(b - \frac{a}{RT^2}\right)\frac{1}{V_m} + \frac{b^2}{V_m^2} + \frac{b^3}{V_m^3}$$

$$P \to 0, \text{ So } \frac{1}{V_m} = \frac{P}{RT}$$

$$Z = 1 + \left(b - \frac{a}{RT^2}\right)\frac{P}{RT} + \frac{b^2P^2}{(RT)^2} + \frac{b^3P^3}{(RT)^3}$$

$$\frac{dZ}{dP} = b - \frac{a}{RT^2} = 0$$

$$b = \frac{a}{RT_b^2}$$

$$T_b = \sqrt{\frac{a}{Rb}}$$

14. Two flasks A and B have equal volumes. A is maintained at 300 K and B at 600 K. While A contain H_2 gas, B has an equal mass of CH_4 gas. Assuming ideal behaviour for both the gases and collision diameter of CH_4 is twice as that of H_2 molecule.

Consider the following statement.

S_1 : Mean free path of molecule of flask A is more than molecule of flask B.

S_2 : Compression factor for both gases is same.

S_3 : The total bimolecular collision (Z_{11}) per unit volume per unit time in flask B is more than A.

S4 : Molar kinetic energy of particle of flask A is more than flask B.

The correct statements is/are

(1) Only S_1, S_2 and S_4
(2) Only S_1 and S_2
(3) Only S_3 and S_4
(4) Only S_2

Sol. Answer (4)

$$\frac{n_A}{n_B} = 8$$

$\lambda_A = \frac{kT_A}{\sqrt{2}\pi\sigma_A^2 P_A}$ $\lambda_B = \frac{kT_A}{\sqrt{2}\pi\sigma_B^2 P_B}$

$\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$

$\frac{(K.E)_A}{(K.E)_B} = \frac{T_A}{T_B}$

$\frac{(Z_{11})_A}{(Z_{11})_B} = \frac{N_A^* Z_{1A}/2}{N_B^* Z_{1B}/2} = 8 \times 4 = 32$

15. Consider the following statements :

I. At high altitudes liquid boils at higher temperature.

II. Surface tension of liquid increases as the temperature increases.

III. Viscosity of liquids decreases as the temperature increases.

The correct statement (s) is/are

(1) Only I (2) Only III (3) Only II and III (4) Only II

Sol. Answer (2)

At high altitudes liquid boils at lower temperature

Surface tension $\propto \frac{1}{\text{Temperature}}$

Viscosity $\propto \frac{1}{\text{Temperature}}$

16. Consider the following statements :

(A) A real gas is liquefied at $T = T_C$ and $P < P_C$ (T_C and P_C are critical temperature and pressure of real gas)

(B) A real gas is liquified at $T < T_C$ and $P = P_C$

(C) All molecules in a gas are moving with the same speed

(D) Average speed of molecule of a gas in a container moving only in one dimension will be zero

(E) The fraction of molecule having speeds in the range of u to u + du of a gas of molar mass M at temperature T is the same as that of the gas of molar mass 2 M at temperature 2T

Correct statement(s) is/are

(1) Only B, D and E (2) Only A and C (3) Only A, B and E (4) Only B, C and D

Sol. Answer (1)

A gas is liquify only when

$T < T_C$ and $P \geq P_C$.

Fraction of molecule having speed in the range of u_1 to u + du $\propto \frac{M}{T}$

17. Select the incorrect statement.

(1) If two gases have same value of b but different values of a (a and b are van der Waal's constant) then the gas having a larger value of 'a' will occupy lesser volume

(2) If two gases have the same value of 'a' but different values of b then the smaller the value of b, larger will be the compressibility of gas

(3) The value of van der Waal's constant a and b are determined by critical constants of gas

(4) At constant temperature, mean free path is directly proportional to pressure of gas

Sol. Answer (4)

If value of b is same, then the gas has larger value of *a* will occupy less volume because it has larger force of attraction.

$l \propto \frac{1}{P}$ (at constant T)

18. Gas P follow the van der Waal's equation of state. Select the correct statement about this gas (Assume $P \to 0$)

(1) Slope of Z versus P graph is positive if $\frac{a}{RT} > b$

(2) Slope of Z versus P graph is negative if $\frac{a}{RT} > b$

(3) Slope of Z versus P graph is negative when a = bRT

(4) Slope of Z versus P graph is zero when a < bRT

Sol. Answer (2)

For van der Waal's gas.

$$\left(\frac{dZ}{dP}\right)_T = \frac{1}{RT}\left(b - \frac{a}{RT}\right) \text{ (at } P \to 0)$$

19. Rate of effusion of a gas through a fine hole in a container placed in vacuum is given by (Notation have their usual meaning)

(1) Rate = $\frac{pN_A A_{hole} T}{\sqrt{2\pi mR}}$ (2) Rate = $\frac{TN_A A_{hole}}{\sqrt{2\pi mpR}}$ (3) Rate = $\frac{pN_A A_{hole}}{\sqrt{2\pi MRT}}$ (4) Rate = $\frac{PN_A MA_{hole}}{\sqrt{2\pi RT}}$

Sol. Answer (3)

Rate is given by

$$\text{Rate} = \frac{pN_A A_{hole}}{\sqrt{2\pi MRT}}$$

20. Consider the following reaction :

$Zn(s) + 2HCl\ (aq) \longrightarrow ZnCl_2(aq) + H_2(g)$

If 520 mL of $H_2(g)$ is collected over water at 28 °C and the atmospheric pressure is 1 atm. If vapour pressure of water at 28°C is 28.3 mm Hg. Then the amount of Zn (in g) taken at the start of the reaction is (assuming all the Zn(s) gets converted in product, molar mass of Zn is 65 g/mol]

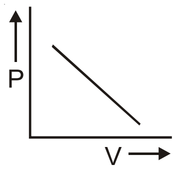
(1) 4.13 g (2) 2.14 g (3) 1.32 g (4) 0.10 g

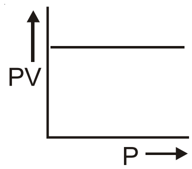
Sol. Answer (3)

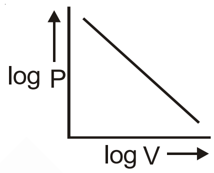
SECTION - B

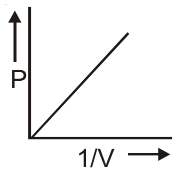
Objective Type Questions (More than one options are correct)

1. Which of the following graphs represent Boyle's law?

(1) 

(2) 

(3) 

(4) 

Sol. Answer (2, 3, 4)

According to Boyle's law,

$V \propto \frac{1}{P}$ (T→ constant)

$\therefore$ PV = K (constant)

$\therefore$ logP = – logV + logK

y = mx + C (straight line}

Slope (m) = negative

2. Which of the following are characteristics of a real gas?

(1) The molecules attract each other

(2) It obeys the ideal gas law at low temperature and high pressure

(3) The mass of molecule is negligible

(4) It shows deviation from the ideal gas law

Sol. Answer (1, 4)

According to van der Waal's equation (for one mole of gas)

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

$\frac{a}{V^2} \rightarrow$ The pressure exerted by gas molecules on each other.

3. If a given mass of gas is expanded at constant temperature

(1) The pressure decreases

(2) The average kinetic energy of gas molecules remain same

(3) Kinetic energy of gas molecules decreases

(4) The number of molecules of gas increases

Sol. Answer (1, 2)

According to Boyle's law,

$V \propto \frac{1}{P}$ (T→ constant)

and K.E $\propto$ T (T → Absolute temperature)

$\therefore$ K.E remains constant.

4. A two litre flask containing 4 g of oxygen is heated from 300 K to 600 K. Which of the following statements are correct?

(1) The pressure of gas increases
(2) The rate of collision increases
(3) The number of moles of the gas increases
(4) The energy of the gaseous molecules increases

Sol. Answer (1, 2, 4)

According to pressure-temperature law,

$P \propto T$ (V → constant)

and according to kinetic theory of gases

$$PV = \frac{1}{3}mnu^2$$

K.E. $\propto$ T

∴ On increase in temperature, kinetic energy of gas increases therefore the rate of collisions also increases.

5. At low pressures, the van der Waal's gas equation for 1 mole of a gas may be written as

(1) PV = RT + Pb
(2) PV = RT
(3) $P + \frac{a}{V^2} = \frac{RT}{V}$
(4) $PV = RT - \frac{a}{V}$

Sol. Answer (3, 4)

At low pressure region (For one mole of gas)

$V - b \cong V$

$$\therefore \left(P + \frac{a}{V^2}\right)V = RT$$

and, $PV + \frac{a}{V} = RT$

$$\therefore PV = RT - \frac{a}{V}$$

6. Which statement is correct regarding van der Waal's constants 'a' and 'b'?

(1) 'a' is the measure of force of attraction in between the particles
(2) 'b' is the excluded or co-volume of the gas
(3) Higher is the value of 'a', easier is the liquefaction of the gas
(4) Lower is the value of 'b', easier is the liquefaction of the gas

Sol. Answer (1, 2, 3)

van der Waal's equation for one mole of gas is

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT \quad \text{or} \quad (P + P')(V - V') = RT$$

$P' \propto \frac{n^2}{V^2}$ [P′-Pressure due to force of interaction between gas molecules]

or, $P' = \frac{an^2}{V^2}$

∴ Greater the value of a, easier is the liquefaction of the gas.

7. The correct relation is

(1) $T_C = \dfrac{8a}{27Rb}$ (2) $P_C = \dfrac{a}{27b^2}$ (3) $V_C = 3b$ (4) $\dfrac{P_C V_C}{RT_C} = \dfrac{3}{8}$

Sol. Answer (1, 2, 3, 4)

Critical temperature (T_C) = $\dfrac{8a}{27Rb}$

Critical pressure (P_C) = $\dfrac{a}{27b^2}$

Critical volume (V_C) = 3 b

and critical coefficient of a gas

$\dfrac{RT_C}{P_C V_C} = 2.66$ [Constant for all real gases)

$\therefore \dfrac{P_C V_C}{RT_C} = \dfrac{3}{8}$

8. The incorrect statement(s) is/are

(1) Gases deviate maximum from ideal behaviour when the temperature is very high and pressure is very low

(2) Gases deviate minimum from the ideal behaviour when the temperature is very low and pressure is very high

(3) Gases tend to become ideal at Boyle's temperature over a wide range of pressure

(4) Gases tend to become ideal at inversion temperature

Sol. Answer (1, 2, 4)

At low pressure and high temperature real gases behave as a ideal gas.

Boyle's temperature (T_b) $\rightarrow$ The temperature at which a real gas obey ideal gas equation at low pressure is known as Boyle's temp.

$T_B = \dfrac{a}{Rb}$

9. The correct statement(s) regarding compressibility factor (Z) is/are

(1) For ideal gas, Z = 1 (2) If Z > 1, then gases are more compressible

(3) If Z < 1, then gases are less compressible (4) For real gas, $Z \neq 1$ (except at Boyle's temperature)

Sol. Answer (1, 4)

Z = 1 (for Ideal gas) and $Z \neq 1$ (for real gas)

10. 4.4 g CO_2 gas and 2.24 litre of H_2 gas at S.T.P. are taken in a 1 litre container at 27ºC. The total pressure of gases in container will be

(1) 4.926 atm (2) 3743.76 mm of Hg (3) 1871.88 mm of Hg (4) 2.463 atm

Sol. Answer (1, 2)

PV = nRT

Total pressure (P_T) = $P_1 + P_2$

or, $P_T = \dfrac{(n_1 + n_2)RT}{V}$ [$P_T \rightarrow$ Total pressure]

$n_1(CO_2)$ = 0.1 mole

$n_2(H_2) = \dfrac{2.24}{22.4}$ = 0.1 mole

$\therefore\ P_T = \dfrac{(0.1+0.1)\times 0.0821\times 300}{1}$

P_T = 4.926 atm

1 atm = 760 mm of Hg

$\therefore\ P_T$ = 3743.76 mm of Hg

11. Which is/are correct for molecular speed of gases?

(1) $u_{rms} = \sqrt{\dfrac{3PV}{M}}$ (2) $u_{rms} > u_{av}$ (3) $u_{mp} > u_{av}$ (4) $u_{mp} = \sqrt{\dfrac{8RT}{\pi M}}$

Sol. Answer (1, 2)

$PV = \dfrac{1}{3}Mu^2$

$RT = \dfrac{1}{3}Mu^2$

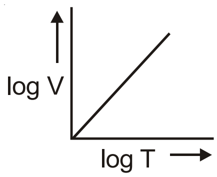
$u_{rms} = \sqrt{\dfrac{3RT}{M}}$

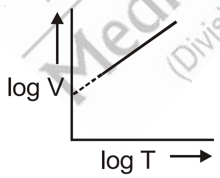
or, $u_{rms} = \sqrt{\dfrac{3PV}{M}}$

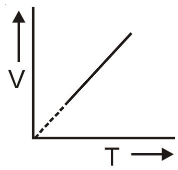
$u_{mp} = \sqrt{\dfrac{2RT}{M}}$

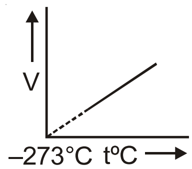
$\therefore\ u_{rms} > u_{av} > u_{mp}$

12. Which of the following graphs correctly represent Charle's law?

(1) 

(2) 

(3) 

(4) 

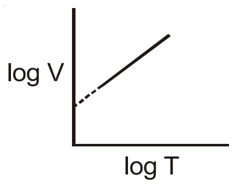
Sol. Answer (2, 3, 4)

$V \propto T$ ($P \rightarrow$ constant)

$\therefore$ log V = log T + log K

y = mx + C

C = log K



And volume of the gas is zero at absolute temperature – 273°C or 0 K

13. Regarding H_2 gas, the correct statement(s) is/are

(1) For H_2 gas, Z > 1 at 273 K

(2) When H_2 gas expands at above inversion temperature, then it shows heating effect

(3) The critical temperature of H_2 gas is very high

(4) The value of van der Waal's constant 'a' is very low for H_2

Sol. Answer (1, 2, 4)

Z > 1 for H_2, and He at 273 K and if $T > T_i$ heating is produced, van der Waals' constant 'a' is very low for He and H_2 gas.

14. Which of the following statements are correct?

(1) He diffuses at a rate of 8.65 times as much as CO does

(2) He escapes at a rate of 2.65 times as fast as CO does

(3) He escapes at a rate of 4 times as fast as CO_2 does

(4) He escapes at a rate of 4 times as fast as SO_2 does

Sol. Answer (2, 4)

(2) $\frac{r_{He}}{r_{CO}} = \sqrt{\frac{M_{CO}}{M_{He}}}$

$\therefore \frac{r_{He}}{r_{CO}} = \sqrt{\frac{28}{4}}$

$\therefore \frac{r_{He}}{r_{CO}} = 2.65$

(4) $\frac{r_{He}}{r_{SO_2}} = \sqrt{\frac{64}{4}} = 4$

15. A certain gas obeys the van der Waal's equation with a = 0.76 m^6 Pa mol^{-2}. Its volume is found to be 4.00×10^{-4} m^3 mol^{-1} at 288 K and 4.0 mega Pa. Select the correct statement(s) (take $N_A = 6 \times 10^{23}$)

(1) The van der Waal's constant 'b' is 1.3×10^{-4} m^3 mol^{-1} (approx)

(2) If atom of gas is assumed hard sphere then radius of an atom is 2.35 Å (approx)

(3) The compressibility factor of gas is 0.67

(4) The compressibility factor at above condition of temperature and pressure is more than the compressibility factor at critical state

Sol. Answer (1, 2, 3, 4)

$$b = V_m - \frac{RT}{P + \frac{a}{V_m^2}} = 1.3 \times 10^{-4} \text{ m}^3 \text{ mol}^{-1}$$

$$Z = \frac{PV_m}{RT} = 0.67$$

$$b = V_m - \frac{RT}{P + \frac{a}{V_m^2}}$$

$$= \left(4 \times 10^{-4}\right) - \frac{(8.314 \times 288)}{4 \times 10^6 + \left(\frac{0.76}{\left(4 \times 10^{-4}\right)^2}\right)}$$

$b = 1.3 \times 10^{-4}\ m^3\ mol^{-1}$

$b = 4\ N_A \times \frac{4}{3}\pi r_3^3$

$$r = \sqrt[3]{\frac{3b}{16 N_A \pi}}$$

r = 2.35 A

$Z = \frac{3}{8}$ at critical state

$$Z = \frac{\left(4 \times 10^6\right)\left(4 \times 10^{-4}\right)}{(8.3145) \times 288} = 0.67$$

16. Under identical conditions, of temperature and pressure the time taken for effusion of 64 mL of oxygen gas will be same as the time taken for effusion by

(1) 54.6 mL of CO_2 (2) 45.26 mL of SO_2 (3) 50 mL of N_2 (4) 64.6 mL of H_2

Sol. Answer (1, 2)

$$\text{Rate} = \frac{V}{t} \propto \sqrt{\frac{1}{M}}$$

$\therefore\ t \propto V\sqrt{M}$

17. 20 ml each of C_2H_6, C_2H_4 and C_2H_2 at STP form a mixture which is allowed to burn in presence of oxygen. Consider the following statements if the product mixture is brought to STP conditions and select the correct statements (Assume all reactions are 100% complete)

(1) Contraction in volume at the end of the combustion process is equal to 120 ml if oxygen is taken in stoichiometric amount

(2) Contraction in volume at the end of the combustion process is equal to 120 ml if oxygen is taken in excess

(3) If the product mixture is passed through KOH solution, there is a further contraction of 120 ml if oxygen was taken in stoichiometric amount

(4) If oxygen was present in excess and 40 ml CO_2 was also added in the initial combustion mixture, and the product mixture was passed through aq. KOH after cooling it to STP conditions, then the total volume contraction is equal to 220 ml

Sol. Answer (1, 2, 3)

Gaseous hydrocarbons on combustion yield CO_2 and H_2O. Volume contraction due to combustion = $V_{reactants} - V_{products}$. KOH absorbs CO_2.

$$C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2\,CO_2(g) + 3H_2O(l)$$

20 70 40

$$C_2H_4 + 3O_2 \longrightarrow 2\,CO_2 + 2\,H_2O$$

20 60 40

$$C_2H_2 + \frac{5}{2}O_2 \longrightarrow 2\,CO_2 + H_2O$$

20 50 40

Volume contraction = $V_R - V_P$

= (60 + 180) – (120)

= 120 mL

The excess O_2 (if any) will appear on either side and volume contraction will not be affected on passing through KOH, all the CO_2 will be absorbed (120 ml)

∴ Total contraction will be 220 ml

If CO_2 is added initially then total contraction = 260 ml

SECTION - C

Linked Comprehension Type Questions

Comprehension-I

Graham's Law of Diffusion : The phenomenon of spontaneous intermixing of gases against the law of gravitation is known as diffusion. If diffusion occurs through small orifice of the container then it is known as effusion.

The rate of diffusion is expressed as

$$\text{Rate of diffusion} = \frac{\text{Volume of gas diffused}}{\text{Time}} = \frac{\text{Moles of gas diffused}}{\text{Time}} = \frac{\text{Distance travelled by gas}}{\text{Time}} = \frac{K}{\sqrt{M}}$$

M is the molar mass of gas.

1. 100 ml of O_2 gas diffuses in 10 seconds. 100 ml of gas 'x' diffuses in 't' seconds. Gas 'x' and time 't' can be respectively

(1) H_2, 2.5 seconds (2) SO_2, 16 seconds (3) CO, 10 seconds (4) He, 4 seconds

Sol. Answer (1)

$V_{O_2} = 100\,ml$, t_1 = 10 s

V_x = 100 ml, t_2 = ?

$$\Rightarrow \frac{r_{O_2}}{r_x} = \sqrt{\frac{M_x}{M_{O2}}}$$

$\Rightarrow \dfrac{V_{O_2} \times t_x}{V_x \times t_{O_2}} = \sqrt{\dfrac{M_x}{32}}$

$\Rightarrow \dfrac{100 \times t_x}{100 \times 10} = \sqrt{\dfrac{M_x}{32}}$

$\Rightarrow \dfrac{t_x^2}{100} = \dfrac{M_x}{32}$ … (i)

if, t = 2.5

Molecular mass = 2

Then equation (i) will be satisfied.

2. 1 mole of gas H_2 and 4 moles of gas O_2 is taken inside the vessel, which effuse through a small orifice of the vessel having same area of cross section and at the same temperature, then which is the correct % of effused volume of gas H_2 and O_2 initially respectively? (Assume that the gas H_2 does not react with O_2 gas)

(1) 50% & 50% (2) 60% & 40% (3) 30% & 70% (4) 10% & 90%

Sol. Answer (1)

$\dfrac{V_1}{V_2} = \sqrt{\dfrac{M_2}{M_1}}$ $\begin{bmatrix} V_1 \to \text{For } H_2 \\ V_2 \to \text{For } O_2 \end{bmatrix}$

$\Rightarrow \dfrac{V_1}{V_2} = \sqrt{\dfrac{32}{2}}$

$\Rightarrow \dfrac{V_1}{V_2} = 4$

$\therefore$ $V_1 = 4V_2$

3. He and Ar are monoatomic gases and their atomic weights are 4 and 40 respectively. Under similar conditions He will diffuse through semipermeable membrane

(1) 3.16 times as fast as Ar (2) 7.32 times as fast as Ar

(3) 1.58 times as fast as Ar (4) 10 times as fast as Ar

Sol. Answer (1)

$\dfrac{r_1}{r_2} = \sqrt{\dfrac{M_2}{M_1}}$ $\begin{bmatrix} He \to 1 \\ Ar \to 2 \end{bmatrix}$

$\Rightarrow \dfrac{r_1}{r_2}\sqrt{\dfrac{40}{4.0}}$

$\Rightarrow \dfrac{r_1}{r_2} = 3.16$

$\therefore$ $r_1 = 3.16\, r_2$

Comprehension-II

The van der Waal's equation of state for 1 mole real gas is

$$\left[P+\frac{a}{V^2}\right](V-b)=RT$$

The virial equation for 1 mole real gas is as follows:

$$PV=RT\left[1+\frac{x}{V}+\frac{y}{V^2}+\frac{z}{V^3}+\text{......to higher power of n}\right]$$

where x, y and z are constants which are known as second, third and fourth virial coefficients respectively.

The temperature at which real gas obeys ideal gas equation *i.e.,* (PV = nRT) is known as Boyle's temperature.

1. The third virial coefficient of a He gas is 4×10^{-2} (litre/mole)^2 then what will be the volume of 2 mole He gas at NTP?

   (1) 44.4 L (2) 44.6 L (3) 44.8 L (4) 45.2 L

Sol. Answer (4)

$y = 4 \times 10^{-2}$ (third virial coefficient}

$y = b^2$

$\therefore$ b = 0.2 [n = 2 moles]

The volume of 2 moles of He at NTP = 44.8 L

$\therefore$ (V – nb) = 44.8 [n = 2]

$\Rightarrow$ V – 2 $\times$ 0.2 = 44.8

$\therefore$ V = 45.2 L

2. If the critical temperature of the gas be $T_C = \frac{8a}{27Rb}$ and T_B is the Boyle's temperature, then which of the following is correct relation between T_C and T_B?

   (1) $T_C = \frac{8}{27}T_B$ (2) $T_C = \frac{27}{8}T_B$ (3) $T_C = \frac{4}{27}T_B$ (4) $T_C = \frac{27}{4}T_B$

Sol. Answer (1)

$T_C = \frac{8a}{27Rb}$ …(i)

$T_B = \frac{a}{Rb}$ …(ii)

$\therefore T_C = \frac{8}{27}T_B$ …(iii)

3. Which of the following is correct statement about Boyle's temperature (T_B)?

(1) Temperature at which second virial coefficient becomes zero

(2) Temperature at which first virial coefficient becomes zero

(3) The value of T_B is equal to $\frac{a}{Rb}$

(4) Both (1) & (3)

Sol. Answer (4)

B = 0 (First virial coefficient)

$T = T_B$ (Boyle's temperature) $\because B = b - \frac{a}{RT}$

$T_b = \frac{a}{Rb}$ $b = \frac{a}{RT}$

Comprehension-III

In Eudiometric calculations, volume of gases are taken into account on behalf of their moles. We must know the solution which absorbs gases.

(a) CO_2 & SO_3 are absorbed by alkalies.

(b) Cl_2 is by H_2O

(c) O_2 is by alkaline pyrogallol

(d) O_3 is by terpentine oil.

(e) NO gas by acidified $FeSO_4$

(f) NH_3 gas by acids and $CuSO_4$ solution.

20 ml of mixture of CH_4 and a gaseous compound of alkyne series were mixed with 100 ml O_2 and exploded. The volume of product after cooling to original room temperature and pressure was 80 ml and on treatment with KOH solution a contraction of 40 ml in volume was observed.

1. What volume of O_2 was used in the above process?

(1) 100 ml (2) 60 ml (3) 40 ml (4) 80 ml

2. The volume of CO_2 formed in the above process was

(1) 80 ml (2) 60 ml (3) 40 ml (4) 10 ml

3. The molecular formula of alkyne is

(1) C_3H_4 (2) C_4H_6 (3) C_2H_2 (4) C_5H_8

Solution of Comprehension-III

1. Answer (2)

2. Answer (3)

3. Answer (1)

$$\underset{x\,ml}{CH_4} + \underset{2x\,ml}{2O_2} \longrightarrow \underset{x\,ml}{CO_2} + 2H_2O$$

$$\underset{20-X}{C_nH_{2n-2}} + \underset{(20-x)\left(\frac{3n-1}{2}\right)}{\frac{3n-1}{2}O_2} \longrightarrow nCO_2 + (n-1)H_2O$$

Volume of CO_2 formed = $x + (20-x)n = 40$ … (i)

Volume of O_2 used = $2x + (20-x)\left(\frac{3n-1}{2}\right)$

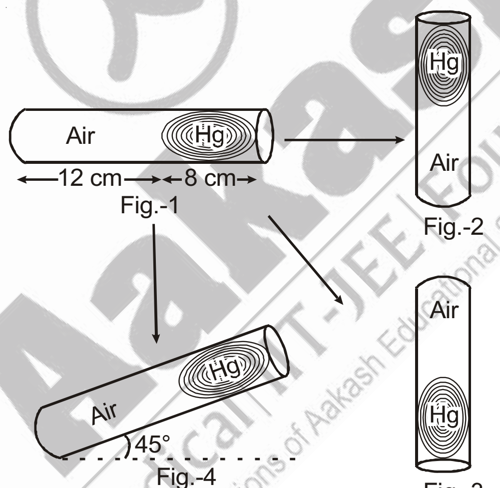
O_2 remaining = $100 - 2x - (20-x)\frac{3n-1}{2} = 40$

$\Rightarrow$ $60 = 2x + (20-x)\frac{(3n-1)}{2}$ … (ii)

Solving (i) and (ii), x = 10 and n = 3

Comprehension-IV

All the tubes are of equal and uniform area of cross section.



1. Find the length of air column trapped in Fig. 2.

(1) 10.85 cm (2) 11.25 cm (3) 12.85 cm (4) 11.75 cm

Sol. Answer (1)

$P_1 l_1 a = P_2 l_2 a$

$\Rightarrow$ 76 × 12 = (76 + 8) l_2

$\Rightarrow$ $l_2 = \frac{76 \times 12}{84} = 10.85$

2. The length of air column in Fig.3. when the open end is placed vertically down is

(1) 10.85 cm (2) 11.41 cm (3) 12.85 cm (4) 13.41 cm

Sol. Answer (4)

$P_1 l_1 a = P_2 l_2 a$, here the open and down.

$76 \times 12 = (76 - 8)\ l_2$

$l_2 = \dfrac{76 \times 12}{68} = 13.41$

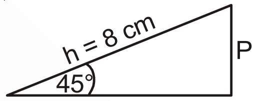
3. When the tube is held at an angle of 45° to the plane with open end up, what should be the length of air column?

(1) 12 cm (2) 11.17 cm (3) 11.0 cm (4) 10.8 cm

Sol. Answer (2)

P = 8 sin 45.

Pressure on air when tube is placed by 45° inclined plane



is $P_2 = 76 + 8 \sin 45 = 76 + \dfrac{8}{\sqrt{2}}$

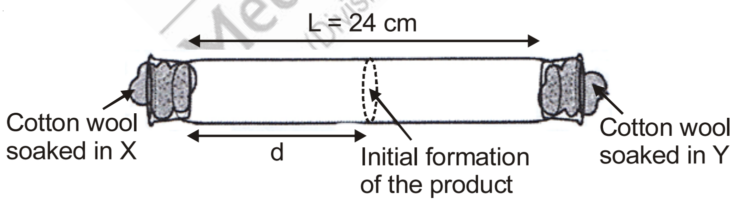
So, $P_1 l_1 a = P_2 l_2 a$,

$\Rightarrow 76 \times 12 = \left(76 + \dfrac{8}{\sqrt{2}}\right) l_2$

$\Rightarrow l_2 = \dfrac{912}{76 + \dfrac{8}{\sqrt{2}}} = \dfrac{912}{81.65} = 11.169$ cm

Comprehension-V

X and Y are two volatile liquids with molar weights of 10 g mol^{-1} and 40 g mol^{-1} respectively. Two cotton plugs, one soaked in X and the other soaked in Y, are simultaneously placed at the ends of a tube of length L = 24 cm, as shown in the figure. The tube is filled with an inert gas at 1 atmosphere pressure and a temperature of 300 K. Vapours of X and Y react to form a product which is first observed at a distance d cm from the plug soaked in X. Take X and Y to have equal molecular diameters and assume ideal behaviour for the inert gas and the two vapours.



1. The value of d in cm (shown in the figure), as estimated from Graham's law, is

(1) 8 (2) 12 (3) 16 (4) 20

Sol. Answer (3)

$$\frac{x}{24-x} = \sqrt{\frac{40}{10}}$$

$$\frac{x}{24-x} = 2$$

x = 16

2. The experimental value of d is found to be smaller than the estimate obtained using Graham's law. This is due to

(1) Larger mean free path for X as compared to that of Y

(2) Larger mean free path for Y as compared to that of X

(3) Increased collision frequency of Y with the inert gas as compared to that of X with the inert gas

(4) Increased collision frequency of X with the inert gas as compared to that of Y with the inert gas

Sol. Answer (4)

Increased collision frequency of X with the inert gas as compared to that of y with the inert gas. Therefore, the experimental value of d is found to be smaller than the estimate obtained using Graham's law.

SECTION - D

Matrix-Match Type Questions

1. Match the following

Column-I	**Column-II**
(A) Rate of diffusion	(p) Directly proportional to pressure of gas
(B) Partial pressure of gas in a closed vessel	(q) Directly proportional to mole fraction
(C) Kinetic energy of gas	(r) Inversely proportional to square root of molecular mass
(D) Average velocity	(s) Increases with temperature

Sol. Answer A(p, q, r, s), B(q, s), C(s), D(r, s)

(A) $r \propto p$

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

or $r \propto \frac{p}{\sqrt{d}}$ [M = 2 × d]

$$\therefore \frac{r_1}{r_2} = \frac{p_1}{p_2}\sqrt{\frac{M_2}{M_1}}$$

and $r = \frac{\text{volume}}{\text{time}}$

or $r = \frac{\text{moles}}{\text{time}}$

$\therefore$ $r \propto$ mole fraction

(B) Partial pressure = mole fraction × total pressure

$p_A = x_A \times p$

and $p_A = C_A RT$

(C) KE $\propto$ T (Kinetic theory of gases)

(D) $u_{Ar} = \sqrt{\dfrac{8RT}{\pi M}}$

2. Match the following

	Column-I		Column-II
(A)	Force of attraction is dominating	(p)	$Z < 1$
(B)	Force of repulsion is dominating	(q)	$Z > 1$
(C)	Volume of gas molecules is negligible	(r)	$PV = RT + Pb$
(D)	Pressure of CH_4 gas is low	(s)	$PV = RT - \dfrac{a}{V}$

Sol. Answer A(p, s), B(q, r), C(p, s), D(p, s)

(A) $\left(p + \dfrac{a}{V^2}\right)(V - b) = RT$ ...(i)

If force of attraction is dominating

$V - b \cong V$

$\therefore$ $pV = \dfrac{a}{V} = RT$ ...(ii)

and $\dfrac{pV}{RT} + \dfrac{a}{VRT} = 1$

$Z = 1 - \dfrac{a}{VRT}$

$\therefore$ $Z < 1$

and from equation (i),

$\left(pV = RT - \dfrac{a}{V}\right)$

(B) When repulsion is dominating

$p + \dfrac{a}{V^2} \cong p$

From equation (i)

$p(V - b) = RT$

$pV - pb = RT$ ...(iii)

$pV = RT + pb$

or $\frac{pv}{RT} = 1 + \frac{pb}{RT}$

$\therefore\ Z = 1 + \frac{pb}{RT}$

$\therefore\ Z > 1$

(C) Similar to part 'a'

$Z < 1$

$pV = RT - \frac{a}{V}$

(D) Similar to part 'a'

at low pressure

$V - b \cong V$

3. Match the following

Column-I	**Column-II**
(A) Molar volume of gas	(p) Temperature dependent
(B) Translational K.E. of gas molecules	(q) Temperature independent
(C) Vapour density of gas	(r) Pressure dependent
(D) Density of a gas	(s) Pressure independent

Sol. Answer A(p, r), B(p), C(q, s), D(p, r)

(A) $Z = \frac{V_{molar}}{V_{ideal}}$

$V_m = Z\ V_{ideal}$

$V_m = \frac{ZnRT}{p}$

(B) According to kinetic theory of gases,

$KE = \frac{2}{3}RT$ …(i)

or $KE \propto T$

(D) $pV = nRT$

$p \propto d$ [T = constant]

4. Match the following

Column-I	**Column-II**
(A) $P \propto \frac{1}{V}$ at constant T and n	(p) Charle's law
(B) Partial pressure $\propto$ mole fraction of gas in mixture	(q) Boyle's law
(C) $V \propto T$ at constant P and n	(r) Avogadro's law
(D) $V \propto n$ at constant T and P	(s) Dalton's law

(where n = number of moles of gas)

Sol. Answer A(q), B(s), C(p), D(r)

(A) Boyle's law

$V \propto \frac{1}{P}$ [T = constant]

(B) $P_A = x_A \times P_{total}$

(C) Charles law

$V \propto T$ (P = constant)

(D) Avogadro's law

$V \propto n$ (T & P = constant)

5. Match the following

Column-I	**Column-II**
Real gases	**Characteristics**
(A) CO_2	(p) At room temperature have Z < 1 for moderate pressure
(B) NH_3	(q) $Z = 1 + \frac{Pb}{RT}$ at high pressure
(C) SO_2	(r) $Z = 1 - \frac{a}{RTV}$ at low pressure
(D) He	(s) At room temperature have Z > 1 for moderate pressure
	(t) Reaches ideality at extremely low pressure & very high temperature.

Sol. Answer A(p, q, r, t), B(p, q, r, t), C(p, q, r, t), D(q, s, t)

Inversion temperature of He is very low.

6. Match the following

Column-I	**Column-II**
(A) Boyle's Law	(p) $P \propto 1/V$ at constant (T, n)
(B) Root mean square velocity	(q) Isothermal process
(C) Graham's Law	(r) Application in successive diffusion
(D) Collision frequency	(s) Directly related to pressure
	(t) Inversely related to square root of density

Sol. Answer A(p, q), B(t), C(q, r, s, t), D(t)

Boyle's law, $V \propto \frac{1}{P}$ (n and t constant)

Root mean square velocity $= \sqrt{\frac{3RT}{M}}$

Graham's law of diffusion.

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

$\propto \sqrt{T}$

$\propto P$

Collision frequency $z = \sqrt{2}\,\pi\,\sigma^2 CN*$

Where $N^* = \frac{N}{V}$ = Number of molecules per unit volume

7. Match the following on the basis of their absorption

Column-I	Column-II
(A) Absorbed by alkali	(p) O_2
(B) Absorbed by turpentine oil	(q) O_3
(C) Absorbed by alkaline pyrogallol	(r) SO_2
(D) Absorbed by acidified $FeSO_4$	(s) NO
	(t) CO_2

Sol. Answer A(r, t), B(q), C(p), D(s)

Fact based

8. Match the following

Column-I	Column-II
(A) Boyle's temperature T_B	(p) $2T_B$
(B) Inversion temperature T_i	(q) $\frac{8a}{27\,Rb}$
(C) Critical temperature T_c	(r) $\frac{a}{Rb}$
(D) Critical pressure P_c	(s) $\frac{2a}{Rb}$
	(t) $\frac{a}{27b^2}$

Sol. Answer A(r), B(p,s), C(q), D(t)

Fact based

SECTION - E

Assertion-Reason Type Questions

1. STATEMENT-1 : Ideal gas cannot be liquefied even by attaining 0.003 K with the help of adiabatic demagnetization.

and

STATEMENT-2 : The van der Waal's constant 'a' is negligible for ideal gas and molecules are assumed as point masses.

Sol. Answer (1)

In adiabatic demagnetization, $\Delta H = 0$ and force of attraction between gas molecules is negligible when it considered as point mass. (Ideal gas)

2. STATEMENT-1 : At constant temperature, the gas density is directly proportional to pressure.

and

STATEMENT-2 : More is the pressure on the gas, the denser it becomes.

Sol. Answer (2)

$PV = nRT$

$\therefore PM = dRT$

$P \propto d$ $(T \rightarrow \text{Constant})$

3. STATEMENT-1 : Compressibility factor for hydrogen and helium varies with pressure with positive slope at all pressures.

and

STATEMENT-2 : Even at low pressures, repulsive forces dominate in hydrogen and helium gas.

Sol. Answer (1)

H_2 and He, show only positive deviations ($z > 1$) from ideality and these gases are less compressible than expected.

4. STATEMENT-1 : The value of van der Waal's constant a is higher for ammonia than for nitrogen.

and

STATEMENT-2 : Intramolecular hydrogen bonding is present in ammonia.

Sol. Answer (3)

$$P = \frac{an^2}{V^2}$$

NH_3 has intermolecular hydrogen bonding, which increases the value of 'a'.

5. STATEMENT-1 : N_2 and CO at same condition of temperature and pressure have same root mean square velocity and same average velocity.

and

STATEMENT-2 : Root mean square velocity lies between average velocity and most probable velocity.

Sol. Answer (3)

N_2 and CO both has similar molecular mass. Therefore, both has same r.m.s. and average velocity

$u_{rms} > u_{av} > u_{mp}$

6. STATEMENT-1 : Rate of diffusion of oxygen is higher than nitrogen gas.

and

STATEMENT-2 : The molecular size of oxygen is smaller than nitrogen.

Sol. Answer (4)

$$\frac{r_{O_2}}{r_{N_2}} = \sqrt{\frac{M_{N_2}}{M_{O_2}}}$$

$$\therefore \frac{r_{O_2}}{r_{N_2}} = \sqrt{\frac{28}{32}}$$

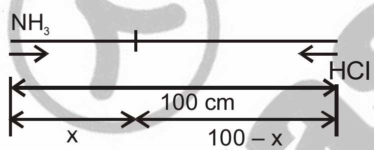
$$r_{O_2} = 0.93\ r_{N_2}$$

7. STATEMENT-1 : A bottle of dry ammonia and a bottle of dry hydrogen chloride connected through a long tube are opened simultaneously at both ends, the white ammonium chloride ring first formed will be near the hydrogen chloride bottle.

and

STATEMENT-2 : Rate of diffusion is inversely proportional to molecular mass.

Sol. Answer (3)



$$\frac{r_{NH_3}}{r_{HCl}} = \sqrt{\frac{M_{HCl}}{M_{NH_3}}}$$

$$\frac{r_{NH_3}}{r_{HCl}} = \sqrt{\frac{36.5}{17}}$$

$$\frac{V_{NH_3}}{V_{HCl}} = 1.46$$

$$\frac{l_{NH_3}}{l_{HCl}} = 1.46$$

$$\frac{x}{100 - x} = 1.46$$

$$\frac{100}{x} - 1 = \frac{1}{1.46}$$

$$\frac{100}{x} = 1.68$$

$$x = \frac{100}{1.68}$$

x = 59.52 cm

$\therefore$ From HCl side

Distance = 100 – 59.52 = 40.48 cm

8. STATEMENT-1 : Ethanol have higher vapour pressure than water at 350 K.

and

STATEMENT-2 : Ethanol have weaker intermolecular interactions than water

Sol. Answer (1)

In H_2O strong H–bonding is present.

9. STATEMENT-1 : Boyle's law is limiting law.

and

STATEMENT-2 : Boyle's law is not valid for every range of temperature and pressure.

Sol. Answer (1)

Fact

10. STATEMENT-1 : Below critical temperature a gas is called vapour.

and

STATEMENT-2 : Vapour pressure is independent from volume.

Sol. Answer (2)

Vapour pressure is measured at equilibrium.

11. STATEMENT-1 : Viscosity of liquid depend on temperature.

and

STATEMENT-2 : Viscosity of H_2O_2 is more than H_2O.

Sol. Answer (2)

SECTION - F

Integer Answer Type Questions

1. Pressure of 1 g of an ideal gas 'X' at 27°C is 2P bar. When 2 g of another ideal gas 'Y' is introduced into the same flask at same temperature, the pressure becomes 1.5 times. How many times is molar mass of Y as compared to X?

Sol. Answer (4)

Since, V and T are constant, we have,

$$\frac{P_1}{n_1} = \frac{P_2}{P_2}$$

$$\frac{P_1M_1}{w_1} = \frac{P_2M_2}{w_2}$$

$$\frac{2P \times M_1}{1} = \frac{P \times M_2}{2} \qquad \Rightarrow \frac{M_2}{M_1} = 4$$

2. One mole of N_2 gas at 0.8 atm, takes 38 seconds to diffuse through a pin hole where as one mole of an unknown compound of xenon with fluorine at twice the pressure of N_2 takes 55 seconds to diffuse through the same pin hole. How many lone pairs are around xenon in xenon fluoride compound? (Given atomic masses Xe = 121 u, F = 19 u)

Sol. Answer (1)

$$\frac{r_1}{r_2} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}$$

$$\frac{r_1}{r_2} = \frac{t_2}{t_1} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}} = \frac{57}{38} = \frac{0.8}{1.6}\sqrt{\frac{M_2}{28}} \quad \text{or} \quad M_2 = 252$$

Hence; $XeF_n = 252$ or $121 + 19n = 252$ or $n = 6$ so $:XeF_6$

3. 100 ml of an O_3, O_2 mixture was passed through turpentine and reduction of 18 ml took place in volume. If 100 ml of this mixture is heated then what will be increase in volume in ml?

Sol. Answer (9)

Turpentine absorbs O_3

Now, volume of O_2 = 100 – 18 = 82 ml

volume of O_3 = 18 ml

$2O_3 = 3O_2$

$O_3 = 3/2\ O_2$

1 ml = 3/2 ml

20 ml = 27 ml

Total volume of O_2 = 82 + 27 = 109 ml, Hence increase = 109 – 100 = 9 ml.

4. Two vessels of volume 2V and 3V contain gases A and B separately at 1.5 and 4 atm respectively. If the vessels are connected through a tube at constant temperature, then what will be total pressure of gaseous mixture?

Sol. Answer (3)

$PV = P_1V_1 + P_2V_2$

$P \times 5V = 1.5 \times 2V + 4 \times 3V$

P = 3 atm.

5. Under identical conditions of temperature, the density of a gas X is twice that of gas Y while molecular mass of gas 'Y' is thrice that of X. What will be ratio of pressure of X and Y?

Sol. Answer (6)

$P_x = d_x\ RT/M_x$

$P_y = d_y\ RT/M_y$

Now, $\frac{P_x}{P_y} = \frac{d_x}{d_y} \times \frac{M_y}{M_x} = 6$

6. A spherical glass bulb of radius 100 cm contains a concentric rubber balloon that contains some N_2 gas and the remaining space in glass bulb contains 50 g H_2. In the given condition, radius of the rubber balloon was found to be 40 cm. Now, the seal of glass bulb was opened and 26 g $H_2(g)$ was further added and resealed. Assuming constant temperature through out, if the radius of rubber balloon in the new conditions is 7*x*, then what is x?

Sol. Answer (5)

In case-I : $P_{H_2} = P_{N_2}$

$$\Rightarrow \frac{V_{H_2}}{n_{H_2}} = \frac{V_{N_2}}{n_{N_2}}$$

$$\Rightarrow \frac{\frac{4}{3}\pi(100^3 - 40^3)}{25} = \frac{\frac{4}{3}\pi 40^3}{n_{H_2}}$$

$$\Rightarrow n_{H_2} = 1.7 \text{ mole}$$

In case-II : Some extra H_2 was introduced in glass bulb to the rubber balloon will contract

Ultimately $P_{H_2} = P_{N_2}$

$$\Rightarrow \frac{V_{H_2}}{n_{H_2}} = \frac{V_{N_2}}{n_{N_2}}$$

$$\Rightarrow \frac{\frac{4}{3}\pi(100^3 - x^3)}{38} = \frac{\frac{4}{3}\pi r^3}{1.7}$$

$$\Rightarrow x = 35.08 \approx 35 = 7 \times 5$$

7. Equation of state for a gas is

$$P = \frac{RT}{V_m} - \frac{B}{V_m^2} + \frac{C}{V_m^3}$$

Where B and C are constant. the value of critical compression factor is x. The value of 6x is

Sol. Answer (2)

$$P = \frac{RT}{V_m} - \frac{B}{V_m^2} + \frac{C}{V_m^3}$$

at critical point

$$\frac{dP}{dV} = 0, \frac{d^2P}{dV^2} = 0$$

$$Z = \frac{P_C V_C}{RT_C} V_C = \frac{3C}{B}$$

$$T_C = \frac{B^2}{3RC}$$

$$P_C = \frac{B^3}{27C^2}$$

$$\text{So } Z_C = \frac{1}{3}$$

8. A mixture of N_2 and O_2 has a density of 1.00 g/litre and the average molecular weight is y g/mole at 27ºC and 600 mm Hg pressure. The mole fraction of nitrogen is x × 10^{-2}. Find the value of x. $\left(R = 0.08\,\frac{\text{atm L}}{\text{mol K}}\right)$

Sol. Answer (40)

PM = dRT

Molar mass of mixture = M

$$P = \frac{dRT}{M} \Rightarrow \frac{600}{760} = \frac{1\times 0.08\times 300}{M}$$

$\Rightarrow$ M = 30.4 gm/mole

mol of N_2 = x, mole of O_2 = 1 – x

30.4 = 32 (1 – x) + 28 (x)

x = 0.4

9. x ml of pure O_2 diffused through an aperture in 200 second. Whereas x ml of mixture of O_2 and unknown gas diffuses from the same aperture in 232 second. Calculate the molar mass of gaseous mixture (in nearest integer).

Sol. Answer (43)

$$\text{Rate of diffusion} \propto \frac{1}{\sqrt{\text{Molar mass}}}$$

Now for diffusion of gaseous mixture and pure O_2.

$$\frac{r_{O_2}}{r_{mix}} = \sqrt{\frac{M_{mix}}{M_{O_2}}}$$

$$\text{(or) } \frac{V_{O_2}}{V_M}\times\frac{T_M}{T_{O_2}} = \sqrt{\frac{M_{Mix}}{M_{O_2}}}$$

$$\frac{1}{1}\times\frac{232}{200} = \sqrt{\frac{M_{mix}}{32}}$$

$\therefore$ M_{mix} = 43

10. Calculate the pressure exerted (nearest integer) by 4 mole of CO_2 in one litre vessel at 37ºC using van der Waal's equation. Given that, a = 3.592 atm litre^2 mole^{-2}, b = 0.0427 litre/mole $\left(R = 0.0821\,\frac{\text{atm L}}{\text{mol K}}\right)$

Sol. Answer (65)

Given n = 4 moles, V = 1 L, T = 37 + 273 = 310 K

a = 3.592 : b = 0.0427

using van der Waal's equation for 4 moles

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

$$\left(P+\frac{4^2\times 3.592}{1}\right)(1-4\times 0.0427)=4\times 0.0821\times 310$$

P = 65.3 ≈ 65 atm

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