PHYSICAL CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 31

Total Marks : 30

Max. Time : 30 min.

Topic : Gaseous State

Type of Questions		M.M., Min.
Comprehension ('–1' negative marking) Q.1 to Q.6	(3 marks, 3 min.)	[18, 18]
Single choice Objective ('–1' negative marking) Q.7 to Q.10	(3 marks, 3 min.)	[12, 12]

Comperhension # (Q.1 to Q.3)

Gas 'A' (Molar Mass = z128 g mol^{-1}) is taken in a closed container at the initial total pressure of 1000 mm of Hg. Pressure of the gas decreases to 900 torr in 5 seconds due to the diffusion though a square cross-section. Another similar sized container is taken in which gaseous mixture of A and B (Molar Mass = 72g mol^{-1}) is taken. Initial molar mass of the mixture is $\frac{472}{5}$ (calculated from density data) at the total pressure of 5000 torr. A rectangular cross-section is made in this container and gases are allowed to diffuse. Width of this cross-section is same as the side of the previous square cross section and length of the rectangular cross-section is 50% more than that of its width. Assume that the gases A and B are non-reacting and rate of diffusion of the gases are only dependent upon the initial total pressure and it is independent of the change in the pressure due to diffusion. Assume all other conditions to be identical.

Now answer the following questions :

1. Gas mixture diffused out initially from 2nd container has composition :

(A) $X_A = \frac{3}{7}$ (B) $X_B = \frac{3}{5}$ (C) $X_A = \frac{1}{3}$ (D) $X_B = \frac{1}{4}$

2. Ratio of the number of moles of A and B left in the container after 10 seconds from the start of diffusion, is :

(A) $\frac{7}{9}$ (B) $\frac{2}{3}$ (C) $\frac{8}{11}$ (D) None of the above

3. What is the time after which container will have same number of moles of A and B :

(A) 15 sec. (B) 50 sec. (C) 25 sec. (D) $\frac{50}{3}$ sec.

Comperhension # (Q.4 to Q.6)

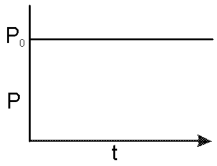
Graham's law tells as about rate of effusion or diffusion of gases. In modern form, it simply states that the rate of effusion or diffusion of any ideal gas is inversely proportional to square root of its molar mass.

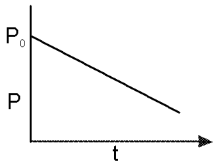
$$\frac{r_1}{r_2} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}$$

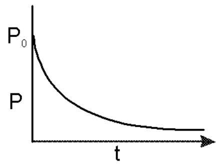
Also, rate of effusion of a gas mixture is simply the sum of rates of effusion of individual gases, since ideal gases do not affect each other.

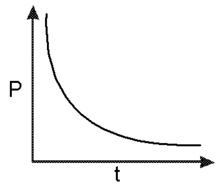
Now answer the following questions :

4. 10 moles of N_2 gas are placed in a vessel of constant volume and temperature. A hole is punctured in the vessel and left in vacuum. The pressure of N_2 in the vessel will vary with time as :

(A) 

(B) 

(C) 

(D) 

5. If a mixture of (80 mol %) He and (20 mol%) SO_2 is taken in an isothermal isochoric vessel, as the gases leak through a small hole in the vessel, when placed in vacuum :

(A) Average molar mass of gas mixture left in vessel increases with time.

(B) Average molar mass of gas mixture left in vessel remains same with time.

(C) Average molar mass of gas mixture left in vessel decreases with time.

(D) Variation of M_{avg} with time depends on temperature as well as area of hole, so it cannot be commented upon, in general.

6. In the previous question, what will be the rate of effusion of the initial gas mixture relative to D_2 under same conditions of total pressure and temperature :

(A) 1/2 (B) 0.29 (C) 2 (D) 0.85

7. A helium atom is two times heavier than a hydrogen molecule. At 298 K, the average translational kinetic energy of helium is :

(A) two times that of hydrogen molecule (B) same as that of hydrogen molecule

(C) four time that of hydrogen molecule (D) half that of hydrogen molecule

8. At what temperature, will hydrogen molecules have the same average translational kinetic energy as nitrogen molecules have, at 35°C?

(A) $\left(\frac{28\times 35}{2}\right)$°C (B) $\left(\frac{2\times 35}{28}\right)$°C (C) $\left(\frac{2\times 28}{35}\right)$°C (D) 35 °C

9. Average translational K.E. of one mole of helium gas at 273 K in calories is :

(A) 819 Cal (B) 81.9 Cal (C) 8.19 Cal (D) None of these

10. Average translational kinetic energy of 14 grams of nitrogen gas at 127°C is nearly : (mol. mass of nitrogen = 28 and gas constant = 8.3 J/mol/K)

(A) 4980 J (B) 1660 J (C) 2490 J (D) 9960 J

Answer Key

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1.	(C)	**2.**	(A)	**3.**	(D)	**4.**	(C)	**5.**	(A)
6.	(D)	**7.**	(B)	**8.**	(D)	**9.**	(A)	**10.**	(C)

Hints & Solutions

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1. $\dfrac{n_A/t}{n_B/t} = \dfrac{P_A}{P_B}\sqrt{\dfrac{M_B}{M_A}}$

$\Rightarrow \quad \dfrac{x_A}{x_B} = \dfrac{2}{3}\sqrt{\dfrac{72}{128}} = \dfrac{1}{2}$

$\Rightarrow \quad X_A = \dfrac{1}{3}, X_B = \dfrac{2}{3}$

$\dfrac{n_1M_1 + n_2M_2}{x_1 + x_2} = M_{mix}$

$X_1M_1 + (1 - X_1)M_2 = M_{mix}$

$\Rightarrow X_1 = \dfrac{2}{5}, X_2 = \dfrac{3}{5}$

2. Initially $r_A = \dfrac{1000 - 900}{5} = 20$ torr/s

In the mix.

$M_{mix} = X_AM_A + (1 - X_A)M_B$

$\Rightarrow \quad \dfrac{472}{5} = X_A \times 128 + (1 - X_A)72$; $\dfrac{472}{5} = 56X_A + 72$

$472 = 280X_A + 360$; $X_A = \dfrac{112}{280} = \dfrac{2}{5}, X_B = \dfrac{3}{5}$

The mix.

$$\frac{r_A}{r'_A} = \frac{P_A.'A_1'}{P_A'A_2}$$; $$\frac{r_A}{r_{A'}} = \frac{1}{2} \times \frac{x^2}{x \times \frac{3x}{2}} = \frac{1}{3}$$

$r_A' = 3r_A = 3 \times 20 = 60$ torr/s ; $$\frac{r'_{A^0}}{r'_{B^0}} = \frac{P'_A}{P'_B}\sqrt{\frac{M_B}{M_A}} = \frac{2}{3} \times \sqrt{\frac{72}{128}} = \frac{1}{2}$$

$r_B' = 120$ torr/s

After 10 sec

$P_A'' = 2000 - 60 \times 10 = 1400$ torr ; $P_B'' = 3000 - 120 \times 10 = 1800$ torr

$$\frac{n''_A}{n''_B} = \frac{7}{9}$$

3. $2000 - 60t = 3000 - 120t$

$60t = 1000 \Rightarrow t = \frac{50}{3}$ sec.

6. $$\frac{r_{mix}}{r_{D_2}} = \frac{r_{He} + r_{SO_2}}{r_{D_2}} = \frac{r_{He}}{r_{D_2}} + \frac{r_{SO_2}}{r_{D_2}} = \frac{P_{He}}{P_{D_2}}\sqrt{\frac{M_{D_2}}{M_{He}}} + \frac{P_{SO_2}}{P_{D_2}}\sqrt{\frac{M_{D_2}}{M_{SO_2}}}$$

$$\therefore \quad \frac{r_{mix}}{r_{D_2}} = \frac{0.8}{1}\sqrt{\frac{4}{4}} + \frac{0.2}{1}\sqrt{\frac{4}{64}} = 0.8 + \frac{0.4}{8} = 0.85$$

7. $$K.E. = \frac{1}{2} M\overline{C}^2$$

Now for the helium atom, $K.E. = \frac{1}{2} M_{He}\, \overline{C}^2 = \frac{1}{2} M_{He} \times \frac{3RT}{M_{He}} = \frac{3}{2} RT$;

Again for H_2 molecules; $KE = \frac{1}{2} M_{H_2} \overline{C^2} = \frac{1}{2} \times M_{H_2} \times \frac{3RT}{M_{H_2}} = \frac{3}{2} RT$

$\therefore$ K.E. of H_2 molecules is same as it is for H_2 molecules.