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Liquid Solution PYQS-2022

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SOLUTIONS - JEE-MAINS (2022) PYQS

1. The depression in freezing point observed for a formic acid solution of concentration $0.5\ \mathrm{mL\ L^{-1}}$ is $0.0405^{\circ}\mathrm{C}$. Density of formic acid is $1.05\ \mathrm{g\ mL^{-1}}$. The Van't Hoff factor of the formic acid solution is nearly :(Given for water $\mathrm{k_f = 1.86\ K\ kg\ mol^{-1}}$)

(A) 0.8 **(B)** 1.1 **(C)** 1.9 ✓ **(D)** 2.4

$\Delta T_f = i \times K_f \times m$

mass of formic acid solution $= V \times d$
$= 0.5 \times 1.05$
$= .525\ g$ in 1 L.

molality $= \frac{.525}{46}$

$\Delta T_f = 0.0405 = \frac{i \times 1.86 \times .525}{46}$

$i = \frac{0.0405 \times 460}{.525 \times 1.86} = \frac{405 \times 460}{525 \times 186}$

$i = 1.90$

2. Two solutions A and B are prepared by dissolving 1 g of non-volatile solutes X and Y. respectively in 1 kg of water. The ratio of depression in freezing points for A and B is found to be $1:4$. The ratio of molar masses of X and Y is:

(A) $1:4$ **(B)** $1:0.25$ ✓ **(C)** $1:0.20$ **(D)** $1:5$

$$\frac{\Delta T_{f_A} = i \times K_{f_A} \times m_A}{\Delta T_{f_B} = i \times K_{f_A} \times m_B}$$

$$\frac{1}{4} = \frac{m_A}{m_B} = \frac{w_A}{M_A} \times \frac{M_B}{w_B}$$

↳ molality

$$\frac{1}{4} = \frac{M_B}{M_A} \longrightarrow \text{molar mass}$$

$$\frac{1}{4} = \frac{Y}{X}$$

$$\frac{X}{Y} = \frac{4}{1}$$

3. Boiling point of a 2% aqueous solution of a nonvolatile solute A is equal to the boiling point of 8% aqueous solution of a non-volatile solute B. The relation between molecular weights of A and B is.

(A) $M_A = 4M_B$ **(B)** $M_B = 4M_A$ **(C)** $M_A = 8M_B$ **(D)** $M_B = 8M_A$

$\Delta T_A = i \times K_b \times \frac{2}{M_A \times 98} \times 1000$

$\Delta T_B = i \times K_b \times \frac{8}{M_B \times 92} \times 1000$

$\frac{8}{M_B \times 92} \times 1000 = \frac{2}{M_A \times 98} \times 1000$

$M_B \times 23 = M_A \times 98$

$B = 4 M_A$ (nearest)

4. Solute A associates in water. When 0.7 g of solute A is dissolved in 42.0 g of water, it depresses the freezing point by $0.2°C$. The percentage association of solute A in water, is [Given : Molar mass of $A = 93$ g mol^{-1}. Molal depression constant of water is 1.86 K kg mol^{-1}]

(A) 50% **(B)** 60% **(C)** 70% **(D)** 80%

$\Delta T_f = i \times K_f \times m$

$0.2 = i \times 1.86 \times \frac{.7}{42 \times 93} \times 1000$

$i = \frac{42 \times 93 \times .2}{.7 \times 1.86 \times 1000}$

$= \frac{84 \times 93}{7 \times 186} \times .1$

$i = .6$

$2A \rightleftharpoons A_2$

$1 \quad 0$

$1-\alpha \quad \alpha/2$

$1-\alpha+\alpha/2 = .6$

$1-\alpha/2 = .6$

$\alpha = .80$

$\alpha = 80\%$

5. When a certain amount of solid A is dissolved in $100\ \mathrm{g}$ of water at $25^{\circ}\mathrm{C}$ to make a dilute solution, the vapour pressure of the solution is reduced to one-half of that of pure water. The vapour pressure of pure water is $23.76\ \mathrm{mmHg}$. The number of moles of solute A added is . (Nearest Integer) Assume moles of A to be less than moles of B

exact

$$\frac{P_A^{\circ} - P_A}{P_A} = \frac{n_B}{n_A}$$

$$\frac{23.76 - \frac{23.76}{2}}{\frac{23.76}{2}} = \frac{n_B \times 18}{100}$$

$$n_B = \frac{100}{18} = 5.55$$

(not exact)

$$\frac{P_A^{\circ} - P_A}{P_A^{\circ}} = \frac{n_B}{n_A}$$

$$\frac{23.76 - \frac{23.76}{2}}{23.76} = \frac{n_B \times 18}{100}$$

$$\frac{23.76}{2 \times 23.76} = \frac{n_B}{5.55}$$

$$n_B = \frac{5.55}{2} = 2.78$$

$$= 3$$

6. $150\ \mathrm{g}$ of acetic acid was contaminated with $10.2\ \mathrm{g}$ ascorbic acid $(C_6H_8O_6)$ to lower down its freezing point by $(x \times 10^{-1})^{\circ}\mathrm{C}$. The value of x is (Nearest integer) [Given $K_f = 3.9\ \mathrm{K\ kg\ mol^{-1}}$; Molar mass of ascorbic acid $= 176\ \mathrm{g\ mol^{-1}}$]

15

$$\Delta T_f = i \times K_f \times m$$

$$= 1 \times 3.9 \times \frac{10.2}{176 \times 150} \times 1000$$

$$= 1.50 = 15 \times 10^{-1}$$

7. A gaseous mixture of two substances A and B, under a total pressure of 0.8 atm is in equilibrium with an ideal liquid solution. The mole fraction of substance A is 0.5 in the vapour phase and 0.2 in the liquid phase. The vapour pressure of pure liquid A is atm. (Nearest integer)

(2)

$P_T = .8 \text{ atm}$

$Y_A = .5 \quad Y_B = .5$

$X_A = .2 \quad X_B = .8$

$$Y_A = \frac{X_A P_A^0}{P_T}$$

$$0.5 = \frac{0.2 \times P_A^0}{.8}$$

$$P_A^0 = \frac{.5 \times 8}{2} = 2 \text{ atm}$$

8. If O_2 gas is bubbled through water at $303\ \mathrm{K}$, the number of millimoles of O_2 gas that dissolve in 1 litre of water is . (Nearest Integer) (Given : Henry's Law constant for O_2 at $303\ \mathrm{K}$ is $46.82\ \mathrm{k}$ bar and partial pressure of $O_2 = 0.920$ bar) (Assume solubility of O_2 in water is too small, nearly negligible)

(1)

$$P_A = K_H X_A$$

$$0.920 = 46.82 \times \frac{n_{O_2}}{n_{H_2O}}$$

$$.920 = 46.82 \times \frac{n_{O_2}}{\frac{1000}{18}}$$

$$n_{O_2} = \frac{.920 \times 1000}{46.82 \times 18}$$

$$= 1.09 \times 10^{-3} \text{ moles}$$

$$= 1 \text{ milimole.}$$

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9. ' x ' g of molecular oxygen (O_2) is mixed with 200 g of neon (Ne). The total pressure of the non- reactive mixture of O_2 and Ne in the cylinder is 25 bar. The partial pressure of Ne is 20 bar at the same temperature and volume. The value of ' x ' is [Given: Molar mass of $O_2 = 32\ \text{g mol}^{-1}$.Molar mass of $\text{Ne} = 20\ \text{g mol}^{-1}$]

80

$P_{Ne} = 20$ bar

$P_T = 25$ bar

$P_{O_2} = 25 - 20 = 5$ bar

$p_{O_2} = X_{O_2} \times P_T$

$$5 = \left(\frac{\frac{x}{32}}{\frac{x}{32} + \frac{200}{20}} \right) \times 25$$

$$1 = \frac{\frac{x}{32}}{\frac{x+320}{32}} \times 5$$

$x + 320 = 5x$

$x = 80$ g

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10. 1.80 g of solute A was dissolved in 62.5 cm^3 of ethanol and freezing point of the solution was found to be 155.1 K. The molar mass of solute A is $g mol^{-1}$.

[Given: Freezing point of ethanol is 156.0 K. Density of ethanol is 0.80 $g\ cm^{-3}$.

Freezing point depression constant of ethanol is 2.00 $K\ kg\ mol^{-1}$]

80

$$\Delta T_f = i \times K_f \times m$$

$$0.9 = i \times 2 \times \frac{1.80 \times 1000}{M \times 62.5 \times .8}$$

$62.5 \times .8 = v \times d$ = mass of solvent

$$M = \frac{2 \times 1.80 \times 1000}{.9 \times 62.5 \times .8}$$

$$= \frac{4000}{62.5 \times 8} = 80$$

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11. The osmotic pressure of blood is 7.47 bar at 300 K. To inject glucose to a patient intravenously, it has to be isotonic with blood. The concentration of glucose solution in gL^{-1} is 54 ____ (Molar mass of glucose $= 180\ g\ mol^{-1} R = 0.083\ L_{bar}\ ^{-1}\ mol^{-1}$) (Nearest integer)

$$\pi = i \times CRT$$

$$7.47 = 1 \times \frac{w}{180} \times .083 \times 300$$

$$w = \frac{7.47 \times 180}{.083 \times 300} = 54\ g/L$$

12. A company dissolves 'X' amount of CO_2 at 298 K in 1 litre of water to prepare soda water $X =$ _____ $\times 10^{-3}$ g. (nearest integer) (Given: partial pressure of CO_2 at 298 K = 0.835 bar. Henry's law constant for CO_2 at 298 K = 1.67 k bar. Atomic mass of H, C and O is 1,12 and 6 g mol^{-1}, respectively)

1223

$$p = K_H \times X$$

$$0.835 = 1.67 \times 10^3 \times \frac{n_{CO_2}}{n_{CO_2} + n_{H_2O}}$$

$$0.835 = 1.670 \times 10^3 \times \frac{\frac{w}{44}}{\frac{w}{44} + 55.55}$$

$$\frac{1}{2} = \frac{w \times 1000}{w + 44 \times 55.55}$$

$$2000\,w = w + 44 \times 55.55$$

$$199w = 44 \times 55.55$$

$$w = \frac{2444.2}{1999} = 1.2227\,g$$

$$= 1222.7 \times 10^{-3}\,g$$

$$= \underline{1223}$$

13. The elevation in boiling point for 1 molal solution of non-volatile solute A is 3 K. The depression in freezing point for 2 molal solution of A in the same solvent is 6 K. The ratio of K_b and K_f i.e., K_b/K_f is $1:X$. The value of X is [nearest integer]

(1)

$$\Delta T_b = 3K = K_b \times 1$$

$$\Delta T_f = 6K = K_f \times 2$$

$$\frac{3}{6} = \frac{K_b}{K_f} \times \frac{1}{2}$$

$$\boxed{K_f = K_b}$$

14. A 0.5 percent solution of potassium chloride was found to freeze at $-0.24^{\circ}C$. The percentage dissociation of potassium chloride is(Nearest integer)(Molal depression constant for water is $1.80\ K\ kg\ mol^{-1}$ and molar mass of KCl is $74.6\ g\ mol^{-1}$)

98%

$\Delta T_f = i \times K_f \times m$

$.24 = i \times 1.80 \times \frac{.5}{74.6 \times 99.5} \times 1000$

$i = 1.98$

$KCl \longrightarrow K^{\oplus} + Cl^{-}$

1   0   0

$1-\alpha$ α α

$1 + \alpha = 1.98$

$\alpha = .98$

$\alpha = 98\%$

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15. The osmotic pressure exerted by a solution prepared by dissolving 2.0 g of protein of molar mass 60 kg mol^{-1} in 200 mL of water at 27°C is ___ Pa. [integer value]

415

$\pi = CRT$

$= \frac{2}{60 \times 10^3} \times \frac{1000}{200} \times 0.083 \times 300$

$= \frac{600}{60 \times 200} \times 0.083$

$= 41.5 \times 10^{-4}$ bar

1 bar = 10^5 Pa

$= 41.5 \times 10^{-4} \times 10^5$ Pa

$= 415$ Pa

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16. $2\ \mathrm{g}$ of a non-volatile non-electrolyte solute is dissolved in $200\ \mathrm{g}$ of two different solvents A and B whose ebullioscopic constants are in the ratio of $1:8$. The elevation in boiling points of A and B are in the ratio $\frac{x}{y}(x:y)$. The value of y is___ (Nearest integer)

(8)

$$\frac{\Delta T_{bA} = 1 \times K_{bA} \times \frac{2}{200 \times M} \times 1000}{\Delta T_{bB} = 1 \times K_{bB} \times \frac{2}{200 \times M} \times 1000}$$

$$\frac{\Delta T_{bA}}{T_{bB}} = \frac{K_{bA}}{K_{bB}} = \frac{1}{8}$$

$$\frac{x}{y} = \frac{1}{8}$$

$$y = 8$$

17. A solution containing 2.5×10^{-3} kg of a solute dissolved in 75×10^{-3} kg of water boils at 373.535 K. The molar mass of the solute is __ $\mathrm{gmol^{-1}}$. [nearest integer] (Given: $K_b(H_2O) = 0.52$ KKg $\mathrm{mol^{-1}}$, boiling point of water $= 373.15$ K)

45

$$\Delta T_b = 373.535 - 373.150 = .385$$

$$.385 = \frac{2.5}{75 \times M} \times 1000 \times .52$$

$$M = \frac{2.5 \times .52 \times 1000}{.385 \times 75}$$

$$M = 45.02 \simeq 45$$

18. The vapour pressures of two volatile liquids A and B at 25°C are 50 Torr and 100 Torr, respectively. If the liquid mixture contains 0.3 mole fraction of A, then the mole fraction of liquid B in the vapour phase is $\frac{x}{17}$. The value of x is

14

$P_A^0 = 50$ torr $\quad P_B^0 = 100$ torr

$X_A = .3 \quad X_B = .7$

$$Y_B = \frac{X_B P_B^0}{P_T}$$

$$= \frac{.7 \times 100}{50 \times .3 + .7 \times 100} = \frac{70}{15 + 70} = \frac{70}{85} = \frac{14}{17}$$

$$Y_B = \frac{14}{17} \Rightarrow x = 14$$

19. 1.2 mL of acetic acid is dissolved in water to make 2.0 L of solution. The depression in freezing point observed for this strength of acid is 0.0198°C. The percentage of dissociation of the acid is (Nearest integer)[Given : Density of acetic acid is 1.02 g mL^{-1} Molar mass of acetic acid is 60 g mol^{-1} $K_f(H_2O) = 1.85 \text{ K kg mol}^{-1}$]

(5)

$$0.0198 = i \times 1.85 \times \frac{1.2 \times 1.02}{60 \times 2}$$

$$i = \frac{.0198 \times 600 \times 2}{1.85 \times 1.2 \times 1.02}$$

$$i = \frac{198 \times 600 \times 2}{185 \times 12 \times 102} = 1.05$$

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

1	0	0
$1-\alpha$	α	α

$1 + \alpha = 1.05$

$\alpha = .05$

$\alpha = 5\%$

20. Elevation in boiling point for 1.5 molal solution of glucose in water is $4\ \mathrm{K}$. The depression in freezing point for 4.5 molal solution of glucose in water is $4\ \mathrm{K}$. The ratio of molal elevation constant to molal depression constant $(\mathrm{K_b}/\mathrm{K_f})$ is..

(3)

$$\frac{4K = K_b \times 1.5}{4K = K_f \times 4.5}$$

$$\frac{K_b}{K_f} \times \frac{1}{3} = 1$$

$$\frac{K_b}{K_f} = 3$$