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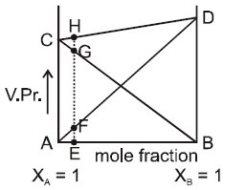
CHEMISTRY

TARGET : JEE Advanced - 2023

CAPS – 13

Liquid Solution

1. Based on the given diagram, which of the following statements regarding the homogenous solutions of two volatile liquids are correct?



(a) Plots AD and BC show the Raoult's law is obeyed for the solution in which B is a solvent and A is the solute and as well as for that in which A is solvent and B is solute.

(b) Plot CD shows that Dalton's law of partial pressure is obeyed by the binary solution of components A and B.

(c) EF + EG = EH; and AC and BD correspond to the vapour pressure of the pure solvents A and B respectively.

Select the correct answer using the options given below :

(A) Only (a) (B) (b) and (c) (C) (a) and (c) (D) All

2. Freezing point of a solution is smaller than that point of a solvent. It is due to :

(A) ΔH of solution and solvent is almost identical since intermolecular forces between solvent molecules are involved

(B) ΔS of solution (between solution and solid) is larger than that of the ΔS of solvent (between solvent and solid)

(C) ΔS of the solution is smaller than that of the solvent

(D) ΔH of the solution is much higher than of solvent but $\square S$ of solution is smaller than that of the solvent

3. At 300 K, 40 mL of O_3 (g) dissolves in 100 g of water at 1.0 atm. What mass of ozone dissolved in 400 g of water at a pressure of 4.0 atm at 300 K ?

(A) 0.1 g (B) 1.2 g (C) 0.48 g (D) 4.8 g

4. The vapour pressure of two pure liquids A and B, that form an ideal solution are 100 and 900 torr respectively at temperature T. This liquid solution of A and B is composed of 1 mole of A and 1 mole of B. What will be the pressure, when 1 mole of mixture has been vaporized ?

(A) 800 torr (B) 500 torr (C) 300 torr (D) None of these

5. 0.1 M KI and 0.2 M $AgNO_3$ are mixed in 3:1 volume ratio. The depression of freezing point of the resulting solution will be [$Kf(H_2O)$ = 1.86 K kg mol^{-1}]

(A) 3.72 K (B) 1.86 K (C) 0.93 K (D) 0.279 K

6. Calculate the freezing point of an aqueous solution having mole fraction of water 0.8. Latent heat of fusion of ice is 1436.3 cal mol^{-1}

(A) 25.97^0C (B) 2.597^0C (C) -25.97^0C (D) -2.59^0C

7. At a constant temperature, ΔS will be maximum for which of the following processes:

(A) Vaporisation of a pure solvent

(B) Vaporisation of solvent from a solution containing nonvolatile and non-electrolytic solute in it

(C) Vaporisation of solvent from a solution containing nonvolatile but electrolytic solute in it

(D) Entropy change will be same in all the above cases

MCQ

8. The azeotropic solutions of two miscible liquids :

(A) can be separated by simple distillation.

(B) may show positive or negative deviation from Raoult's law.

(C) are supersaturated solution .

(D) behave like a single component and boil at a constant temperature.

9. A graph plotted between $\frac{P}{d}$ vs d (where P is osmotic pressure of solution of a solute of mol. wt. m and d is its density at temperature T. Pick out the correct statements about the plots:

(A) $\left[\frac{P}{d}\right]_{d\to 0} = \frac{RT}{m}$ (B) The intercept of the plot = $\frac{RT}{m}$

(C) The intercept of the plot = $\left[\frac{P}{d}\right]_{d\to 0}$ (D) $\left[\frac{P}{d}\right]_{d\to 0}$ is independent of temperature

COMPREHENSION

Passage - 1 :

The vapour pressure of two pure liquids A and B which form an ideal solution are 500 and 800 torr respectively at 300 K. A liquid solution of A and B for which the mole fraction of A is 0.60 is contained in a cylinder closed by a piston on which the pressure can be varied. The solution is slowly vaporized at 300 K by decreasing the applied pressure.

10. The composition of vapour when first bubble formed is:

(A) $Y_A = 0.6$; $Y_B = 0.4$ (B) $Y_A = 0.48$; $Y_B = 0.52$

(C) $Y_A = 0.52$; $Y_B = 0.48$ (D) $Y_A = 0.5$; $Y_B = 0.5$

11. What is the composition of last droplet of liquid remaining in equilibrium with vapour?

(A) $x_A = 0.6$; $X_B = 0.4$ (B) $x_A = 0.5$; $x_B = 0.5$

(C) $x_A = 0.7$; $x_B = 0.3$ (D) $x_A = 0.3$; $x_B = 0.7$

Numeric

12. A '100 proof' solution of ethanol in water consists of 50.00 ml of $C_2H_5OH(1)$ and 50.00 ml of $H_2O(1)$ mixed at 15.56ºC. The density of the solution is 0.9344 g/ml, that of pure H_2O is 1.0000 g/ml and that of pure C_2H_5OH is 0.7939 g/ml. Is the solution ideal ?

    Answer '1', if the solution is ideal and answer '2', if the solution is non-ideal.

13. The freezing point of an aqueous solution of KCN containing 0.2 mole/kg water was –0.80ºC. On adding 0.1 mole of $Hg(CN)_2$ in the solution containing 1 kg of water, the freezing point of the solution was –0.6ºC. Assuming that the complex is formed according to the equation :

    $Hg(CN)_2 + mCN^- \rightarrow Hg(CN)_{m+2}^{m-}$ and $Hg(CN)_2$ is the limiting reactant, the value of m is

14. Safrole is contained in oil of sassafras and was once used to flavour root beer. A 2.4 mg sample of safrole was dissolved in 100.0 mg of diphenyl ether. The solution had a freezing of 25.64ºC. The freezing point of pure diphenyl ether is 26.84ºC, and the freezing-point-depression constant, K_f, is 8.00ºC/m. The molecular mass of safrole is:

15. When 3.24 g of mercuric nitrate Hg $(NO_3)_2$ dissolved in 1 kg of water, the freezing point of the solution is found to be – 0.0558°C. When 10.84 g of mercuric chloride $HgCl_2$ is dissolved in 1 kg of water, the freezing point of the solution is –0.0744°C. K_f = 1.86 mol^{-1} K kg. Will either of these dissociate into ions in an aqueous solution?

16. A radiator was filled with 10 L of water to which 2.5 L of methanol (density = 0.8 g mL^{-1}) were added. At 9:00 pm, the vehicle is parked outdoors where the temperature is 0°C. The temperature is decreasing at a uniform rate of 0.5°C / min. Up to what time will there be no danger to the radiator of the car.

K_f (water) = 1.86 kg mol^{-1} K. Assume methanol to be non-volatile.

17. At 10°C, the osmotic pressure of urea solution is 500 mm. The solution is diluted and the temperature is raised to 25°C, when the osmotic pressure is found to be 105.3 mm. Determine extent of dilution.

18. Dry air was drawn through bulbs containing a solution of 40 grams of urea in 300 grams of water, then through bulbs containing pure water at the same temperature and finally through a tube in which pumice moistened with strong H_2SO_4 was kept. The water bulbs lost 0.0870 grams and the sulphuric acid tube gained 2.036 grams. Calculate the molecular weight of urea.

19. A protein has been isolated as sodium salt with their molecular formula Na_xP (this notation means that x Na^+ ions are associated with a negatively charged protein P^{-x}). A solution of this salt was prepared by dissolving 0.25 g of this sodium salt of protein in 10 g of water and ebulliscopic analysis revealed that solution boils at temperature 5.93×10^{-3} °C higher than the normal boiling point of pure water. K_b of water 0.52 kg mol^{-1}. Also, elemental analysis revealed that the salt contains 1% sodium metal by weight. Deduce molecular formula and determine molecular weight of acidic form of protein H_xP.

20. 1.5 g of monobasic acid when dissolved in 150 g of water lowers the freezing point by 0.165°C. 0.5 g of the same acid when titrated, after dissolution in water, requires 37.5 mL of N/10 alkali. Calculate the degree of dissociation of the acid (K_f for water = 1.86° C mol^{-1}).

21. The vapour pressure of a certain liquid is given by the equation:

$\log_{10} P = 3.54595 - \frac{313.7}{T} + 1.40655 \log_{10} T$, where P is the vapour pressure in mm and T = Kelvin Temperature. Determine the molar latent heat of vaporisation as a function of temperature. Calculate the its value at 80 K.

22. An organic liquid, A is immiscible with water. When boiled together with water, the boiling point is 900C at which the partial vapour pressure of water is 526 mm Hg. The super incumbent (atmospheric) pressure is 736 mm Hg. The weight ratio of the liquid and water collected is 2.5:1. What is the molecular weight of the liquid?

23. 0.001 molal solution of a ionic complex with molecular formula $Pt(NH_3)_4\ Cl_4$ lowers the freezing point of water by 0.0054 °C. Assume the above compound to be 100% ionised and k_f for water = 1.80 k kg mol^{-1}.

(i) Write IUPAC name of the above compound.

Now 0.001 moles of above complex are taken separately and enough $AgNO_3$(aq.) is added to it for complete precipitation of free Cl^- as AgCl. The precipitate is filtered and dried. It requires at least five times the volume of NH_3(aq.) needed stoichiometrically for its dissolution.

(ii) Calculate the volume of 1.0 M NH_3(aq.) required for this purpose.

(iii) Write IUPAC name of the second complex formed.

Assume molality to be equal to molarity whenever needed.