

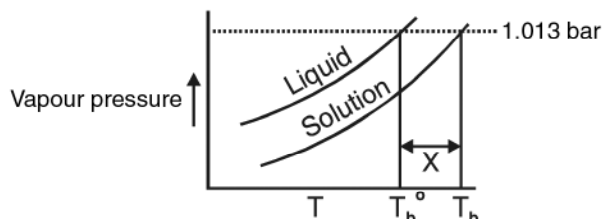
**Unit - 2****SOLUTIONS**

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**VSA QUESTIONS (1 - MARK QUESTIONS)**

1. Give an example of 'liquid in solid' type solution.
2. Which type of solid solution will result by mixing two solid components with large difference in the sizes of their molecules?
3. What is meant by semimolar and decimolar solutions? [Ans.:  $\frac{M}{2}$ ,  $\frac{M}{10}$ ]
4. What will be the mole fraction of water in  $C_2H_5OH$  solution containing equal number of moles of water and  $C_2H_5OH$ ? [Ans. : 0.5]
5. Which of the following is a dimensionless quantity : molarity, molality or mole fraction? [Ans. : mole fraction]
6. 10 g glucose is dissolved in 400 g. of solution. Calculate percentage concentration of the solution. [Ans. : 2.5% w/w]
7. Gases tend to be less soluble in liquids as the temperature is raised. Why?
8. State the conditions which must be satisfied if an ideal solution is to be formed.
9. A mixture of chlorobenzene and bromobenzene forms nearly ideal solution but a mixture of chloroform and acetone does not. Why?
10. How is the concentration of a solute present in trace amount in a solution expressed?
- \*12.  $N_2$  and  $O_2$  gases have  $K_H$  values 76.48 kbar and 34.86 kbar respectively at 293 K temperature. Which one of these will have more solubility in water?

- \*13. Under what condition molality and molarity of a solution are identical. Explain with suitable reason.
- \*14. Addition of  $\text{H}_2\text{I}_2$  to  $\text{KI}$  (aq.) shows decrease in vapour pressure. Why?
15. What will happen to the boiling point of the solution formed on mixing two miscible liquids showing negative deviation from Raoult's law?
16. Liquid 'Y' has higher vapour pressure than liquid 'X', which of them will have higher boiling point?
17. When 50 mL of ethanol and 50 mL of water are mixed, predict whether the volume of the solution is equal to, greater than or less than 100 mL. Justify.
18. Which type of deviation is shown by the solution formed by mixing cyclohexane and ethanol?
19. A and B liquids on mixing produce a warm solution. Which type of deviation from Raoult's law is there?
20. Define cryoscopic constant (molal freezing point depression constant.)
21. Mention the unit of ebullioscopic constant (molal boiling point elevation constant.)
22. If  $k_f$  for water is  $1.86 \text{ K kg mol}^{-1}$ , what is the freezing point of 0.1 molal solution of a substance which undergoes no dissociation or association of solute?
- [Hint :  $\Delta T_f = iK_f \cdot m$ ]
24. What is reverse osmosis? Give one large scale use of it.
- \*25. What is the maximum value of van't Hoff factor (i) for  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ?
- [Ans. :  $i = 3$ ]
26. What is the value of van't Hoff factor (i) if solute molecules undergo dimerisation.
- [Ans. :  $i = 0.5$ ]
27. Under what condition is van't Hoff factor less than one?
- [Ans. : Association]
- \*28. The Phase Diagram for pure solvent and the solution containing nonvolatile solute are recorded below. The quantity indicated by 'X' in the figure is known as :
- [Ans. :  $\Delta T_b$ ]



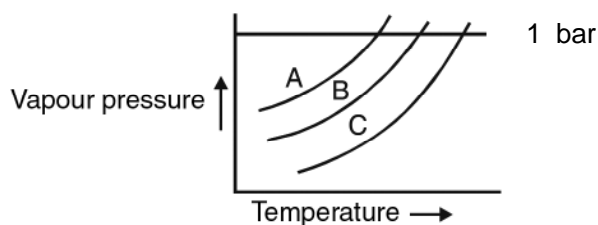
- \*29.  $\text{AgNO}_3$  on reaction with  $\text{NaCl}$  in aqueous solution gives white precipitate. If the two solutions are separated by a semi-permeable membrane, will there be appearance of a white ppt. in the side 'X' due to osmosis?

0.1 M $\text{AgNO}_3$ X	S P M	0.01 M $\text{NaCl}$ Y
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[Ans. : No ppt, because only solvent particles moves through SPM]

### SA (I) - TYPE QUESTIONS (2 - MARK QUESTIONS)

- Explain the following :
  - Solubility of a solid in a liquid involves dynamic equilibrium.
  - Ionic compounds are soluble in water but are insoluble in nonpolar solvents.
- Give two examples each of a solution :
  - showing positive deviation from Raoult's Law.
  - showing negative deviation from Raoult's Law.
- Draw vapour pressure vs composition (in terms of mole fraction) diagram for an ideal solution.
- Define azeotropes with one example of each type.
- Draw the total vapour pressure vs. mol fraction diagram for a binary solution exhibiting non-ideal behaviour with negative deviation.
- The vapour pressure curve for three solutions having the same non-volatile solute in the same solvent are shown. The curves are parallel to each other and do not intersect. What is the correct order of the concentrations of the solutions.  
[Hint. :  $A < B < C$ ]

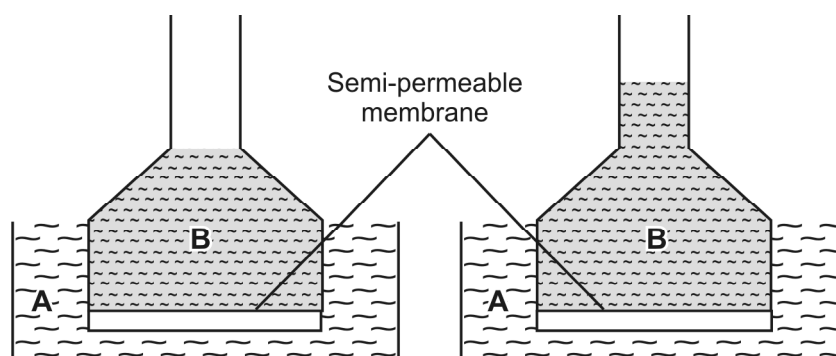


7. Show that the relative lowering of vapour pressure of a solvent is a colligative property.
8. Benzene and toluene form a nearly ideal solution. At a certain temperature, calculate the vapour pressure of solution containing equal moles of the two substances.  
[Given :  $P^{\circ}_{\text{Benzene}} = 150 \text{ mm of Hg}$ ,  $P^{\circ}_{\text{Toluene}} = 55 \text{ mm of Hg}$ ]
9. What is meant by abnormal molecular mass? Illustrate it with suitable examples.
- \*10. When 1 mole of NaCl is added to 1 litre water, the boiling point increases? When 1 mole of  $\text{CH}_3\text{OH}$  is added to 1 litre water, the boiling point decreases? Suggest reasons.
11. Can we separate water completely from  $\text{HNO}_3$  solution by vapourisation? Justify your answer.
- \*12. 1 gram each of two solutes 'A' and 'B' (molar mass of A > molar mass of B) are dissolved separately in 100 g each of the same solvent. Which solute will show greater elevation in boiling point and Why?

## Solution

### 2 - MARK QUESTIONS

13. Examine the following illustrations and answer the following questions



- (a) Identify the liquid A and liquid B (pure water or sugar solution)
- (b) Name the phenomenon involved in this experiment so that the level of liquid in this the funnel has risen after some time.
14. How relative lowering in vapour pressure is related with depression in freezing point and elevation in boiling point?

### SA (II) TYPE QUESTIONS (3 - MARK QUESTIONS)

- (a) State Henry's Law.

(b) If  $O_2$  is bubbled through water at 393 K, how many millimoles of  $O_2$  gas would be dissolved in 1L of water? Assume that  $O_2$  exerts a pressure of 0.95 bar.

(Given  $K_H$  for  $O_2$  = 46.82 bar at 393K).
- Given reason for the following :-

(a) Aquatic species are more comfortable in cold waters than in warm waters.

(b) To avoid bends scuba divers use air diluted with helium.

(c) Cold drinks bottles are sealed under high pressure of  $CO_2$ .
- Why should a solution of a non-volatile and non-eletrolyte solute boil at a higher temperature? Explain with the help of a diagram. Derive the relationship between molar mass and elevation in boiling point.
- Account for the following :-

(a)  $CaCl_2$  is used to clear snow from roads in hill stations.

(b) Ethylene glycol is used as antifreeze solution in radiators of vehicles in cold countries.

(c) The freezing point depression of 0.01 m NaCl is nearly twice that of 0.01 m glucose solution.
- Why do colligative properties of solution of a given concentration are found to give abnormal molecular weight of solute. Explain with the help of suitable examples.
- Give reasons for the following :-

(a) RBC swell up and finally burst when placed in 0.1% NaCl solution.

(b) When fruits and vegetables that have been dried are placed in water, they slowly swell and return to original form.

- (c) A person suffering from high blood pressure is advised to take less amount of table salt.
- \*7. Glycerine, ethylene glycol and methanol are sold at the same price per kg. Which would be cheaper for preparing an antifreeze solution for the radiator of an automobile? **[Ans. : Methanol]**
- \*8. Determine the correct order of the property mentioned against them :
- (a) 10% glucose ( $p_1$ ), 10% urea ( $p_2$ ), 10% sucrose ( $p_3$ ) **[Osmotic pressure]**
- (b) 0.1 m NaCl, 0.1 m urea, 0.1 m  $\text{MgCl}_2$  **[Elevation in b.pt.]**
- (c) 0.1 m  $\text{CaCl}_2$ , 0.1 m sucrose, 0.1 m NaCl **[Depression in f.pt.]**
9. For a dilute solution containing 2.5 g of a non-volatile non-electrolyte solute in 100 g of water, the elevation in boiling point at 1 atm pressure is  $2^\circ\text{C}$ . Assuming concentration of solute is much lower than the concentration of solvent, determine the vapour pressure (mm of Hg) of the solution.
- [Given :  $K_b$  for water =  $0.76 \text{ kg mol}^{-1}$ ] **[Ans.: 724 mm of Hg]****
- [Hind :  $\Delta T_b = K_b \cdot m \Rightarrow 0.76 \times \frac{2.5}{M_b} \times \frac{1000}{100} = 2\text{k}$**
- $$M_b = 9.5 \text{ g mol}^{-1}$$
- $$\frac{p_A^\circ - p_A}{p_A^\circ} = \frac{25}{95} \times \frac{18}{100}$$
- $$\frac{760 - p_A}{760} = \frac{25}{95} \times \frac{18}{100} \Rightarrow p_A = 724 \text{ mm of Hg]$$
10. 15.0 g of an unknown molecular substance was dissolved in 450 g of water. The resulting solution was found to freeze at  $-0.34^\circ\text{C}$ . What is the molar mass of this substance. ( $K_f$  for water =  $1.86 \text{ K kg mol}^{-1}$ ).

### LONG ANSWER TYPE QUESTIONS (5 MARKS)

1. (a) What are ideal solutions? Write two examples.
- (b) Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0g of polymer of molar mass 185000 in 450 mL of water at  $37^\circ\text{C}$ .

2. (a) Describe a method of determining molar mass of a non-volatile solute from vapour pressure lowering.  
 (b) How much urea (mol. mass  $60 \text{ g mol}^{-1}$ ) must be dissolved in 50g of water so that the vapour pressure at the room temperature is reduced by 25%? Also calculate the molality of the solution obtained.  
**[Ans. : 55.55 g and 18.5 m]**
3. (a) Why is the freezing point depression considered as a colligative property?  
 (b) The cryoscopic constant of water is  $1.86 \text{ K kg mol}^{-1}$ . Comment on this statement.  
 (c) Calculate the amount of ice that will separate out on cooling solution containing 50 g of ethylene glycol in 200 g  $\text{H}_2\text{O}$  to  $-9.3^\circ\text{C}$ . ( $K_f$  for water =  $1.86 \text{ K kg mol}^{-1}$ )  
**[Ans. : 38.71g]**
4. (a) Define osmotic pressure.  
 (b) Why osmotic pressure is preferred over other colligative properties for the determination of molecular masses of macromolecules?  
 (c) What is the molar concentration of particles in human blood if the osmotic pressure is 7.2 atm at normal body temperature of  $37^\circ\text{C}$ ?  
**[Ans. : 0.283 M]**

### NUMERICAL PROBLEMS

1. Calculate the mass percentage of benzene ( $\text{C}_6\text{H}_6$ ) and carbon tetrachloride ( $\text{CCl}_4$ ), If 22g of benzene is dissolved in 122g of carbon tetrachloride.  
**[Ans. :  $\text{C}_6\text{H}_6 = 15.3\%$ ,  $\text{CCl}_4 = 84.7\%$ ]**
2. Calculate the molarity of a solution prepared by mixing 500 mL of 2.5 M urea solution and 500 mL of 2M urea solution.  
**[Ans. : 2.25 m]**  
**[Hint :  $M = \frac{M_1 V_1 + M_2 V_2}{V_1 + V_2}$ ]**
3. The mole fraction of  $\text{CH}_3\text{OH}$  in an aqueous solution is 0.02 and density of solution  $0.994 \text{ g cm}^{-3}$ . Determine the molality and molarity.  
**[Ans. : 1.13m, 1.08m]**
4. 200 mL of calcium chloride solution contains  $3.011 \times 10^{22} \text{ Cl}^-$  ions. Calculate the molarity of the solution. Assume that calcium chloride is completely ionized.  
**[Ans. : 0.125 M]**

5.  $6 \times 10^{-3}$  g oxygen is dissolved per kg of sea water. Calculate the ppm of oxygen in sea water. **[Ans. : 6 ppm]**
6. The solubility of oxygen in water is  $1.35 \times 10^{-3}$  mol L<sup>-1</sup> at 20°C and 1 atm pressure. Calculate the concentration of oxygen at 20°C and 0.2 atm pressure. **[Ans. :  $2.7 \times 10^{-4}$  mol L<sup>-1</sup>]**
7. Two liquids X and Y on mixing form an ideal solution. The vapour pressure of the solution containing 2 mol of X and 1 mol of Y is 550 mm Hg. But when 4 mol of X and 1 mole of Y are mixed, the vapour pressure of solution thus formed is 560 mm Hg. What will be the vapour pressure of pure X and pure Y at this temperature?  
**[Ans. : X = 600 mm Hg; Y = 400 mm Hg]**
8. An aqueous solution containing 3.12 g of barium chloride in 250 g of water is found to be boil at 100.0832°C. Calculate the degree of dissociation of barium chloride.  
[Given molar mass BaCl<sub>2</sub> = 208 g mol<sup>-1</sup>, K<sub>b</sub> for water = 0.52 K/m]  
**[Ans. : 83.3%]**
9. The degree of dissociation of Ca(NO<sub>3</sub>)<sub>2</sub> in a dilute aqueous solution, containing 7.0 g of salt per 100 g of water at 100°C is 70%. If the vapour pressure of water at 100°C is 760 mm of Hg, calculate the vapour pressure of the solution. **[Ans. : 745.3 mm of Hg]**
10. 2g of C<sub>6</sub>H<sub>5</sub>COOH dissolved in 25g of benzene shows depression in freezing point equal to 1.62K. Molar freezing point depression constant for benzene is 4.9 K kg mol<sup>-1</sup>. What is the percentage association of acid if it forms a dimer in solution? **[Ans. : 99.2%]**
11. Calculate the amount of NaCl which must added to one kg of water so that the freezing point is depressed by 3K. Given K<sub>f</sub> = 1.86 K kg mol<sup>-1</sup>, Atomic mass : Na = 23, Cl = 35.5). **[Ans. : 0.81 mol NaCl]**
12. Three molecules of a solute (A) associate in benzene to form species A<sub>3</sub>. Calculate the freezing point of 0.25 molal solution. The degree of association of solute A is found to be 0.8. The freezing point of benzene is 5.5°C and its K<sub>f</sub> value is 5.13 K/m. **[Ans. : 4.9°C]**
13. A 5% solution of sucrose (C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>) is isotonic with 0.877% solution of urea. NH<sub>2</sub>CONH<sub>2</sub>) Calculate the molecular mass of urea. **[Ans. : 59.99 g mol<sup>-1</sup>]**
14. Osmotic pressure of a 0.0103 molar solution of an electrolyte was found to be 0.75 atm at 27°C. Calculate Van't Hoff factor. **[Ans. :  $i = 3$ ]**



- \*15. The maximum allowable level of nitrates in drinking water is 45 mg nitrate ions/dm<sup>3</sup>. Express this level in ppm? [Ans. : 45 ppm]
16. 75.2 g of Phenol (C<sub>6</sub>H<sub>5</sub>OH) is dissolved in 1 kg solvent of K<sub>f</sub> = 14 K m<sup>-1</sup>, if the depression in freezing point is 7K, then find the % of phenol that dimerises. [Ans. : 75%]
- \*17. An aqueous solution of glucose boils at 100.01°C. The molal boiling point elevation constant for water is 0.5 K kg mol<sup>-1</sup>. What is the number of glucose molecule in the solution containing 100 g of water. [Ans. : 1.2 × 10<sup>21</sup> molecules]
18. A bottle of commercial H<sub>2</sub>SO<sub>4</sub> [density = 1.787 g/mL] is labelled as 86% by mass.
- What is the molarity of the acid?
  - What volume of the acid has to be used to make 1 litre 0.2 M H<sub>2</sub>SO<sub>4</sub>?
  - What is the molality of the acid?
- [Ans. : 15.7 M, 12.74 mL, 62.86 m]
19. A solution containing 30g of non-volatile solute exactly in 90g of water has a vapour pressure of 2.8 kPa at 298 K. Further, 18 g of water is then added to the solution and the new vapour pressure becomes 2.9 kPa at 298 K. Calculate :
- molar mass of the solute
  - Vapour pressure of water at 298 K. [Ans. : 34 g mol<sup>-1</sup>, 3.4 kPa]
20. The vapour pressure of pure liquids A and B are 450 and 750 mm Hg respectively, at 350K. Find out the composition of the liquid mixture if total vapour pressure is 600 mm Hg. Also find the composition of the vapour phase. [Ans. : X<sub>A</sub> = 0.4, X<sub>B</sub> = 0.6, Y<sub>A</sub> = 0.3, Y<sub>B</sub> = 0.7]
21. An aqueous solution of 2% non-volatile solute exerts a pressure of 1.004 bar at the normal boiling point of the solvent. What is the molar mass of the solute? [Ans. : 41.35 g mol<sup>-1</sup>]

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