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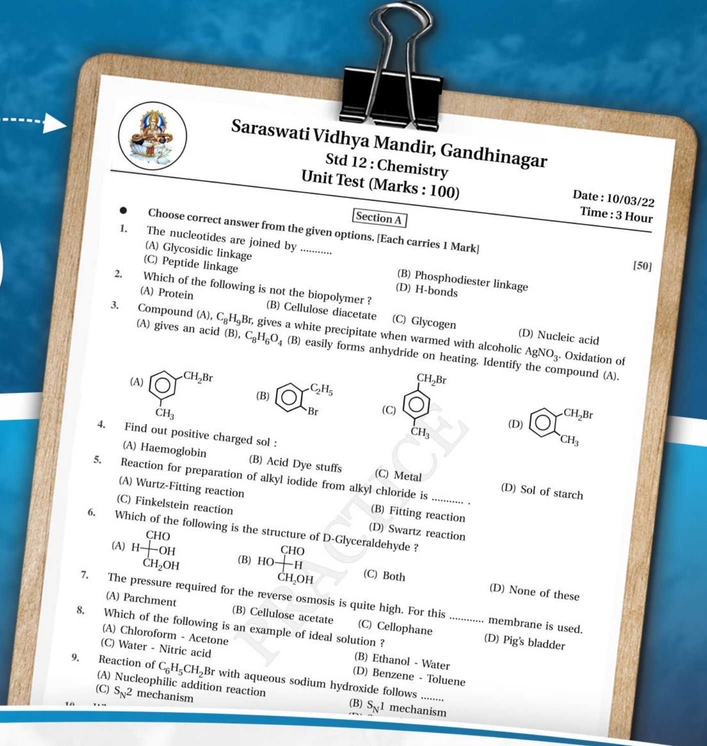

Saraswati Vidhya Mandir, Gandhinagar
Std 12 : Chemistry
Unit Test (Marks : 100)

Date : 10/03/22
Time : 3 Hour

Section A

- Choose correct answer from the given options. [Each carries 1 Mark] [50]

1. The nucleotides are joined by ....
(A) Glycosidic linkage (B) Phosphodiester linkage
(C) Peptide linkage (D) H-bonds

2. Which of the following is not the biopolymer ?
(A) Protein (B) Cellulose diacetate (C) Glycogen (D) Nucleic acid

3. Compound (A), C_8H_9Br, gives a white precipitate when warmed with alcoholic $AgNO_3$. Oxidation of (A) gives an acid (B), $C_8H_6O_4$ (B) easily forms anhydride on heating. Identify the compound (A).
(A) (B) (C) (D)

4. Find out positive charged sol :
(A) Haemoglobin (B) Acid Dye stuffs (C) Metal (D) Sol of starch

5. Reaction for preparation of alkyl iodide from alkyl chloride is ....
(A) Wurtz-Fitting reaction (B) Fitting reaction
(C) Finkelstein reaction (D) Swartz reaction

6. Which of the following is the structure of D-Glyceraldehyde ?
(A) (B) (C) Both (D) None of these

7. The pressure required for the reverse osmosis is quite high. For this .... membrane is used.
(A) Parchment (B) Cellulose acetate (C) Cellophane (D) Pig's bladder

8. Which of the following is an example of ideal solution ?
(A) Chloroform - Acetone (B) Ethanol - Water
(C) Water - Nitric acid (D) Benzene - Toluene

9. Reaction of $C_6H_5CH_2Br$ with aqueous sodium hydroxide follows ....
(A) Nucleophilic addition reaction (B) S_N1 mechanism
(C) S_N2 mechanism

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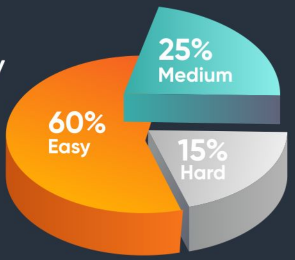

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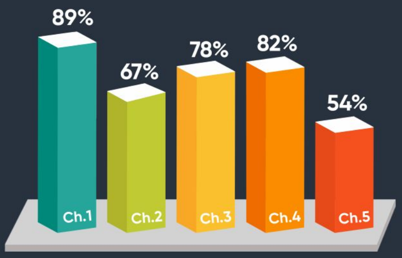

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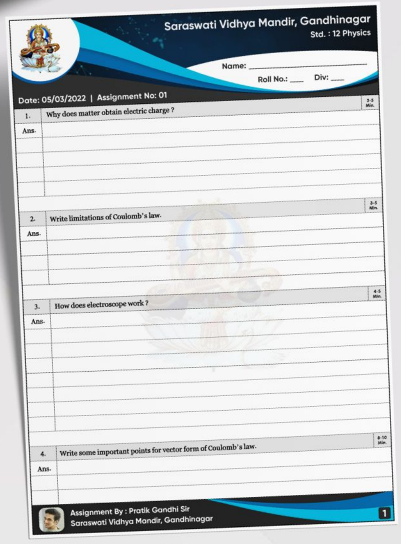

Saraswati Vidhya Mandir, Gandhinagar
Std. : 12 Physics
Name: ____
Roll No.: ___ Div: ___

Date: 05/03/2022 | Assignment No: 01

1.	Why does matter obtain electric charge ?	3-5 Min.
Ans.		
2.	Write limitations of Coulomb's law.	3-5 Min.
Ans.		
3.	How does electroscope work ?	4-5 Min.
Ans.		
4.	Write some important points for vector form of Coulomb's law.	8-10 Min.
Ans.		

Assignment By : Pratik Gandhi Sir
Saraswati Vidhya Mandir, Gandhinagar
1

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2

Solutions

Questions asked in PART - B in board exam from this chapter

Section - A

❖ **Answer the following questions in short : (2 marks of each)** **[16]**

No questions have been asked yet in the board exam in this section.

Section - B

❖ **Answer the following questions : (3 marks of each)** **[18]**

1) If depression in freezing point of a solution prepared by dissolving 1 gram benzoic acid to the 25 gram of benzene is 0.81 Kelvin then find out degree of association. Molal depression constant of solvent is 4.9 Kelvin kilogram mole^{-1}. [July - 2019]

Section - C

❖ **Answer the following questions in detail : (4 marks of each)** **[16]**

1) Write Raoult's law for non-volatile solute and volatile solvent. Derive it and also write two limitations of it. [July - 2018]

2) Write about Raoult's law for non-volatile solute and prove it. Write the formula to find out molecular mass of solute according to above rule. [March, July - 2018]

3) Write Van't Hoff law of osmotic pressure and explain its mathematical formation and also derive the formula to identify osmotic pressure. [March - 2019]

4) Two elements A and B form compounds having formula AB_2 and AB_4. When dissolved in 20g of benzene (C_6H_6), 1g of AB_2 lowers the freezing point by 2.3 K whereas 1g of AB_4 lowers it by 1.3 K. The molal depression constant for benzene is 5.1 K Kg mol^{-1}. Calculate atomic masses of A and B. [March - 2020]

5) Calculate the depression in the freezing point of water when 10 g of $CH_3CH_2CHCl\ COOH$ is added to 250 g of water. $K_a = 1.4 \times 10^{-3}$, $K_f = 1.86$ K kg mol^{-1}. [August - 2020]

6) (i) 18 g of glucose ($C_6H_{12}O_6$) is dissolved in 1 kg of water in a saucepan. At what temperature will the solution boil at 1.013 bar ? K_b for water is 0.52 k kg mol^{-1} [C = 12, H = 1, O = 16 g mol^{-1}]

   (ii) 200 cm^3 of aqueous solution contains 1.26 g of the protein. The osmotic pressure of such a solution at 300 K is found to be 2.57×10^{-3} bar. Calculate the molar mass of the proteins. [May - 2021]

Section-1 Questions S1

2.1 Types of Solutions :

1) Explain types of solution on the basis of physical states of solute and solvent with suitable examples. #

- **Solution :** Homogeneous mixture of two or more substance is called solution.

Type of solution	Solute	Solvent	Examples
Gaseous solution	Gas	Gas	Mixture of H_2 and O_2 gas.
	Liquid	Gas	Air containing moisture
	Solid	Gas	Homogeneous mixture of camphor in N_2 gas.
Liquid solution	Gas	Liquid	Homogeneous mixture of CO_2 gas in water
	Liquid	Liquid	Homogeneous mixture of water and ethanol.
	Solid	Liquid	Homogeneous mixture of sugar and water.
Solid solution	Gas	Solid	Absorption of H_2 gas in Pd.
	Liquid	Solid	Zinc amalgam-Zinc dissolved in mercury (Zn/Hg)
	Solid	Solid	Alloy formed from copper and zinc (Brass)

❖ SELF - PRACTICE QUESTIONS ❖ S7

[1] Give examples of gaseous solute and solvent.

[2] Give physical state of solution of camphor as solute and N_2 gas as solute.

[3] German silver is a mixture or which metals ?

[4] Bronze is a mixture of which metals ?

[5] What is meant by binary solution ?

2.2 Expressing Concentration of Solutions :

2) What is the mean of concentration of solution ? Discuss different types of concentration of solutions ?

- The amount of solute in a unit volume of solution or unit weight of solvent is called concentration of solution.
- Normality formality, molarity, molality mole-fraction, weight-fraction (% w/w, %w/V, %V/V), ppm are units of concentration.

3) Explain %V/V in brief.

- The volume of solute (mL) dissolved in 100 mL solution, is expressed as volume percentage (%V/V).

  Volume % of a component =

$$\frac{\text{Volume of the component} \times 100}{\text{Total volume of solution}}$$

- For example, 10% ethanol solution in water means that 10 mL of ethanol is dissolved in water such that the total volume of the solution is 100 mL. Solutions containing liquids are commonly expressed in this unit.
- For example, a 35% (V/V) solution of ethylene glycol, an antifreeze, is used in cars for cooling the engine.
- At this concentration the antifreeze lowers the freezing point of water to 255.4 K (–17.6°C).

4) Explain % w/V and % w/w in brief.

- Mass by volume percentage (% w/V): It is the mass of solute dissolved in 100 mL of the solution. Another unit which is commonly used in medicine and pharmacy is mass by volume percentage.
- **Mass percentage (w/w) :** The mass percentage of a component of a solution is defined as :

  Mass % of a component =

$$\frac{\text{Mass of the component in the solution}}{\text{Total mass of the solution}} \times 100$$

- For example, if a solution is described by 10% glucose in water by mass, it means that 10 g of glucose is dissolved in 90 g of water resulting in a 100 g solution.

\# UID : P1-C2-S1-Q1

- Concentration described by mass percentage is commonly used in industrial chemical-applications.
- For example, commercial bleaching solution contains 3.62 mass percentage of sodium hypochlorite in water.

5) Explain parts per million in brief.

- When a solute is present in trace quantities, it is convenient to express concentration in parts per million (ppm)

  Parts per million =

$$\frac{\text{Number of parts of the component}}{\text{Total number of parts of all components of the solution}} \times 10^6$$

- As in the case of percentage, concentration in parts per million can also be expressed as mass to mass, volume to volume and mass to volume.
- A litre of sea water (which weighs 1030 g) contains about 6×10^{-3} g of dissolved oxygen (O_2). Such a small concentration is also expressed as 5.8 g per 10^6 g (5.8 ppm) of seawater. The concentration of pollutants in water or atmosphere is often expressed in terms of $\mu g\ mL^{-1}$ or ppm.

6) What is mole fraction ? Explain in brief.

- **Definition :** The ration between mole of one component of solution and total moles of solution is known as mole fraction of component.
- Commonly used symbol for mole fraction is x and subscript used on the right hand side of x denotes the component.

  Mole fraction of a component =

$$\frac{\text{Number of moles of the component}}{\text{Total number of moles of all the components}}$$

- For example, in a binary mixture, if the number of moles of A and B are n_A and n_B respectively, the mole fraction of A will be

$$x_A = \frac{n_A}{n_A + n_B}$$

- For a solution containing 'i' number of components, we have :

$$x_i = \frac{n_i}{n_1 + n_2 + \ldots\ldots + n_i} = \frac{n_i}{\Sigma n_i}$$

- It can be shown that in a given solution sum of all the mole fractions is unity, i.e.

  $x_1 + x_2 + \ldots\ldots\ldots\ldots\ldots\ldots + x_i = 1$

- Mole fraction unit is very useful in relating some physical properties of solutions, say vapour pressure with the concentration of the solution and quite useful in describing the calculations involving gas mixtures.

❖ TRY YOURSELF ❖ S7

[6] If 5.85 gm of NaCl is dissolved in 90 gm of water, then find out the mole fraction of NaCl.

[Ans : 0.0196]

[7] Find out mole fraction of methanol in 5.2 m solution of methanol. [Ans : 0.086]

[8] Find out mole fraction of glycerine, in solution of 46 gm of glycerine and 36 gm water.

[Ans : 0.2]

Example 2.1 Calculate the mole fraction of ethylene glycol ($C_2H_6O_2$) in a solution containing 20% of $C_2H_6O_2$ by mass. S8

- Assume that we have 100g of solution (one can start with any amount of solution because the results obtained will be the same). Solution will contain 20g of ethylene glycol and 80g of water.

  Molar mass of $C_2H_6O_2$ $= 12 \times 2 + 1 \times 6 + 16 \times 2$

  $= 62\text{g mol}^{-1}$

$$\text{Moles of } C_2H_6O_2 = \frac{20\text{g}}{62\text{g mol}^{-1}} = 0.322 \text{ mol}$$

$$\text{Moles of water} = \frac{80\text{g}}{18\text{g mol}^{-1}} = 4.444 \text{ mol}$$

$$X_{glycol} = \frac{\text{Moles of } C_2H_6O_2}{\text{Moles of } C_2H_6O_2 + \text{moles of } H_2O}$$

$$= \frac{0.322 \text{ mol}}{0.322 \text{ mol} + 4.444 \text{ mol}} = 0.068$$

$$\text{Similarly, } X_{water} = \frac{4.444 \text{ mol}}{0.322 \text{ mol} + 4.444 \text{ mol}} = 0.932$$

- Mole fraction of water can also be calculated as : $1 - 0.068 = 0.932$

7) Explain molarity and molality in short.

- **Molarity :** Molarity (M) is defined as number of moles of solute dissolved in one litre (or one cubic decimeter) of solution.

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution in litre}}$$

For example : 0.25 mol L^{-1} (or 0.25 M) solution of NaOH means that 0.25 mol of NaOH has been dissolved in one litre (or one cubic decimeter).

- **Molality :** Molality (m) is defined as the number of moles of the solute per kilogram (kg) of the solvent and is expressed as :

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

For example : 1.00 mol kg^{-1} (or 1.00 m) solution of KCl means that 1 mol (74.5g) of KCl is dissolved in 1 kg of water. Each method of expressing concentration of the solutions has it sown merits and demerits. Mass %, ppm, mole fraction and molality are independent of temperature, whereas not only molarity but also %w/V, %V/V and normality are temperature. Dependant this is because volume depends on temperature and the mass does not.

Example 2.2 : Calculate the molarity of a solution containing 5g of NaOH in 450 mL solution. S8

- $$\text{Moles of NaOH} = \frac{5\text{g}}{40\text{g mol}^{-1}} = 0.125 \text{ mol}$$

Volume of the solution in liters = 450 mL/ 1000 mL L^{-1}

- $$\text{Molarity} = \frac{0.125 \text{ mol} \times 1000 \text{ mL L}^{-1}}{450 \text{ mL}} = 0.278 \text{ M}$$

$$= 0.278 \text{ mol L}^{-1}$$

$$= 0.278 \text{ mol dm}^{-3}$$

Example 2.3 : Calculate molality of 2.5g of ethanoic acid (CH_3COOH) in 75g of benzene. S8

- Molar mass of $C_2H_4O_2$: $12 \times 2 + 1 \times 4 + 16 \times 2$

$$= 60 \text{ g mol}^{-1}$$

- $$\text{Moles of } C_2H_4O_2 = \frac{2.5\text{g}}{60\text{g mol}^{-1}} = 0.0417 \text{ mol}$$

- Mass of benzene in kg = 75 g / 1000 g kg^{-1}

$$= 75 \times 10^{-3} \text{ kg}$$

- $$\text{Molality of } C_2H_4O_2 = \frac{\text{Moles of } C_2H_4O_2}{\text{kg of benzene}}$$

$$= \frac{0.0417 \text{ mol} \times 1000 \text{ g kg}^{-1}}{75 \text{ g}}$$

$$= 0.556 \text{ mol kg}^{-1}$$

❖ TRY YOURSELF ❖ S7

[9] If 6.022×10^{23} atoms are present in 100 mL of urea solution then find out the molarity of urea solution. **[Ans. : 0.01 M]**

[10] Find out molarity of solution when 0.01 mole substance is dissolved in its 10 mL aqueous solution. **[Ans. : 1.0 M]**

❖ SELF - PRACTICE QUESTIONS ❖ S7

[11] Write meaning of 10% aqueous solution (by weight) of glucose.

[12] Write formula for percentage by weight.

[13] When is the unit of ppm used ?

[14] In which branch of science is the unit %w/V used ?

[15] What is molarity ?

2.3 Solubility :

8) What is solubility ? Explain solubility of solid solute in liquid solvent.

- Solubility of a substance is its maximum amount that can be dissolved in a specified amount of solvent at a specified temperature.
- Every solid does not dissolve in a given liquid. While sodium chloride and sugar dissolve readily in water, naphthalene and anthracene do not. On the other hand, naphthalene and anthracene dissolve readily in benzene but sodium chloride and sugar do not.
- It is observed that polar solutes dissolve in polar solvents and non-polar solutes in nonpolar-solvents.
- In general, a solute dissolves in a solvent if the intermolecular interactions are similar in the two or we may say like dissolves like.

- When a solid solute is added to the solvent, some solute dissolves and its concentration increases in solution. This process is known as dissolution. Some solute particles in solution collide with the solid solute particles and get separated out of solution. This process is known as crystallisation.
- A stage is reached when the two processes occur at the same rate. Under such conditions, number of solute particles going in to solution will be equal to the solute particles separating out and a state of dynamic equilibrium is reached. Solute + Solvent $\rightleftharpoons$ Solution
- At this stage the concentration of solute in solution will remain constant under the given conditions, i.e., temperature and pressure. Similar process is followed when gases are dissolved in liquid solvents.
- Such a solution in which no more solute can be dissolved at the same temperature and pressure is called a saturated **solution.**
- **An unsaturated solution** is one in which more solute can be dissolved at the same temperature. The solution which is in dynamic equilibrium with undissolved solute is the saturated solution and contains the maximum amount of solute dissolved in a given amount of solvent. Thus, the concentration of solute in such a solution is its solubility.
- Earlier we have observed that solubility of one substance into another depends on the nature of the substances. In addition to these variables, two other parameters, i.e., temperature and pressure also control this phenomenon.
- (i) **Effect of temperature :** The solubility of a solid in a liquid is significantly affected by temperature changes. This, being dynamic equilibrium, must follow Le Chateliers Principle.

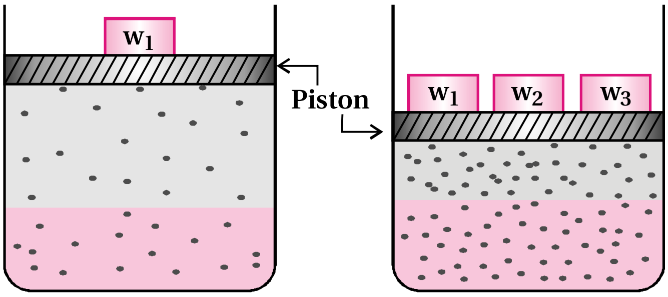
  Solid (Solute) + Liquid (Solvent) $\rightleftharpoons$ Solution

  In general, if in a nearly saturated solution, the dissolution process is endothermic $\Delta H < 0$ means $\Delta H = -ve$. This indicates exothermic reaction (non-endothermic). While $\Delta H > 0$ means $\Delta H = +ve$ (endothermic) (non-exothermic). The solubility should increase with rise in temperature and if it is exothermic ($\Delta_{sol}H > 0$) the solubility should decrease.
- (ii) **Effect of pressure :** Pressure does not have any significant effect on solubility of solids in liquids.
- It is so because solids and liquids are highly incompressible and practically remain unaffected by changes in pressure.

9) Explain solubility of solution formed by gaseous solute and liquid solvent.

- Solubility of a gas is maximum amount gaseous solute that can be dissolved in a specified amount of solvent at a specified temperature and pressure.
- Oxygen dissolves only to a small extent in water. It is this dissolved oxygen which sustains all aquatic life. On the other hand, hydrogen chloride gas (HCl) is highly soluble in water.

  Solubility of gases in liquids is greatly affected by pressure and temperature.



(a) (b)

Effect of pressure on the solubility of a gas. The concentration of dissolved gas is proportional to the pressure on the gas above the solution.

- (i) **Effect of pressure :** The solubility of gases increase with increase of pressure. For solution of gases in a solvent, consider a system as shown in Fig. (a). The lower part is solution and the upper part is gaseous system at pressure P and temperature T. Assume this system to be in a state of dynamic equilibrium, i.e., under these conditions rate of gaseous particles entering and leaving the solution phase is the same.

  Now increase the pressure over the solution phase by compressing the gas to a smaller volume [Fig. (b)]. This will increase the number of gaseous particles per unit volume over the solution and also the rate at which the gaseous particles are striking the surface of solution to enter it. The solubility of the gas will increase until a new equilibrium is reached resulting in an increase in the pressure of a gas above the solution and thus its solubility increases.

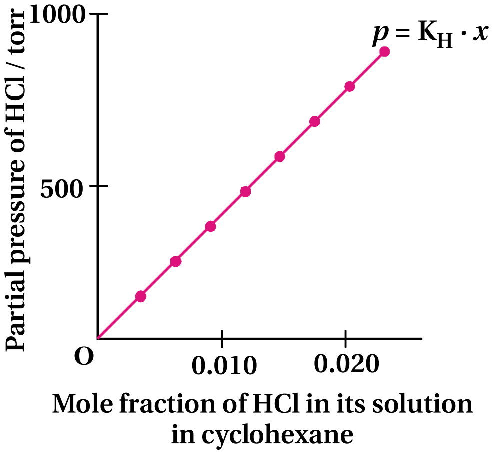
UID : P1-C2-S1-Q9

- **(ii) Effect of temperature :** Solubility of gases in liquid decreases with increase in temperature. When gases are dissolves at that time they are in liquid phase and phenomenon of dissolution is called condensation. In this reaction heat produces. Dissolution process is exothermic in nature so on increase in temperature solubility decreases.

10) Write and explain Henry's law. Also write its application. #

- Henry was the first to give a quantitative relation between pressure and solubility of a gas in a solvent which is known as Henry's law. The law states that at a constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas.
- Dalton, a contemporary of Henry, also concluded independently that the solubility of a gas in a liquid solution is a function of partial pressure of the gas.
- If we use the mole fraction of a gas in the solution as a measure of its solubility, then it can be said that the mole fraction of gas in the solution is proportional to the partial pressure of the gas over the solution.
- The most commonly used form of Henry's law states that "the partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution" and is expressed as :

  Here, K_H is the Henry's law constant.
- If we draw a graph between partial pressure of the gas versus mole fraction of the gas in solution, then we should get a plot of the type as shown in Fig.



Experimental results for the solubility of HCl gas in cyclohexane at 293 K. The slope of the line is the Henry's Law constant, K_H.

- Different gases have different K_H values at the same temperature. This suggests that K_H is a function of the nature of the gas.
- Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid.

Values of Henry's Law Constant for Some Selected Gases in Water

GAS	Temperature/K	K_H/k bar	Gas	Temperature/K	K_H/k bar
He	293	144.97	Argon	298	40.3
H_2	293	69.16	CO_2	298	1.67
N_2	293	76.48	Formaldehyde	298	1.83×10^{-5}
N_2	303	88.84	Methane	298	0.413
O_2	293	34.86	Vinyl chloride	298	0.611
O_2	303	46.82			

- Henry's law finds several applications in industry and explains some biological phenomena. Notable among these are :
- To increase the solubility of CO_2 in soft drinks and soda water, the bottle is sealed under high pressure.
- Scuba divers must cope with high concentrations of dissolved gases while breathing air at high pressure underwater. Increased pressure increases the solubility of atmospheric gases in blood. When the divers come towards surface, the pressure gradually decreases. This releases the dissolved gases and leads to the formation of bubbles of nitrogen in the blood. This blocks capillaries and creates a medical condition known as bends, which are painful and dangerous to life.

UID : P1-C2-S1-Q10

- To avoid bends, as well as, the toxic effects of high concentrations of nitrogen in the blood, the tanks used by scuba divers are filled with air diluted with helium (11.7% helium, 56.2% nitrogen and 32.1% oxygen).
- At high altitudes the partial pressure of oxygen is less than that at the ground level. This leads to low concentrations of oxygen in the blood and tissues of people living at high altitudes or climbers. Low blood oxygen causes climbers to become weak and unable to think clearly, symptoms of a condition known as anoxia.

Example 2.4 If N_2 gas is bubbled through water at 293 K, how many millimoles of N_2 gas would dissolve in 1 litre of water ? Assume that N_2 exerts a partial pressure of 0.987 bar. Given that Henry's law constant for N_2 at 293 K is 76.48 k bar. **S8**

- The solubility of gas is related to the mole fraction in aqueous solution. The mole fraction of the gas in the solution is calculated by applying Henry's law. Thus :

$$x\,(\text{Nitrogen}) = \frac{p\,(\text{nitrogen})}{K_H}$$

$$= \frac{0.987 \text{ bar}}{76480 \text{ bar}} = 1.29 \times 10^{-5}$$

- As 1 litre of water contains 55.5 mol of it, therefore if n represents number of moles of N_2 in solution,

$$x\,(\text{Nitrogen}) = \frac{n \text{ mol}}{n \text{ mol} + 55.5 \text{ mol}}$$

$$= \frac{n}{55.5} = 1.29 \times 10^{-5}$$

(n in denominator is neglected as it is << 55.5)

Thus, $n = 1.29 \times 10^{-5} \times 55.5 \text{ mol} = 7.16 \times 10^{-4} \text{ mol}$

$$= \frac{7.16 \times 10^{-4} \text{ mol} \times 1000 \text{ m mol}}{1 \text{ mol}}$$

$= 0.716$ m mol

❖ TRY YOURSELF ❖ **S7**

[16] Find out the molality of solution formed by dissolving 29.22 g of NaCl in 2.00 kg of water. **[Ans. : 0.25 m]**

[17] Find out the molality of solution prepared by dissolving 2.89 g of NaCl in 0.159 litre of water. Density is 1.00 gm / mL. **[Ans. : 0.311 m]**

❖ SELF - PRACTICE QUESTIONS ❖ **S7**

[18] What is solubility ?

[19] What is saturated solution ?

[20] What is dissolution ?

[21] Give Le Chatelier's law ?

[22] Write Henry's law.

2.4 Vapour Pressure of Liquid Solutions :

11) Derive an equation for solution which shows relation between total pressure and mole fraction of volatile solute and volatile solvent and explain it by plotting graph. #

- Suppose in a binary meaning volatile solution component 1 and component 2 is present. Their mole fraction is X_1 and X_2 and their vapour pressure is p_1 and p_2 respective.
- According to the Raoult's law; a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction present in solution.
- Thus, for component 1 ;

  $p_1 \propto X_1$ and $p_1 = p_1^0 \cdot X_1$ where p_1 is the vapour pressure of pure component 1 at the same temperature.
- Similarly, for component 2 ;

  $p_2 \propto X_2$ and $p_2 = p_2^0 \cdot X_2$,

  where p_2^0 represents the vapour pressure of the pure component 2.
- According to Dalton's law of partial pressures, the total pressure (total p) over the solution phase in the container will be the sum of the partial pressures of the components of the solution.

$$p_{\text{total}} = p_1 + p_2$$

$$p_{\text{total}} = p_1^0 \cdot x_1 + p_2^0 \cdot x_2$$

$$= (1 - x_2)\, p_1^0 + x_2\, p_2^0$$

$$p_{\text{total}} = p_1^0 + x_2(p_2^0 - p_1^0)$$

- Following conclusions can be drawn from equation :

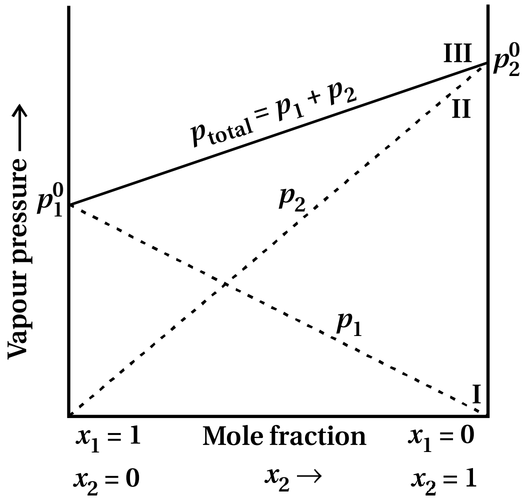
UID : P1-C2-S1-Q11

(i) Total vapour pressure over the solution can be related to the mole fraction of any one component.

(ii) Total vapour pressure over the solution varies linearly with the mole fraction of component 2.

(iii) Depending on the vapour pressures of the pure components 1 and 2, total vapour pressure over the solution decreases or increases with the increase of the mole fraction of component 1.

➠ A plot of p_1 or p_2 versus the mole fractions X_1 and X_2 for a solution gives a linear plot as shown in figure.



➠ These lines (I and II) pass through the points for which X_1 and X_2 are equal to unity. Similarly the plot (line III) of p_{total} versus X_2 is also linear.

➠ The minimum value of p_{total} is p_1^0 and the maximum value is p_2^0, assuming that component 1 is less volatile than component 2, i.e., $p_1^0 < p_2^0$.

➠ The composition of vapour phase in equilibrium with the solution is determined by the partial pressures of the components.

➠ If Y_1 and Y_2 are the mole fractions of the components 1 and 2 respectively in the vapour phase then, using Dalton's law of partial pressures :

$p_1 = Y_1\ p_{total}$ and $p_2 = Y_2\ p_{total}$

So, in general, $p_i = Y_i\ p_{total}$

Example 2.5 : Vapour pressure of chloroform ($CHCl_3$) and dichloromethane (CH_2Cl_2) at 298 K are 200 mm Hg and 415 mm Hg respectively.

(i) Calculate the vapour pressure of the solution prepared by mixing 25.5 g of $CHCl_3$ and 40 g of CH_2Cl_2 at 298 K and,

(ii) Mole fractions of each component in vapour phase. # **S8**

➠**(i)** Molar mass of CH_2Cl_2

$= 12 \times 1 + 1 \times 2 + 35.5 \times 2$

$= 85\ g\ mol^{-1}$

➠**(ii)** Molar mass of $CHCl_3$

$= 12 \times 1 + 1 \times 1 + 35.5 \times 3$

$= 119.5\ g\ mol^{-1}$

$$\text{Moles of } CH_2Cl_2 = \frac{40\ g}{85\ g\ mol^{-1}} = 0.47\ mol$$

$$\text{Moles of } CHCl_3 = \frac{25.5\ g}{119.5\ g\ mol^{-1}} = 0.213\ mol$$

Total number of moles = 0.47 + 0.213

= 0.683 mol

$$x_{CH_2Cl_2} = \frac{0.47\ mol}{0.683\ mol} = 0.688$$

$x_{CHCl_3} = 1.00 - 0.688 = 0.312$

Using equation (2.16)

$$\begin{aligned} p_{total} &= p_1^0 + (p_2^0 - p_1^0)\ x_2 \\ &= 200 + (415 - 200) \times 0.688 \\ &= 200 + 147.9 = 347.9 \text{ mm Hg} \end{aligned}$$

➠**(ii) Using the relation $p_i = y_1/p_{total}$ we can calculate the mole :**

$p_{CH_2Cl_2} = 0.688 \times 415$ mm Hg = 285.5 mm Hg

$p_{CHCl_3} = 0.312 \times 200$ mm Hg = 62.4 mm Hg

$y_{CH_2Cl_2}$ = 285.5 mm Hg/347.9 mm Hg = 0.82

$y_{CH_2Cl_3}$ = 62.4 mm Hg/347.9 mm Hg = 0.18

Note : Since, CH_2Cl_2 is a more volatile component than $CHCl_3$.

[$p^0_{CH_2Cl_2}$ = 415 mm Hg and $p^0_{CHCl_3}$ = 200 mm Hg]

and the vapour phase is also richer in CH_2Cl_2 .

[$y_{CH_2Cl_2}$ = 0.82 and y_{CHCl_3} = 0.18]

➠ It may thus be concluded that at equilibrium, vapour phase will be always rich in the component which is more volatile.

UID : P1-C2-S8-Q2.5♦

12) Explain "Solubility of gaseous solute and vapour pressure of liquid solution follows Henry's and Raoult's law."

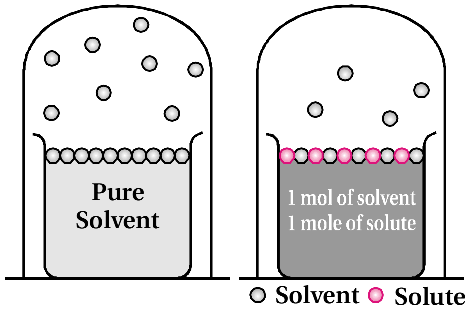
- According to Raoult's law, the vapour pressure of a volatile component in a given solution is given by $p_i = x_i\ p_i^0$
- In the solution of a gas in a liquid, one of the components is so volatile that it exists as a gas and we have already seen that its solubility is given by Henry's law which states that

$$p = K_H \cdot x$$

- If we compare the equations for Raoult's law and Henry's law, it can be seen that the partial pressure of the volatile component or gas is directly proportional to its mole fraction in solution. Only the proportionality constant K_H differs from p_i^0.
- Thus, Raoult's law becomes a special case of Henry's law in which K_H becomes equal to p_i^0.

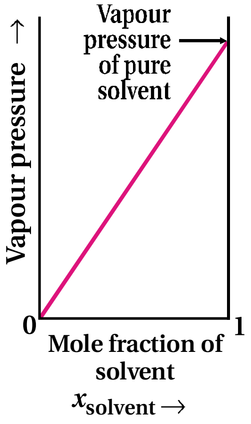
13) Explain vapour pressure of solutions of solids in liquids.

- Liquids at a given temperature vapourise and under equilibrium conditions the pressure exerted by the vapours of the liquid over the liquid phase is called vapour pressure.



(a) (b)

- In a pure liquid the entire surface is occupied by the molecules of the liquid. If anon-volatile solute is added to a solvent to give a solution, the vapour pressure of the solution is solely from the solvent alone.
- This vapour pressure of the solution at a given temperature is found to be lower than the vapour pressure of the pure solvent at the same temperature. In the solution, the surface has both solute and solvent molecules; there by the fraction of the surface covered by the solvent molecules gets reduced. Consequently, the number of solvent molecules escaping from the surface is correspondingly reduced, thus, the vapour pressure is also reduced.
- The decrease in the vapour pressure of solvent depends on the quantity of non-volatile solute present in the solution, irrespective of its nature.



- Let p_1 be the vapour pressure of the solvent, x_1 be its mole fraction, p_1^0 be its vapour pressure in the pure state. Then according to Raoult's law

$p_1 \propto x_1$ and $p_1 = x_1 \times p_1^0$

- The proportionality constant is equal to the vapour pressure of pure solvent, p_1^0.

A plot between the vapour pressure and the mole fraction of the solvent is linear.

❖ TRY YOURSELF ❖ S7

[23] How many milimoles of CO_2 gas will dissolve when CO_2 gas is passed in 900 mL water at 298 K temperature ?

[The value of K_H is 6.02×10^{-4} bar and partial pressure of CO_2 gas is 2×10^{-8} bar.]

[Ans. : 1.661 milimoles]

[24] How many milimoles of nitrogen dissolve when nitrogen is passed in 1 litre water at 293 K temperature ?

[The value of K_H is 7.648×10^{4} bar and partial pressure of N_2 gas is 0.987 bar.]

[Ans. : 0.72 milimoles]

[25] Calculate K_H when 2 milimoles of O_2 dissolve in 540 mL of water at 27°C temperature. ($P_{O_2} = 2 \times 10^{-8}$ bar) **[Ans. : 3×10^{-4} bar]**

❖ SELF - PRACTICE QUESTIONS ❖ S7

[26] Write Dalton's law for the partial pressure.

[27] Write formula which relationship between total pressure of solution and mole fraction.

[28] What is vapour pressure ?

[29] Graph between vapour pressure and mole fraction of solvent is......

UID : P1-C2-S1-Q12

2.5 Ideal and Non-ideal Solutions :

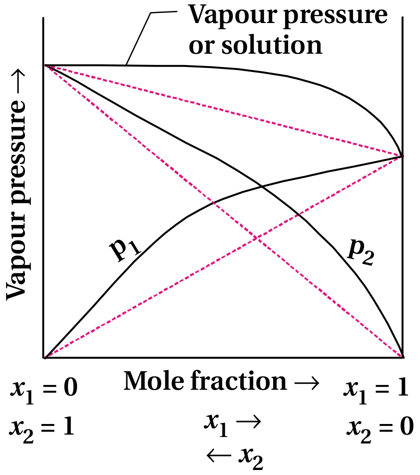
14) Explain ideal solution. #

- The solutions which obey Raoult's law over the entire range of concentration are known as ideal solutions. The ideal solutions have two other important properties.
- The enthalpy of mixing of the pure components to form the solution is zero and the volume of mixing is also zero,

  i.e., $\Delta_{mix}H = 0$, $\Delta_{mix}V = 0$.
- It means that no heat is absorbed or evolved when the components are mixed. Also, the volume of solution would be equal to the sum of volumes of the two components. At molecular level, ideal behaviour of the solutions can be explained by considering two components A and B.
- In pure components, the intermolecular attractive interactions will be of types A-A and B-B, whereas in the binary solutions in addition to these two interactions, A-B type of interactions will also be present.
- If the intermolecular attractive forces between the A-A and B-B are nearly equal to those between A-B, this leads to the formation of ideal solution. A perfectly ideal solution is rare but some solutions are nearly ideal in behaviour.
- Solution of n-hexane and n-heptane, bromoethane and chloroethane, benzene and toluene, etc. fall into this category.

15) What are non ideal solutions ? Explain non ideal solutions with positive deviation and those with negative deviation.

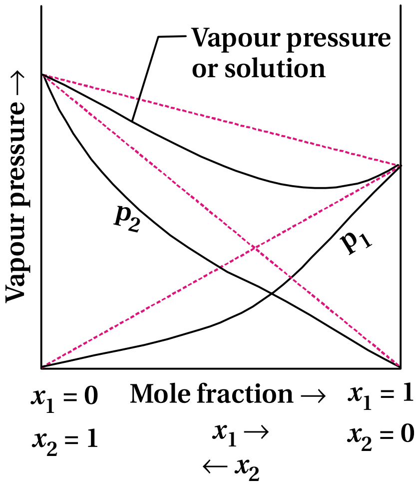
- When a solution does not obey Raoult's law over the entire range of concentration, then it is called non-ideal solution.
- The vapour pressure of such a solution is either higher or lower than that predicted by Raoult's law. If it is higher, the solution exhibits positive deviation and if it is lower, it exhibits negative deviation from Raoult's law.
- **Positive deviation :**



(a)

- In case of positive deviation from Raoult's law, A-B interactions are weaker than those between A-A or B-B, i.e., in this case the intermolecular attractive forces between the solute-solvent molecules are weaker than those between the solute-solute and solvent-solvent molecules. This means that in such solutions, molecules of A (or B) will find it easier to escape than in pure state. This will increase the vapour pressure and result in positive deviation.

  Example : Mixtures of ethanol and acetone.
- In pure ethanol, molecules are hydrogen bonded. On adding acetone, its molecules get in between the host molecules and break some of the hydrogen bonds between them. Due to weakening of interactions, the solution shows positive deviation from Raoult's law. Another example: CS_2 and Acetone
- **Negative deviation :**

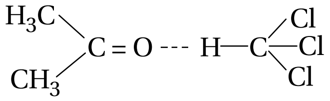


(b)

UID : P1-C2-S1-Q14

- In case of negative deviations from Raoult's law, the intermolecul arattractive forces between A-A and B-B are weaker than those between A-B and leads to decrease in vapour pressure resulting in negative deviations.

  Example : (i) Mixture of phenol and aniline. In this case the intermolecular hydrogen bonding between phenolicproton and lone pair on nitrogen atom of aniline is stronger than the respective intermolecular hydrogen bonding between similar molecules. (ii) A mixture of chloroform and acetone forms a solution with negative deviation from Raoult's law. This is because chloroform molecule is able to form hydrogen bond with acetone molecule as shown.



- This decreases the escaping tendency of molecules for each component and consequently the vapour pressure decreases resulting in negative deviation from Raoult's law.

16) What is azeotropes ? Explain their types.

- Some liquids on mixing, form azeotropes which are binary mixtures having the same composition in liquid and vapour phase and boil at a constant temperature. In such cases, it is not possible to separate the components by fractional distillation.
- There are two types of azeotropes called minimum boiling azeotrope and maximum boiling azeotrope.
- (i) **Minimum Boiling azeotrope :** The solutions which show a large positive deviation from Raoult's law form minimum boiling azeotrope at a specific composition.

  For Example : ethanol-water mixture on fractional distillation gives a solution containing approximately 95 % by volume of ethanol. Once this composition, known as azeotrope composition, has been achieved, the liquid and vapour have the same composition, and no further separation occurs.
- (ii) **Maximum Boiling azeotropes :** The solutions that show large negative deviation from Raoult's law form maximum boiling azeotrope at a specific composition.

  Example : Nitric acid and water is an example of this class of azeotrope. This azeotrope has the approximate composition, 68% nitric acid and 32% water by mass, with a boiling point of 393.5 K.

❖ TRY YOURSELF ❖ S7

[30] The vapour pressure of benzene and toluene are 0.9 and 0.85 respectively. Calculate vapour pressure of solvent in solution prepared by dissolving 7.8 gm benzene in 180 gm of toluene.
[Ans. : 0.8254 Bar]

[31] The vapour pressure of ethanol and methanol at 298 K is 44.5 mm and 88.7 mm respectively. At same temperature, if ideal solution is prepared by mixing 60 gm of ethanol and 40 gm of methanol. Then find out mole fraction of methanol in vapour state. **[Ans. : 0.656]**

[32] For two volatile liquid A and B if the vapour pressure ratio of $P^0_A : P^0_B = 1 : 2$ and $X_A : X_B = 1 : 2$, then find out mole fraction of component A in vapour state ? **[Ans. : 0.20]**

[33] Mole of Chlorobenzene and bromo benzene is 0.1 and 0.2 respectively. The vapour pressure of chlorobenzene and bromo benzene is 0.350 bar and 0.500 bar respectively. So find out total vapour pressure of solution prepared by mixing of chlorobenzene and bromo benzene.
[Ans. : 0.450 bar]

❖ SELF - PRACTICE QUESTIONS ❖ S7

[34] Give examples of ideal solution.
[35] What is non - ideal solution ?
[36] Write examples of azeotropes.
[37] What is positive deviation ?
[38] Give value for ΔH and ΔV for ideal solution

2.6 Colligative Properties and Determination of Molar Mass :

17) What is colligative properties ? Explain.

- The vapour pressure of solution decreases when a non-volatile solute is added to a volatile solvent. There are many properties of solutions which are connected with this decrease of vapour pressure. These are :

  (i) Relative lowering of vapour pressure of the solvent.

UID : P1-C2-S1-Q16

(ii) Depression of freezing point of the solvent.

(iii) Elevation of boiling point of the solvent and

(iv) Osmotic pressure of the solution.

➠ All these properties depend on the number of solute particles irrespective of their nature relative to the total number of particles present in the solution. Such properties are called colligative properties.

18) Write Raoult's law for non-volatile solute and volatile solvent and explain it. [July-2018] OR Write about Raoult's law for non-volatile solute and prove it. Write the formula to find out molecular mass of solute according to above rule. # [March, July - 2018]

➠ The vapour pressure of a solvent in solution is less than that of the pure solvent because the lowering of vapour pressure depends only on the concentration of the solute particles.

➠ A relation between vapour pressure of the solution, mole fraction and vapour pressure of the solvent, i.e., $p_1 = x_1 \cdot p_1^0$

➠ The reduction in the vapour pressure of solvent (Δp_1) is given as : $p_1 = x_1 \cdot p_1^0$

It should be decrease in vapour pressure = $p_1^0 - p_1 = p_1^0 - p_1^0 x_1$

$1 - x_1 = x_2$

$\Delta p_1 = x_2 \cdot p_1^0$

➠ In a solution containing several non-volatile solutes, the lowering of the vapour pressure depends on the sum of the mole fraction of different solutes.

$$\frac{\Delta p_1}{p_1^0} = \frac{p_1^0 - p_1}{p_1^0} = x_2$$

So, relative lowering of vapour pressure $\left(\frac{p_1^0 - p_1}{p_1^0}\right)$ is equal to the mole fraction (X_2) of the solute.

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{n_2}{n_1 + n_2}$$

where, n_1 = moles of solvent and

n_2 = moles of solute

➠ For dilute solutions n2<< n1, hence neglecting n2 in the denominator we have,

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{n_2}{n_1}$$

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

where, w_1 = weight of solvent

w_2 = weight of solute

M_1 = molar weight of solvent

M_2 = molar weight of solute

Example 2.6 : The vapour pressure of pure benzene at a certain temperature is 0.850 bar. A non-volatile, non-electrolyte solid weighing 0.5 g when added to 39.0 g of benzene (molar mass 78 g mol^{-1}). Vapour pressure of the solution, then, is 0.845 bar. What is the molar mass of the solid substance ? S8

➠ The various quantities known to us are as follows :

$p_1^0 = 0.850$ bar, $p_1 = 0.845$ bar

$M_1 = 78.0$ g mol^{-1}; $w_2 = 0.5$ g; $w_1 = 39$ g

➠ Substituting these values in equation :

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

$$\frac{0.850 \text{ bar} - 0.845 \text{ bar}}{0.850 \text{ bar}} = \frac{0.5 \text{ g} \times 78 \text{ g mol}^{-1}}{M_2 \times 39 \text{ g}}$$

➠ Therefore, $M_2 = 170$ g mol^{-1}

19) What is elevation in boiling point? Explain.

➠ The temperature at which, the vapour pressure of solvent or solution is equal to the atmospheric pressure, such temperature is known as boiling point of such solvent or solution.

➠ For example, water boils at 373.15 K (100° C) because at this temperature the vapour pressure of water is 1.013 bar (1 atmosphere).

➠ For example, the vapour pressure of an aqueous solution of sucrose is less than 1.013 bar at 373.15 K.

➠ In order to make this solution boil, its vapour pressure must be increased to 1.013 bar by raising the temperature above the boiling temperature of the pure solvent (water).

20) What is molal elevation ? Explain.

➠ Increase in boiling point of a solution prepared by dissolving one gram molar mass of non volatile solute in one kilogram of solvent is called as molal elevation.

➠ The boiling point of a solution is always higher than that of the boiling point of the pure solvent in which the solution is prepared, the elevation of boiling point also depends on the number of solute molecules rather than their nature.

➠ Let T_b^0 be the boiling point of pure solvent and T_b be the boiling point of solution. The increase in the boiling point $\Delta T_b = T_b - T_b^0$ is known as elevation of boiling point.

UID : P1-C2-S1-Q18

➠ For dilute solutions the elevation of boiling point (ΔT_b) is directly proportional to the molal concentration of the solute in a solution. Thus,

$$\Delta T_b \propto m$$

$$\Delta T_b = K_b m \qquad \ldots\ldots(1)$$

Where, m = molality

K_b = Boiling Point Elevation Constant or Molal Elevation Constant (Ebullioscopic Constant)

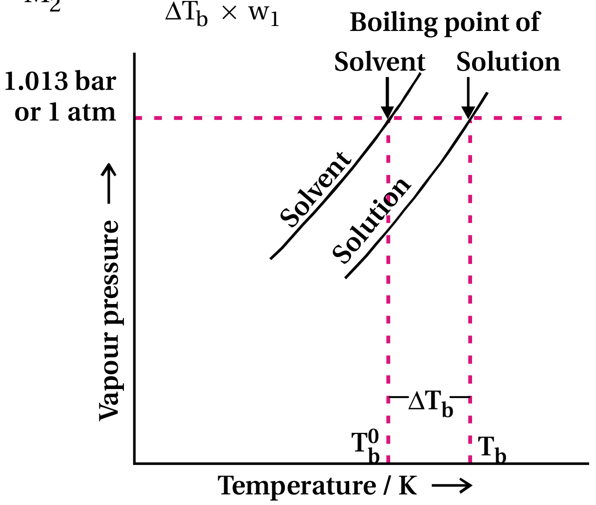
➠ The unit of K_b is K kg mol^{-1}. If w_2 gram of solute of molar mass M_2 is dissolved in w_1 gram of solvent, then molality, m of the solution is given by the expression :

$$m = \frac{w_2 \times M_2}{w_1/1000} = \frac{1000 \times w_2}{M_2 \times w_1}$$

➠ Substituting the value of molality in equation (1) we get

$$\Delta T_b = \frac{K_b \times 1000 \times w_2}{M_2 \times w_1}$$

$$M_2 = \frac{1000 \times w_2 \times K_b}{\Delta T_b \times w_1}$$



Example 2.7 18 g of glucose, $C_6H_{12}O_6$, is dissolved in 1 kg of water in a saucepan. At what temperature will water boil at 1.013 bar ? K_b for water is 0.52 K kg mol^{-1}. S8 [May - 2021]

➠ Moles of glucose = 18 g/180 g mol^{-1} = 0.1 mol

Number of kilograms of solvent = 1 kg

Thus molality of glucose solution = 0.1 mol kg^{-1}

For water, change in boiling point

$$\Delta T_b = K_b \times m$$
$$= 0.52 \text{ K kg mol}^{-1} \times 0.1 \text{ mol kg}^{-1} = 0.052 \text{ K}$$

➠ Since water boils at 373.15 K at 1.013 bar pressure.

➠ Therefore, the boiling point of solution will be 373.15 + 0.052 = 373.202 K.

Example 2.8 The boiling point of benzene is 353.23 K. When 1.80 g of a non-volatile solute was dissolved in 90 g of benzene, the boiling point is raised to 354.11 K. Calculate the molar mass of the solute. K_b for benzene is 2.53 K kg mol^{-1}. S8

➠ The elevation (ΔT_b) in the boiling point = 354.11 K – 353. 23 K = 0.88 K

➠ Substituting these values in expression

$$M_2 = \frac{1000 \times w_2 \times K_b}{\Delta T_b \times w_1}$$

we get,

$$M_2 = \frac{2.53 \text{ K kg mol}^{-1} \times 1.8 \text{ g} \times 1000 \text{ g kg}^{-1}}{0.88 \text{ K} \times 90 \text{ g}}$$
$$= 58 \text{ g mol}^{-1}$$

Therefore, molar mass of the solute,

$$M_2 = 58 \text{ g mol}^{-1}$$

21) What is depression of freezing point ? Explain.

➠ The freezing point of a substance may be defined as the temperature at which the vapour pressure of the substance in its liquid phase is equal to its vapour pressure in the solid phase.

➠ At any temperature the vapour pressure of solution is lower than that of pure solvent. The lowering of freezing point in solution as compared to solvent is known as depression of freezing point.

22) What is molal depression constant (K_f) ? Derive equation relating K_f with molar mass of solute.

➠ Decrease in freezing point of a solution prepared by dissolving one gram molar mass of non-volatile solute into one kilogram of solvent is called molal depression constant.

➠ Let T_f^0 be the freezing point of pure solvent and T_f be its freezing point when non-volatile solute is dissolved in it. The decrease in freezing point. $\Delta T_f = T_f^0 - T_f$ is known as depression in freezing point.

➠ For dilute solution (ideal solution) is directly proportional to molality, m of the solution. Thus, $\Delta T_f \propto m$

$$\Delta T_f = K_f \cdot m \qquad \ldots.(i)$$

UID : P1-C2-S1-Q21

- The proportionality constant K_f, which depends on the nature of the solvent is known as Freezing Point Depression Constant or Molal Depression Constant or Cryoscopic Constant. The unit of K_f is K kg mol^{-1}.

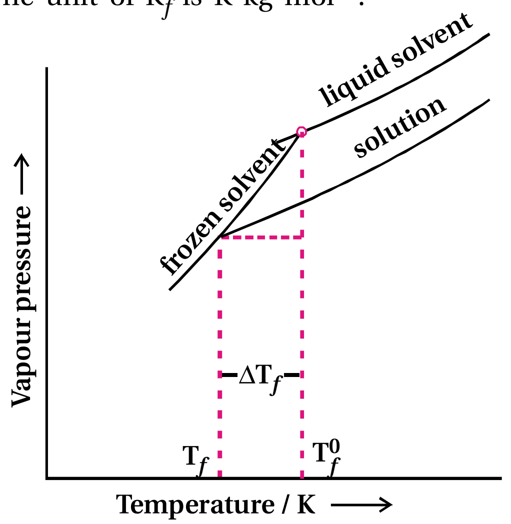


Diagram showing ΔT_f, depression of the freezing point of a solvent in a solution.

- If w_2 gram of the solute having molar mass as M_2, present in w_1 gram of solvent, produces the depression in freezing point ΔT_f of the solvent then molality of the solute is given by the equation.

$$m = \frac{w_2 / M_2}{w_1 / 1000}$$

- Substituting this value of molality in equation (i) we get,

$$\Delta T_f = \frac{K_f \times w_2 / M_2}{w_1 / 1000}$$

$$\Delta T_f = \frac{K_f \times w_2 \times 1000}{w_1 \times M_2}$$

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

Example 2.9. 45 g of ethylene glycol ($C_2H_6O_2$) is mixed with 600 g of water. Calculate (a) the freezing point depression and (b) the freezing point of the solution. S8

- Depression in freezing point is related to the molality, therefore, the molality of the solution with respect to ethylene glycol.

$$= \frac{\text{moles of ethylene glycol}}{\text{mass of water in kilogram}}$$

∴ Moles of ethylene glycol $= \frac{45 \text{ g}}{62 \text{ g mol}^{-1}}$

$= 0.73$ mol

∴ Mass of water in kg $= \frac{600 \text{ g}}{1000 \text{ g kg}^{-1}} = 0.6$ kg

∴ Hence molality of ethylene glycol

$= \frac{0.73 \text{ mol}}{0.60 \text{ kg}}$

$= 1.2$ mol kg^{-1}

∴ Therefore freezing point depression,

$\Delta T_f = 1.86$ K kg mol^{-1} × 1.2 mol kg^{-1}

$= 2.2$ K

∴ Freezing point of the aqueous solution,

$= 273.15$ K − 2.2 K

$= 270.95$ K

Example : 2.10. 1.00 g of a non-electrolyte solute dissolved in 50 g of benzene lowered the freezing point of benzene by 0.40 K. The freezing point depression constant of benzene is 5.12 K kg mol^{-1}. Find the molar mass of the solute. S8

- Substituting the values of various terms involved in following equation, we get

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

$$M_2 = \frac{5.12 \text{K kg mol}^{-1} \times 1.00 \text{ g} \times 1000 \text{ g kg}^{-1}}{0.40 \times 50 \text{ g}}$$

$= 256$ g mol^{-1}

- Thus, molar mass of the solute = 256 g mol^{-1}

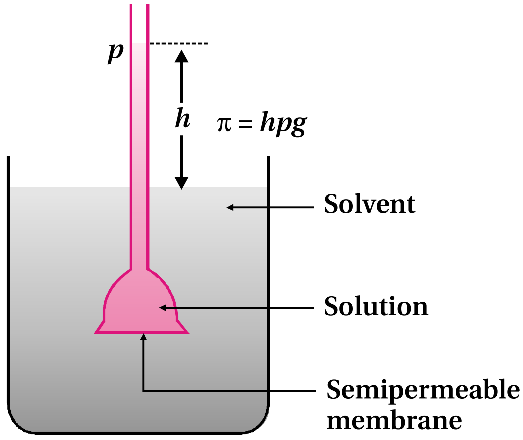
23) What is semi permeable membrane ? Give examples.

- The membrane which allows only the small molecule of solvent to pass but can't pass solute molecule as semi permeable membrane.
- **Example :** These membranes can be of animal or vegetable origin and these occur naturally such as pig's bladder or parchment or can be synthetic such as cell ophane.
- These membranes appear to be continuous sheets or films, yet they contain a network of submicroscopic holes or pores.

UID : P1-C2-S1-Q23

24) Explain : What is osmosis ? Give example.

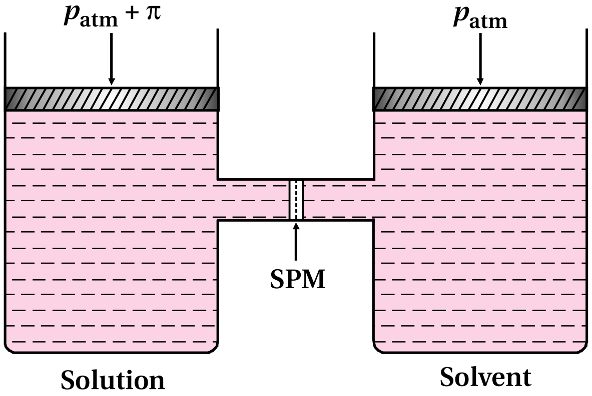
- Assume that only solvent molecules can pass through these semipermeable membranes. If this membrane is placed between the solvent and solution, the solvent molecules will flow through the membrane from pure solvent to the solution. This process of flow of the solvent is called osmosis. The flow will continue till the equilibrium is attained.
- **Examples :** (i) Raw mangoes shrivel when pickled in brine (salt water) (ii) wilted flowers revive when placed in fresh water (iii) blood cells collapse when suspended in saline water, etc.



Level of solution rises in the thistle funnel due to osmosis of solvent.

25) What is osmotic pressure ? Explain and derive equation. [March-2019]

- The flow of the solvent from its side to solution side across a semipermeable membrane can be stopped if some extra pressure is applied on the solution. This pressure that just stops the flow of solvent is called osmotic pressure (π) of the solution. In short, the pressure which stops the spontaneous flow of solvent is known as osmotic pressure (π) of the solution.
- The flow of solvent from dilute solution to the concentrated solution across a semipermeable membrane is due to osmosis. The important point to be kept in mind is that solvent molecules always flow from lower concentration to higher concentration of solution. The osmotic pressure has been found to depend on the concentration of the solution.



- Osmotic pressure is a colligative property as it depends on the number of solute molecules and not on their identity. For dilute solutions, osmotic pressure is proportional to the molarity, C of the solution at a given temperature T. Thus;

$$\therefore \quad \pi = CRT \qquad \therefore \quad \pi = \frac{n_2}{V}RT$$

- Here, π is the osmotic pressure; R is the gas constant and V is the volume of solution.
- V is volume of a solution in litres containing n_2 moles of solute. If w_2 grams of solute, of molar mass, M_2 is present in the solution, then $n_2 = \frac{w_2}{M_2}$

$$\therefore \quad \pi V = \frac{w_2 RT}{M_2}$$

- Thus, knowing the quantities w_2, T, π and V we can calculate the molar mass of the solute.

26) Which method is most suitable to determine molecular mass of polymer ?

- Measurement of osmotic pressure provides another method of determining molar masses of solutes. This method is widely used to determine molar masses of proteins, polymers and other macro molecules.
- The osmotic pressure method has the advantage over other methods as pressure measurement is around the room temperature and the molarity of the solution is used instead of molality.
- As compared to other colligative properties, its magnitude is large even for very dilute solutions. The technique of osmotic pressure for determination of molar mass of solutes is particularly useful for bio molecules as they are generally not stable at higher temperatures and polymers have poor solubility.

UID : P1-C2-S1-Q24

27) Explain isotonic solutions.

- Two solutions having same osmotic pressure at a given temperature are called isotonic solutions.
- When such solutions are separated by semipermeable membrane no osmosis occurs between them. For example, the osmotic pressure associated with the fluid inside the blood cell is equivalent to that of 0.9% (mass/volume) sodium chloride solution, called normal saline solution and it is safe to inject intravenously.
- **Hypertonic solution :** The solution which possess more osmotic pressure with respect to other solution possessing less osmotic pressure is known as Hypertonic solution.

  For example : Out of 10 %w/V and 20 %w/V urea solutions. 20 %w/V is hypertonic.
- **Hypotonic solution :** The solution which possess less osmotic pressure, such solution is known as hypotonic solution with respect to the solution possessing more osmotic pressure.

  For example : Out of 10 %w/V and 20 %w/V urea solutions. 10 %w/V solution is hypotonic.

Example : 2.11 200 cm^3 of an aqueous solution of a protein contains 1.26 g of the protein. The osmotic pressure of such a solution at 300 K is found to be 2.57 × 10^{-3} bar. Calculate the molar mass of the protein. S8 [May - 2021]

- The various quantities known to us are as follows :

π = 2.57 × 10^{-3} bar,

V = 200 cm^3 = 0.200 litre

T = 300 K

R = 0.083 L bar mol^{-1} K^{-1}

- Putting above value in equation :

$$M_2 = \frac{w_2 RT}{\pi V}$$

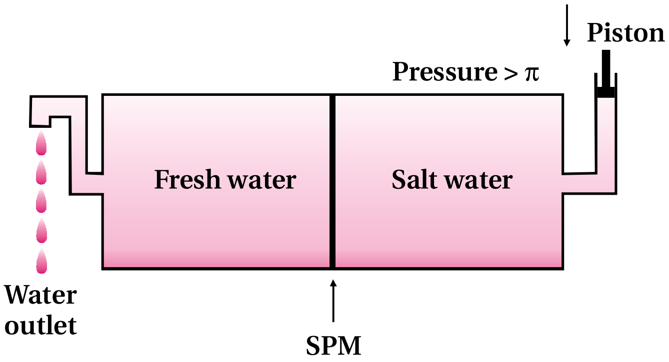
$$M_2 = \frac{1.26\text{g} \times 0.083\,\text{L bar K}^{-1}\,\text{mol}^{-1} \times 300\text{K}}{2.57 \times 10^{-3}\,\text{bar} \times 0.200\,\text{L}}$$

$$= 61{,}022 \text{ g mol}^{-1}$$

UID : P1-C2-S1-Q27

28) Explain reverse osmosis and purification of water.

- The direction of osmosis can be reversed if a pressure larger than the osmotic pressure is applied to the solution side. That is, now the pure solvent flows out of the solution through the semi permeable membrane. This phenomenon is called reverse osmosis.



- The pressure required for the reverse osmosisis quite high. A workable porous membrane is a film of cellulose acetate placed over a suitable support. Cellulose acetate is permeable to water but impermeable to impurities and ions present in sea water. These days many countries used esalination plants to meet their potable water requirements.

❖ TRY YOURSELF ❖ **S7**

[39] Calculate freezing point of solution prepared by dissolving 1.8 gm glucose in 500 gm water. K_f value for solvent is 1.8 K kg mol^{-1}.

[Ans. : 272.964 K]

[40] If freezing point of 5% w/w aqueous solution of sucrose has 271 K and pure water has freezing point of 273.15 K then calculate freezing point of 5% w/w aqueous solution of glucose.

[Ans. : 269.07 K]

[41] When 0.01 mol sodium sulphate is dissolve in 1 kg of water then complete ionization of solution is observed. Find out decrease in freezing point of such solution. (K_f = 1.86 K kg mol^{-1})

[Ans. : 0.0186 K]

[42] The aqueous solution of urea has freezing point –0.6°C. To prepare such solution how much gram of urea is needed to dissolve in 3 kg of water ? (M = 60 gm/mol) (K_f = 1.5°C kg mol^{-1})

[Ans. : 72 gm]

[43] Calculate osmotic pressure of solution which is prepared by dissolving 1.75 gm glucose in 150 mL of solution at 17°C. **[Ans. : 0.812]**

[44] At which temperature 0.006 % w/V urea solution has osmotic pressure 0.0246 atmosphere ? **[Ans. : 300 K]**

[45] If 5% sugar solution is isotonic with 1% solution of unknown substance, then find out molecular mass of unknown substance. **[Ans. : 68.4 gm / mol]**

[46] Find out osmotic pressure of 12 % w/V KCl solution at 27°C. **[Ans. : 73.30 atm]**

[47] Find out osmotic pressure of 0.2 M solution of glucose at 300 K. **[Ans. : 4.92 atm]**

[48] If solution have osmotic pressure of 0.82 bar at 27°C, then find out concentration of such solution ? **[Ans. : 0.033 M]**

❖ SELF - PRACTICE QUESTIONS ❖ S7

[49] What are colligative properties ?

[50] Give name of colligative properties.

[51] What is boiling point ?

[52] Give unit for molal elevation in boiling point.

[53] Give formula for boiling constant.

[54] Find out relation between freezing point and fusion enthalpy of solvent.

[55] Write formula which shows the relation between boiling point and evaporation enthalpy of solvent.

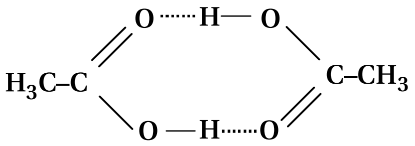
2.7 Abnormal Molar Masses :

29) Explain abnormal molar masses. Also explain association and dissociation of solute. #

➠ **Dissociation :** When ionic compounds when dissolved in water dissociate into cations and anions, and increase number of soluble particles in solution which is known as dissociation. For example, if we dissolve one mole of KCl in water, we expect one mole each of K^+ and Cl^- ions to be released in the solution.

➠ If we ignore interionic attractions, one mole of KCl in one kg of water would be expected to increase the boiling point by 2 × 0.52 K = 1.04 K. Now if we did not know about the degree of dissociation, we could be led to conclude that the mass of 2 mol particles is 74.5 g and the mass of one mole of KCl would be 37.25 g. This brings into light the rule that, when there is dissociation of solute into ions, the experimentally determined molar mass is always lower than the true value.

$$2\,CH_3COOH \rightleftharpoons (CH_3COOH)_2$$



➠ Molecules of acetic acid dimerise in benzene due to hydrogen bonding. This normally happens in solvents of low dielectric constant. In this case the number of particles is reduced due to dimerisation.

➠ Association of molecules is depicted as follows : It can be undoubtedly stated here that if all the molecules of ethanoic acid associate in benzene, then ΔT_b or ΔT_f for ethanoic acid will be half of the normal value. The molar mass calculated on the basis of this ΔT_b or ΔT_f will, therefore, be twice the expected value.

➠ Such a molar mass that is either lower or higher than the expected or normal value is called as abnormal molar mass.

30) Explain van't Hoff factor.

➠ van't Hoff introduced a factor *i*, known as the van't Hoff factor, to account for the extent of dissociation or association. This factor *i* is defined as :

$$i = \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$$

$$= \frac{\text{Observed colligaitve property}}{\text{Calculated colligative property}}$$

$$i = \frac{\text{Total number of moles of particles after association/dissociation}}{\text{Number of molar of particles before association/dissociation}}$$

UID : P1-C2-S1-Q29

- Here abnormal molar mass is the experimentally determined molar mass and calculated colligative properties are obtained by assuming that the non-volatile solute is neither associated nor dissociated.
- In case of association, value of i is less than unity while for dissociation it is greater than unity, while when no association / dissociation, then $i = 1$
- For example, the value of i for aqueous KCl solution is close to 2, while the value for ethanoic acid in benzene is nearly 0.5.
- Inclusion of van't Hoff factor modifies the equations for colligative properties as follows :

$$\frac{P_1^0 - P_1}{P_1^0} = i\,\frac{n_2}{n_1}$$

Relative lowering of vapour pressure of solvent,

Elevation of Boiling point, $\Delta T_b = i\,K_b\,m$

Depression of Freezing point, $\Delta T_f = i\,K_f\,m$

Osmotic pressure of solution, $\pi = iCRT = i\left(\frac{n}{V}\right)RT$

-

Salt	*Values of i			van't Hoff factor i for complete dissociation
	0.1 m	0.01 m	0.001 m	of solute
NaCl	1.87	1.94	1.97	2.00
KCl	1.85	1.94	1.98	2.00
$MgSO_4$	1.21	1.53	1.82	2.00
K_2SO_4	2.32	2.70	2.84	3.00

Example-2.12 : 2 g of benzoic acid (C_6H_5COOH) dissolved in 25g of benzene shows a depression in freezing point equal to 1.62 K. Molal depression constant for benzene is 4.9 K kg mol^{-1}. What is the percentage association of acid if it forms dimer in solution ? # **S8**

- The given quantities are :

$w_2 = 2$ g ; $K_f = 4.9$ K kg mol^{-1} ;

$w_1 = 25$ g, $\Delta T_f = 1.62$ K

- Substituting these values in equation,

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

$$= \frac{4.9\ \text{K kg mol}^{-1} \times 2\ \text{g} \times 1000\ \text{g kg}^{-1}}{25\ \text{g} \times 1.62\ \text{K}}$$

$$= 241.98\ \text{g mol}^{-1}$$

- Thus, experimental molar mass of benzoic acid in benzene is = 241.98 g mol^{-1}

Now consider the following equilibrium for the acid : $2\ C_6H_5COOH \rightleftharpoons (C_6H_5COOH)_2$

- If x represents the degree of association of the solute then we would have $(1 - x)$ mol of benzoic acid left in unassociated form and correspondingly $\frac{x}{2}$ as associated moles of benzoic acid at equilibrium. Therefore, total number of moles of particles at equilibrium is :

$$1 - x + \frac{x}{2} = 1 - \frac{x}{2}$$

- Thus, total number of moles of particles at equilibrium equals van't Hoff factor (i).

$$\text{But } i = \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$$

$$= \frac{122\ \text{g mol}^{-1}}{241.98\ \text{g mol}^{-1}}$$

$$\text{or } \frac{x}{2} = 1 - \frac{122}{241.98} = 1 - 0.504 = 0.496$$

or $x = 2 \times 0.496 = 0.992$

- Therefore, degree of association of benzoic acid in benzene is 99.2 %.

❖ **If depression in freezing point of a solution prepared by dissolving 1 gram benzoic acid to the 25 gram of benzene is 0.81 Kelvin then find out degree of association. Molal depression constant of solvent is 4.9 Kelvin kilogram mole^{-1}. S8** **[July - 2019]**

- **Similar to Ex.-2.12 (Calculate accordingly)**

UID : P1-C2-S8-Q2.12♦

Example-2.13 : 0.6 mL of acetic acid (CH_3COOH), having density 1.06 g mL^{-1}, is dissolved in 1 litre of water. The depression in freezing point observed for this strength of acid was 0.0205°C. Calculate the van't Hoff factor and the dissociation constant of acid. # S8

➠ Number of moles of acetic acid,

$$= \frac{0.6\ mL \times 1.06\ g\ mL^{-1}}{60\ g\ mol^{-1}} = 0.0106\ mol = n$$

➠ Molality $= \dfrac{0.0106\ mol}{1000\ mL \times 1 g\ mL^{-1}}$

$$= 0.0106\ mol\ kg^{-1}$$

$$\therefore \quad \Delta T_f = 1.86\ K\ kg\ mol^{-1} \times 0.0106\ mol\ kg^{-1}$$

$$= 0.0197\ K$$

$$\text{van't Hoff factor } (i) = \frac{\text{Observed freezing point}}{\text{Calculated freezing point}}$$

$$= \frac{0.0205\ K}{0.0197\ K} = 1.041$$

➠ Acetic acid is a weak electrolyte and will dissociate into two ions : acetate and hydrogen ions per molecule of acetic acid. If X is the degree of dissociation of acetic acid, then we would have $n(1-X)$ moles of undissociated acetic acid, nx moles of CH_3COO^- and nx moles of H^+ ions,

$$\begin{array}{ccc} CH_3COOH & \rightleftharpoons H^+ & + \ CH_3COO^- \\ n\ mol & 0 & 0 \\ n(1-x) & nx\ mol & nx\ mol \end{array}$$

➠ Thus total moles of particles are :

$$n\,(1 - x + x + x) = n\,(1 + x)$$

$$i = \frac{n\,(1 + x)}{n} = 1 + x = 1.041$$

➠ Thus degree of dissociation of acetic acid

$$= x = 1.041 - 1.000 = 0.041$$

Then $[CH_3COOH] = n(1 - x)$

$$= 0.0106\ (1 - 0.041)$$

$$[CH_3COO^-] = nx = 0.0106 \times 0.041,$$

$$[H^+] = nx = 0.0106 \times 0.041$$

➠ $K_a = \dfrac{[CH_3COO^-][H^+]}{[CH_3COOH]}$

$$= \frac{0.0106 \times 0.041 \times 0.0106 \times 0.041}{0.0106\ (1.00 - 0.041)} = 1.86 \times 10^{-5}$$

❖ TRY YOURSELF ❖ S7

[56] When 1.0 gm of KCl is dissolved in 200 gm water, the decrease in freezing point of such solution is 0.24 K, calculate Van't Hoff factor (*i*) for such solution. K_f of water = 1.86 K kg / mol.

[Ans. : 1.92]

[57] If solution prepared by adding 6.1 gm of benzoic acid in 500 gm benzene is freeze at –0.290°C. Then find out association percentage ?

(K_f of water = 5.52°K kg / mol.) **[Ans. : 95%]**

[58] 3×10^{-3} kg acetic acid is added into 500 cm^3 water. If dissociation of acetic acid is 23% then find out depression in freezing ? K_f of water = 1.86 K kg / mol and density = 0.997 gm cm^{-3}.

[Ans. : 0.229]

[59] 1.7920 gm K_2SO_4 is present in 1000 mL of solution. If such solution have osmotic pressure of 0.680 bar at 26°C then find out van't Hoff factor value. **[Ans. : 2.66]**

[60] When 1.5 gm phenol is dissolved in 100 gm of toluene, decrease in freezing point is 0.56 K is observed. If its association is dimeric in nature, then find out percentage of association. [K_f = 4 K kg mol^{-1}]. **[Ans. : 25%]**

❖ SELF - PRACTICE QUESTIONS ❖ S7

[61] Write value of i for K_2SO_4.

[62] Write value of *i* for $K_4[Fe(CN)_6]$.

[63] What is association ?

[64] What is dissociation ?

[65] Write formula for van't Hoff factor.

[66] What is abnormal molar mass ?

UID : P1-C2-S8-Q2.13♦

Section-2 Intext Questions and Answers

S2

1) Calculate the mass percentage of benzene (C_6H_6) and carbon tetrachloride (CCl_4) if 22 of benzene is dissolved in 122 g of carbon tetrachloride. #

➠ Mass percentage of C_5H_6

$$= \frac{\text{Mass of } C_6H_6}{\text{Total mass of the solution}} \times 100\ \%$$

$$= \frac{\text{Mass of } C_6H_6}{\text{Mass of } C_6H_6 + \text{Mass of } CCl_4} \times 100\ \%$$

$$= \frac{22}{22 + 122} \times 100\% = 15.28\ \%$$

➠ Mass percentage of CCl_4

$$= \frac{\text{Mass of } CCl_4}{\text{Total mass of the solution}} \times 100\ \%$$

$$= \frac{\text{Mass of } CCl_4}{\text{Mass of } C_6H_6 + \text{Mass of } CCl_4} \times 100\ \%$$

$$= \frac{122}{22 + 122} \times 100\ \% = 84.72\ \%$$

➠ Alternatively,

Mass percentage of $CCl_4 = (100 - 15.28)\ \%$

$= 84.72\ \%$

2) Calculate the mole fraction of benzene in solution containing 30% by mass in carbon-tetrachloride.

➠ Let the total mass of the solution be 100 g and the mass of benzene be 30 g.

∴ Mass of carbon tetrachloride = (100 – 30)g = 70g

Molar mass of benzene (C_6H_6) = $(6 \times 12 + 6 \times 1)$g mol^{-1}

$= 78$ mol^{-1}

∴ Number of moles of $= C_6H_6$

$$= \frac{30}{78} \text{ mol} = 0.3846 \text{ mol}$$

Molar mass of carbon tetrachloride (CCl_4)

$= (1 \times 12) + (4 \times 35.5) = 154$

∴ Number of moles of $CCl_4 = \frac{70}{154} = 0.4545$ mol

➠ Thus, the mole fraction of C_6H_6 is given as :

$$= \frac{\text{Number of moles of } C_6H_6}{\text{Number of moles of } C_6H_6 + \text{Number of moles } CCl_4}$$

$$= \frac{0.3846}{0.3846 + 0.4545} = 0.458$$

3) Calculate the molarity of each of the following solutions :

(a) 30 g of $Co(NO_3)_2 \cdot 6H_2O$ in 4.3 L of solution

(b) 30 mL of 0.5 M H_2SO_4 diluted to 500 mL.

➠(a) Molarity is given by :

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution in litre}}$$

Moles of $Co(NO_3)_2 \cdot 6H_2O$

$= 59 + 2\ (14 + 3 \times 16) + 6 \times 18$

$= 291$ g mol^{-1}

∴ Moles of $Co(NO_3)_2 \cdot 6H_2O$

$$= \frac{30}{291} = 0.103 \text{ mol}$$

Therefore, molarity $= \frac{0.103 \text{ mol}}{4.3 \text{ L}}$

$= 0.023$ M

➠(b) Number of moles present in 1000 mL 0.5 M H_2SO_4 = 0.5 mol

∴ Number of moles present in 30 mL of 0.5 M

$$H_2SO_4 = \frac{0.5 \times 30}{1000} \text{ mol}$$

$= 0.015$ mol

Therefore, molarity $= \frac{0.015}{0.5 \text{ L}}$ mol

$= 0.03$ mol

4) Calculate the mass of urea (NH_2CONH_2) required in making 2.5 kg of 0.25 molal aqueous solution.

➠ Molar mass of urea (NH_2CONH_2)

$= 2(1 \times 14 + 2 \times 1) + 1 \times 12 + 1 \times 16$

$= 60$ g mol^{-1}

➠ 0.25 molar aqueous solution of urea means :

1000 g of water contains 0.25 mol

$= (0.25 \times 60)$ g of urea

$= 15$ g of urea

➠ That is,

(1000 + 15) g of solution contains 15 g of urea

Therefore, 2.5 kg (2500 g) of solution contains

$$= \frac{15 \times 2500}{1000 \times 15} \text{ g}$$

$= 36.95$ g

$= 37$ g of urea (approximately)

\# UID : P1-C2-S2-Q1

➠ Hence, mass of urea required = 37 g

Note : There is a slight variation in this answer and the one given in the NCERT textbook.

5) Calculate (a) molality (b) molarity and (c) mole fraction of KI if the density of 20 % (mass/mass) aqueous KI is 1.202 g mL^{-1}. #

➠(a) Molar mass of KI = 39 + 127 = 166 g mol^{-1}

20% (mass/mass) aqueous solution of KI means 20 kg of KI is present in 100 g of solution.

That is,

20 g of KI is present in (100 – 20) g of water

= 80 g of water

Therefore, molality of the solution

$$= \frac{\text{Moles of KI}}{\text{Mass of water in kg}} = \frac{\frac{20}{166}}{0.08} = 1.506 \text{ m}$$

= 1.51 m (approximately)

➠(b) It is given that the density of the solution

= 1.202 g mL^{-1}

∴ Volume of 100 g solution

$$= \frac{\text{Mass}}{\text{Density}} = \frac{100 \text{ g}}{1.202 \text{ g mL}^{-1}}$$

= 83.19 mL

= 83.19 × 10^{-3} L

Therefore, molarity of the solution

$$= \frac{\frac{20}{166}}{83.19 \times 10^{-3} \text{ L}} = 1.45 \text{ M}$$

➠(c) Moles of KI $= \frac{20}{166} = 0.12$ mol

Moles of water $= \frac{80}{18} = 4.44$ mol

Mole fraction of KI $= \frac{0.12}{0.12 + 4.44} = 0.0263$

6) H_2S, a toxic gas with rotten egg like smell, is used for the qualitative analysis. If the solubility of H_2S in water at STP is 0.195 m, calculate Henry's law constant.

➠ It is given that the solubility of H_2S in water at STP is 0.195 m, i.e., 0.195 mol of H_2S is dissolved in 1000 g of water.

➠ Moles of water $= \frac{1000}{18} = 55.56$ mol

∴ Mole fraction of H_2S, X_{H_2O}

$$= \frac{\text{Moles of } H_2S}{\text{Moles of } H_2S + \text{Moles of water}}$$

$$= \frac{0.195}{0.195 + 55.56} = 0.0035$$

➠ At STP, pressure (p) = 0.987 bar According to Henry's law : $p = K_H \cdot x$

$$K_H = \frac{p}{x} = \frac{0.987}{0.0035} = 282 \text{ bar}$$

7) Henry's law constant for CO_2 in water is 1.67 × 108 Pa at 298 K. Calculate the quantity of CO_2 in 500 mL of soda water when packed under 2.5 atm CO_2 pressure at 298 K.

➠ It is given that :

$K_H = 1.67 \times 10^8$ Pa

$p_{CO_2} = 2.5 \text{ atm} = 2.5 \times 1.01325 \times 10^5$ Pa

$= 2.533125 \times 10^5$ Pa

➠ **According to Henry's law :**

$p_{CO_2} = K_H \cdot x$

$$x = \frac{p_{CO_2}}{K_H} = \frac{2.533125 \times 10^5}{1.67 \times 10^8} = 0.00152$$

$$x = \frac{n_{CO_2}}{n_{CO_2} + n_{H_2O}} = \frac{n_{CO_2}}{n_{H_2O}}$$

➠ nCO_2 is neglected as compared to nH_2O [since], in 500 mL of soda water, the volume of water = 500 mL [Neglecting the amount of soda present] We can write :

➠ Mole of water $= \frac{500}{18} = 27.78$ mol

$$x = \frac{n_{CO_2}}{n_{H_2O}} = \frac{n_{CO_2}}{27.78} = 0.00152$$

$n_{CO_2} = 0.042$ mol

➠ Hence, quantity of CO_2 in 500 mL of soda water = (0.042 × 44) g

= 1.848 g

8) The vapour pressure of pure liquids A and B are 450 and 700 mm Hg respectively, at 350 K. Find out the composition of the liquid mixture if total vapour pressure is 600 mm Hg. Also find the composition of the vapour phase.

➠ **Composition of Liquid mixture :**

Vapour pressure of pure liquid A (p_A^0) = 450 mm

Vapour pressure of pure liquid B (p_B^0) = 450 mm

Total vapour pressure of solution (P) = 600 mm

➠ According to Roult's law: $p = p_A^0 x_A + p_B^0 x_B$

$p = p_A^0 \cdot x_A + p_B^0 (1 - x_A)$

$p = 450 \cdot x_A + 700 (1 - x_A)$

$600 = 450x_A + 700 - 700x_A$

$600 - 700 = -250 x_A$

$x_A = 0.40$

➠ So, mole fraction of B = 0.60

UID : P1-C2-S2-Q5

➠ Composition of vapour phase :

$p_A = p_A^0 \cdot x_A = 450 \times 0.40 = 180$ mm

$p_B = p_B^0 \cdot x_B = 700 \times 0.60 = 420$ mm

➠ Mole fraction of A in vapour $= \frac{p_A}{p_A + p_B}$

$$= \frac{180}{180 + 420} = 0.30$$

➠ So, mole fraction of B is = 0.70

9) Vapour pressure of pure water at 298 K is 23.8 mm Hg. 50 g of urea (NH_2CONH_2) is dissolved in 850 g of water. Calculate the vapour pressure of water for this solution and its relative lowering. #

➠ It is given that vapour pressure of water,

$p_A^0 = 23.8$ mm of Hg

Weight of water taken, $w_1 = 850$ g

Weight of urea taken, $w_2 = 50$ g

Molecular weight of water, $M_1 = 18$ g mol^{-1}

Molecular weight of urea, $M_2 = 60$ g mol^{-1}

➠ Now, we have to calculate vapour pressure of water in the solution. We take vapour pressure as p_1.

➠ Now, from Raoult's law, we have :

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{n_2}{n_1 + n_2}$$

$$\therefore \frac{p_1^0 - p_1}{p_1^0} = \frac{\frac{w_2}{M_2}}{\frac{w_1}{M_1} + \frac{w_2}{M_2}}$$

$$\therefore \frac{23.8 - p_1}{23.8} = \frac{\frac{50}{60}}{\frac{850}{18} + \frac{50}{60}}$$

$$\therefore \frac{23.8 - p_1}{23.8} = \frac{0.83}{47.22 + 0.83}$$

$$\therefore \frac{23.8 - p_1}{23.8} = 0.0173$$

$p_1 = 23.4$ mm of Hg

➠ Hence, the vapour pressure of water in the given solution is 23.4 mm of Hg and its relative lowering is 0.0173.

10) Boiling point of water at 750 mm Hg is 99.63 °C. How much sucrose is to be added to 500 g of water such that it boils at 100 °C. Molal elevation constant for water is 0.52 K kg mol^{-1}.

➠ Here, elevation of boiling point

$\Delta T_b = (100 + 273) - (99.63 + 273) = 0.37$ K

Mass of water, $w_1 = 500$ g

Molar mass of sucrose ($C_{12}H_{22}O_{11}$),

$M_2 = 11 \times 12 + 22 \times 1 + 11 \times 16 = 342$ g mol^{-1}

Molal elevation constant,

$K_b = 0.52$ K kg mol^{-1}

➠ We know that :

$$\Delta T_f = \frac{K_b \times 1000 \times w_2}{M_2 \times w_1}$$

$$w_2 = \frac{\Delta T_b \times M_2 \times w_1}{K_b \times 1000} = \frac{0.37 \times 342 \times 500}{0.52 \times 1000}$$

= 121.7 (approximately)

➠ Hence, 121.67 g of sucrose is to be added.

11) Calculate the mass of ascorbic acid (Vitamin C, $C_6H_8O_6$) to be dissolved in 75 g of acetic acid to lower its melting point by 1.5°C. [K_f = 3.9 K kg mol^{-1}]

➠ Mass of acetic acid, $w_1 = 75$ g

Molar mass of ascorbic acid ($C_6H_8O_6$),

$M_2 = 6 \times 12 + 8 \times 1 + 6 \times 16 = 176$ g mol^{-1}

Lowering of melting point, $\Delta T_f = 1.5$ K

➠ We know that :

$K_f = 3.9$ K kg mol^{-1}

$$\Delta T_f = \frac{K_f \times w_2 \times 1000}{M_2 \times w_1}$$

$$w_2 = \frac{\Delta T_f \times M_2 \times w_1}{K_f \times 1000} = \frac{1.5 \times 176 \times 75}{3.9 \times 1000}$$

= 5.08 gram

= 5.08 g (approx)

➠ Hence, 5.08 g of ascorbic acid is needed to be dissolved.

12) Calculate the osmotic pressure in pascals exerted by a solution prepared by dissolving 1.0 g of polymer of molar mass 185,000 in 450 mL of water at 37°C.

➠ It is given that:

Volume of water, V = 450 mL = 0.45 L;

Temperature, T = (37 + 273)K = 310 K

Number of moles of the polymer,

$$n = \frac{1}{185000}$$

➠ We know that,

Osmotic pressure, $X = \frac{n}{V}RT$

$$= \frac{1}{185000}\text{ mol} \times \frac{1}{0.45\text{ L}} \times 8.314 \times 10^3$$

$\text{Pa} \cdot \text{L} \cdot \text{K}^{-1}\ \text{mol}^{-1} \times 310$ K

= 30.96 Pa (approximately)

UID : P1-C2-S2-Q9

Section-3 Textual Exercise

S3

1) Define the term solution. How many types of solutions are formed? Write briefly about each type with an example. #

➠ **For answer see Section-A, Q. no. 1**

2) Give an example of solid solution in which the solute is a gas.

➠ In case a solid solution is formed between two substances, an interstitial solid solution (smaller size particle will occupy interstitial position in solid crystal) will be formed. For example, a solution of hydrogen in palladium is a solid solution in which the solute is a gas.

3) Define the following terms :

(i) Mole fraction

(ii) Molality

(iii) Molarity

(iv) Mass percentage.

➠**(i) Mole fraction :** The mole fraction of a component in a mixture is defined as the ratio of the number of moles of the component to the total number of moles of all the components in the mixture. i.e.,

Mole fraction of a complex

$$= \frac{\text{Number of moles of the component}}{\text{Total number of moles of all components}}$$

Mole fraction is denoted by 'x'.

If in a binary solution, the number of moles of the solute and the solvent are n_A and n_B respectively, then the mole fraction of the solute in the solution is given by,

$$x_A = \frac{n_A}{n_A + n_B}$$

Similarly, the mole fraction of the solvent in the solution is given as :

$$x_B = \frac{n_B}{n_A + n_B}$$

➠**(ii) Molality :** Molality (m) is defined as the number of moles of the solute per kilogram of the solvent. It is expressed as :

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

➠**(iii) Molarity :** Molarity (M) is defined as the number of moles of the solute dissolved in one Litre of the solution. It is expressed as :

$$\text{Molality (M)} = \frac{\text{Moles of solute}}{\text{Volume of solvent in Litre}}$$

➠**(iv) Mass percentage :** The mass percentage of a component of a solution is defined as the mass of the solute in grams present in 100 g of the solution. It is expressed as :

Mass % of component

$$= \frac{\text{Mass of component in solution}}{\text{Total mass of solution}} \times 100$$

4) Concentrated nitric acid used in laboratory work is 68 % nitric acid by mass in aqueous solution. What should be the molarity of such a sample of the acid if the density of the solution 1.504 gm L^{-1} is ?

➠ Concentrated nitric acid used in laboratory work is 68% nitric acid by mass in an aqueous solution. This means that 68 g of nitric acid is dissolved in 100 g of the solution.

Molar mass of nitric acid (HNO_3)

$$= 1 \times 1 + 1 \times 14 + 3 \times 16$$

$$= 63 \text{ g mol}^{-1}$$

$$\text{Then, number of moles } HNO_3 = \frac{68}{63} \text{ mol}$$

$$= 1.079 \text{ mol}$$

Given,

Density of solution = 1.504 g mL^{-1}

Therefore, Volume of 100 g solution

$$= \frac{100}{1.504} \text{ mL}$$

$$= 66.49 \text{ mL}$$

$$= 66.49 \times 10^{-3} \text{ L}$$

$$\text{Molarity of solution} = \frac{1.079 \text{ mol}}{66.49 \times 10^{-3} \text{L}} = 16.23 \text{ M}$$

5) A solution of glucose in water is labelled as 10% w/w, what would be the molality and mole fraction of each component in the solution? If the density of solution is 1.2 g mL^{-1}, then what will be the molarity of the solution ?

UID : P1-C2-S3-Q1

➠ 0 % w/w solution of glucose in water means that 10 g of glucose in present in 100 g of the solution i.e., 10 g of glucose is present in (100 – 10) g = 90 g of water.

Molar mass of glucose ($C_6H_{12}O_6$)

$= 6 \times 12 + 12 \times 1 + 6 \times 16$

$= 180 \text{ g mol}^{-1}$

➠ Then, number of moles of glucose

$$= \frac{10}{180} \text{ mol}$$

$= 0.056$ mol

$$\text{Molarity of solution} = \frac{0.056 \text{ mol}}{0.09 \text{ kg}} = 0.62 \text{ m}$$

$$\text{Number of moles of water} = \frac{90 \text{ g}}{18 \text{ g mol}^{-1}} = 5 \text{ mol}$$

$$\text{Mole fraction of glucose } (x_g) = \frac{0.056}{0.056 + 5} = 0.011$$

And, mole fraction of water $X_w = 1 - x_g$

$= 1 - 0.011$

$= 0.989$

➠ If the density of the solution is 1.2 kg mL^{-1}, then the volume of the 100 g solution can be given as,

$$= \frac{100 \text{ g}}{1.2 \text{ g mol}^{-1}}$$

$= 83.33$ mL

$= 83.33 \times 10^{-3}$ L

$$\therefore \text{ Molarity of the solution} = \frac{0.056 \text{ mol}}{83.33 \times 10^{-3} \text{L}}$$

$= 0.67$ M

6) How many mL of 0.1 M HCl are required to react completely with 1 g mixture of Na_2CO_3 and $NaHCO_3$ containing equimolar amounts of both ? #

➠ Let the amount of Na_2CO_3 in the mixture be x_g. Then, the amount of $NaHCO_3$ in the mixture is $(1 - x)$g.

➠ Molar mass of $Na_2CO_3 = 2 \times 23 + 1 \times 12 + 3 \times 16$

$= 106 \text{ g mol}^{-1}$

$$\therefore \text{ Number of moles } Na_2CO_3 = \frac{x}{106} \text{ mol}$$

➠ Molar mass of $NaHCO_3 = 1 \times 23 + 1 \times 12 + 3 \times 16$

$= 84 \text{ g mol}^{-1}$

$$\text{Number of moles } NaHCO_3 = \frac{1-x}{84} \text{ mol}$$

➠ According to the question,

$$\frac{x}{106} = \frac{1-x}{84}$$

$\therefore\ 84x = 106 - 106\,x$

$\therefore\ 190x = 106$

$\therefore\ x = 0.5579$

➠ Therefore, number of moles of Na_2CO_3

$$= \frac{0.5579}{106} \text{ mol}$$

$= 0.053$ mol

And, number of moles of $NaHCO_3$

$$= \frac{1 - 0.5579}{84}$$

$= 0.0053$ mol

➠ HCl reacts with Na_2CO_3 and $NaHCO_3$ according to the following equation.

$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$

$HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2$

1 mol of Na_2CO_3 reacts with 2 mol of HCl.

➠ Therefore, 0.0053 mol of Na_2CO_3 reacts with 2×0.0053 mol = 0.0106 mol of HCl.

Similarly, 1 mol of $NaHCO_3$ reacts with 1 mol of HCl.

Therefore, 0.0053 mol of $NaHCO_3$ reacts with 0.0053 mol of HCl.

➠ Total moles of HCl required = (0.0106 + 0.0053) mol

= 0.0159 mol

In 0.1 M of HCl

0.1 mol of HCl is preset in 1000 mL of the solution

➠ Therefore, 0.0159 mol of HCl is present in

$$= \frac{1000 \times 0.0159}{0.1} \text{ mol}$$

= 159 mL of the solution

➠ Hence, 159 mL of 0.1 M of HCl is required to react completely with 1 g mixture of Na_2CO_3 and $NaHCO_3$ containing equimolar amounts of both.

7) A solution is obtained by mixing 300 g of 25% solution and 400 g of 40% solution by mass. Calculate the mass percentage of the resulting solution.

UID : P1-C2-S3-Q6

➠ $300 \times \frac{25}{100} + 400 \times \frac{40}{100} = 75 + 160 = 235$ g

Total amount of solution $= 300 + 400 = 700$ g

➠ Therefore, mass percentage (w/w) of the solute in the resulting solution,

$$= \frac{235}{700} \times 100\ \%$$

$$= 33.57\ \%$$

➠ And, mass percentage (w/w) the solvent in the resulting solution,

$$= 100 - 33.57$$

$$= 66.43\ \%$$

8) An antifreeze solution is prepared from 222.6 g of ethylene glycol ($C_2H_6O_2$) and 200 g of water. Calculate the molality of the solution. If the density of the solution is 1.072 g mL^{-1}, then what shall be the molarity of the solution ? #

➠ Molar mass of ethylene glycol [$C_2H_4(OH)_2$]

$$= 2 \times 12 + 6 \times 1 + 2 \times 16$$

$$= 62 \text{ g mol–1}$$

Number of moles of ethylene glycol

$$= \frac{222.6 \text{ g}}{62 \text{ g mol}^{-1}} = 3.59 \text{ mol}$$

➠ Therefore, molality of the solution

$$= \frac{3.59 \text{ mol}}{0.200 \text{ kg}} = 17.95 \text{ m}$$

➠ Total mass of the solution $= (222.6 + 200)$ g

$$= 422.6 \text{ g}$$

Given,

➠ Density of the solution $= \frac{422.6 \text{ g}}{1.072 \text{ g mL}^{-1}}$

$$= 394.2 \text{ mL}$$

$$= 0.3942 \times 10^{-3} \text{ L}$$

➠ Molarity of the solution $= \frac{3.59 \text{ mol}}{0.39422 \times 10^{-3} \text{ L}}$

$$= 9.11 \text{ M}$$

9) A sample of drinking water was found to be severely contaminated with chloroform ($CHCl_3$) supposed to be a carcinogen. The level of contamination was 15 ppm (by mass) :

(i) Express this in percent by mass.

(ii) Determine the molality of chloroform in the water sample.

➠ (i) 15 ppm (by mass) means 15 parts per milion 10^6 of the solution.

Therefore, Percent by mass $= \frac{15}{10^6} \times 100$

$$= 1.5 \times 10^{-3}\ \%$$

➠ (ii) Molar mass of chloroform ($CHCl_3$)

$$= 1 \times 12 + 1 \times 1 + 3 \times 35.5$$

$$= 119.5 \text{ g mol}^{-1}$$

Now, according to the question,

15 g of chloroform is present in 10^6 g of the solution.

i.e. 15 g of chloroform is present in (10^6 – 15) per 10^6 g of water :

Therefore, Molality of the solution

$$= \frac{\frac{15}{119.5}\text{mol}}{10^6 \times 10^{-3}\text{kg}} = 1.26 \times 10^{-4} \text{ m}$$

10) What role does the molecular interaction play in a solution of alcohol and water ?

➠ In pure alcohol and water, the molecules are held tightly by a strong hydrogen bonding. The interaction between the molecules of alcohol and water is weaker than alcohol-alcohol and water-water interactions.

➠ As a result, when alcohol and water are mixed, the intermolecular interactions become weaker and the molecules can easily escape.

➠ This increases the vapour pressure of the solution, which in turn lowers the boiling point of there sulting solution.

11) Why do gases always tend to be less soluble in liquids as the temperature is raised ?

➠ Solubility of gases in liquids decreases with an increase in temperature. This is becaused is solution of gases in liquids is an exothermic process.

Gas + Liquid → Solution + Heat

➠ Therefore, when the temperature is increased, heat is supplied and the equilibrium shifts backwards (exothermic reactions are favoured at low temp. only according to Le-Chaterlie Principle) thereby decreasing the solubility of gases.

UID : P1-C2-S3-Q8

12) State Henry's law and mention some important applications. #

➠ **For answer see Section-A, Q. no. 10**

13) The partial pressure of ethane over a solution containing 6.56×10^{-3} g of ethane is 1 bar. If the solution contains 5.00×10^{-2} g of ethane, then what shall be the partial pressure of the gas ?

➠ Molar mass of ethane (C_2H_6)

$= 2 \times 12 + 6 \times 1$

= 30 g mol–1

$\therefore$ Number of molar present in 6.56×10^{-3} g of ethane $= \dfrac{6.56 \times 10^{-2}}{1} = 2.187 \times 10^{-4}$

➠ Let the number of moles of the solvent be 55.55 assuming solvent is water.

According to Henry's low,

$p = K_H X$

1 bar = KH $(2.187 \times 10^{-4} / 55.455)$

[Assuming dilution condition i.e. moles of solvent >> moles of solute]

$K_H = 1 \text{ bar} / (0.039 \times 10^{-4})$

➠ If mass of ethane = 0.05 g then moles of ethane

= 0.05/30 mol = 0.00166 mol

➠ As per Henry's Law : $m = K_H \times p$

In first case : 6.56×10^{-3} g $= K_H \times 1$ bar

$K_H = 6.56 \times 10^{-3} \text{ g bar}^{-1}$

In the second case :

$5.00 \times 10^{-2} \text{ g} = 6.56 \times 10^{-3} \text{ g bar}^{-1} \times p$

$$\therefore\ p = \frac{5.00 \times 10^{-2} \text{ g}}{6.56 \times 10^{-3} \text{ gb } ar^{-1}} = 7.62 \text{ bar}$$

14) What is meant by positive and negative deviations from Raoult's law and how is the sign of $\Delta_{Sol}H$ related to positive and negative deviations from Raoult's law ?

➠ **For answer see Section-A, Q. no. 15**

15) 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 ?

➠ Here,

Vapour pressure of the solution at normal boiling point (p_1) = 1.004 bar

Vapour pressure of pure water at normal boiling point, (p_1^0) = 1.013 bar

Mass of solute, (w_2) = 2 g

Mass of solvent (water), (w_1) = 98 g

Molar mass of solvent (water), (M_1) = 18 g mol^{-1}

➠ According to Raoult's law,

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

$$\frac{1.013 - 1.004}{1.013} = \frac{2 \times 18}{M_2 \times 98}$$

$$M_2 = \frac{1.013 \times 2 \times 18}{0.009 \times 98}$$

= 41.35 g mol^{-1}

➠ Hence, the molar mass of the solute is 41.35 g mol^{-1}.

16) Heptane and octane form an ideal solution. At 373 K, the vapour pressures of the two liquid components are 105.2 kPa and 46.8 kPa respectively. What will be the vapour pressure of a mixture of 26.0 g of heptane and 35 g of octane ?

➠ Vapour pressure of heptane (p_1^0) = 105.2 kPa

We know that,

Molar mass of heptane (C_7H_{16})

$= 7 \times 12 + 16 \times 1$

= 100 g mol^{-1}

➠ Therefore, Number of moles of heptane

$= \dfrac{26}{100} = 0.26$ mol

➠ Molar mass of octane (C_3H_{18})

$= 8 \times 12 + 18 \times 1$

= 114 g mol^{-1}

➠ Therefore, Number of moles of octane

$= \dfrac{35}{114} = 0.31$ mol

Mole fraction of heptane, x_1

$= \dfrac{0.26}{0.26 + 0.31}$

= 0.456

And, mole fraction of octane, x_2

= 1 – 0.456

= 0.544

➠ Now, partial pressure of heptane,

$p_1 = x_1 p_1^0$

$= 0.456 \times 105.2$

= 47.97 kPa

UID : P1-C2-S3-Q12

➠ Partial pressure of octane,

$$p_2 = x_2 p_2^0$$
$$= 0.544 \times 46.8$$
$$= 25.46 \text{ kPa}$$

➠ Hence, vapour pressure of solution,

$$p_{\text{total}} = p_1 + p_2$$
$$= 47.97 + 25.46$$
$$= 73.43 \text{ kPa}$$

17) The vapour pressure of water is 12.3 kPa at 300 K. Calculate vapour pressure of 1 molal solution of a non-volatile solute in it. #

➠ 1 molal solution means 1 mol of the solute is present in 1000 g of the solvent (water).

Molar mass of water = 18 g mol^{-1}

Therefore, Number of moles present in 1000 g of water $= \dfrac{1000}{18} = 55.56$ mol

➠ Therefore, mole fraction of the solute in the solution is,

$$x_2 = \frac{1}{1 + 55.56} = 0.0177$$

It is given that,

Vapour pressure of water $(p_1^0) = 12.3$ kPa

➠ Applying the relation,

$$\frac{p_1^0 - p_1}{p_1^0} = x_2 = 0.0177$$

$$x_2 = \frac{12.3 - p_1}{12.3} = 0.0177$$

$$\Rightarrow p_1 = 12.0823$$

$= 12.08$ kPa (approximately)

➠ Hence, the vapour pressure of the solution is 12.08 kPa

18) Calculate the mass of a non-volatile solute (molar mass 40 g) which should be dissolved in 114 g octane to reduce its vapour pressure to 80%.

➠ Let the vapour pressure of pure octane be p_1^0

$$\frac{80}{100} p_1^0 = 0.8\, p_1^0$$

Molar mass of solute, $M_2 = 40$ g mol^{-1}

Mass of octane, $w_1 = 114$ g

Molar mass of octane, (C_3H_{18}),

$= M_1 = 8 \times 12 + 18 \times 1 = 114$ g mol^{-1}

➠ Applying the reaction,

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

$$\therefore \frac{p_1^0 - 0.8\, p_1^0}{p_1^0} = \frac{w_2 \times 114}{40 \times 114}$$

$$\therefore \frac{0.2\, p_1^0}{p_1^0} = \frac{w_2}{40}$$

$$\therefore w_2 = 8 \text{ g}$$

19) A solution containing 30 g of non-volatile solute exactly in 90 g 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 :

(i) Molar mass of the solute.

(ii) Vapour pressure of water at 298 K.

➠(i) Let, the molar mass of the solute be M g mol^{-1}

Now, the no. of moles of solvent (water),

$$n_1 = \frac{90 \text{ g}}{18 \text{ g mol}^{-1}} = 5 \text{ mol}$$

And, the no. of solute,

$$n_2 = \frac{30 \text{ g}}{\text{M mol}^{-1}} = \frac{30}{\text{M}} \text{ mol}$$

$$p_1 = 2.8 \text{ kPa}$$

➠ Applying the relation :

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{n_2}{n_1 + n_2}$$

$$\therefore \frac{p_1^0 - 2.8}{p_1^0} = \frac{\frac{30}{M}}{5 + \frac{30}{M}}$$

$$\therefore 1 - \frac{2.8}{p_1^0} = \frac{\frac{30}{M}}{\frac{5M + 30}{M}}$$

$$\therefore 1 - \frac{2.8}{p_1^0} = \frac{30}{5M + 30}$$

$$\therefore \frac{2.8}{p_1^0} = 1 - \frac{30}{5M + 30}$$

$$\therefore \frac{28}{p_1^0} = \frac{5M + 30 - 30}{5M + 30}$$

$$\therefore \frac{2.8}{p_1^0} = \frac{5M}{5M + 30}$$

$$\therefore \frac{p_1^0}{2.8} = \frac{5M + 30}{5M} \qquad \text{....(i)}$$

UID : P1-C2-S3-Q17

- After the addition of 18 g of water :

$$n_1 = \frac{90 + 18}{18} = 6 \text{ mol}$$

$$p_1 = 2.9 \text{ kPa}$$

- Aganin, applying the relation :

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{n_2}{n_1 + n_2}$$

$$\therefore \quad \frac{p_1^0 - 2.9}{p_1^0} = \frac{\frac{30}{M}}{6 + \frac{30}{M}}$$

$$\therefore \quad 1 - \frac{2.9}{p_1^0} = \frac{\frac{30}{M}}{\frac{6M + 30}{M}}$$

$$\therefore \quad 1 - \frac{2.9}{p_1^0} = \frac{30}{6M + 30}$$

$$\therefore \quad \frac{2.9}{p_1^0} = 1 - \frac{30}{6M + 30}$$

$$\therefore \quad \frac{2.9}{p_1^0} = \frac{6M + 30 - 30}{6M + 30} -$$

$$\therefore \quad \frac{2.9}{p_1^0} = \frac{6M}{6M + 30}$$

$$\therefore \quad \frac{p_1^0}{2.9} = \frac{6M + 30}{6M} \qquad ....(ii)$$

- Dividing equation (i) bu (ii), we have :

$$\frac{2.9}{2.8} = \frac{\frac{5M + 30}{5M}}{\frac{6M + 30}{6M}}$$

$$\frac{2.9}{2.8} \times \frac{6M + 30}{6} = \frac{5M + 30}{5}$$

$$2.9 \times 5 \times (6M + 30) = 2.8 \times 6 \times (5M + 30)$$

$$87\ M + 435 = 84\ M + 504$$

$$3\ M = 69$$

$$M = 23$$

Therefore, the molar mass of the solute is 23 g mol^{-1}.

- **(ii)** Putting the value of M in equation (i), we have :

$$\frac{p_1^0}{2.8} = \frac{5 \times 23 + 30}{5 \times 23}$$

$$\therefore \quad \frac{p_1^0}{2.8} = \frac{145}{115}$$

$$\therefore \quad p_1^0 = 3.53 \text{ kPa}$$

Hence, the vapour pressure of water at 298 K is 3.53 kPa.

20) A 5% solution (by mass) of cane sugar in water has freezing point of 271 K. Calculate the freezing point of 5% glucose in water if freezing point of pure water is 273.15 K. #

- Here, $\Delta T_f = (273.15 - 271)$ K

$$= 2.15 \text{ K}$$

- Molar mass of sugar ($C_{12}H_{22}O_{11}$)

$$= 12 \times 12 + 22 \times 1 + 11 \times 16$$

$$= 342 \text{ g mol}^{-1}$$

- 5% solution (by mass) of cane sugar in water means 5 g of cane sugar is present in (100 g – 5)g = 95 g of water.

Now, number of cane sugar

$$= \frac{5}{342} = 0.0146 \text{ mol}$$

Therefore, molality of the solution,

$$m = \frac{0.0146 \text{ mol}}{0.095 \text{ kg}} = 0.1537 \text{ mol kg}^{-1}$$

- Applying the relation,

$$\Delta T_f = K_f\ m$$

$$\therefore \quad K_f = \frac{\Delta T_f}{m}$$

$$= \frac{2.15 \text{ K}}{0.1537 \text{ K kg mol}^{-1}}$$

$$= 13.99 \text{ K kg/mol}$$

- Molar of glucose ($C_6H_{12}O_6$)

$$= 6 \times 12 + 12 \times 1 + 6 \times 16$$

$$= 180 \text{ g mol}^{-1}$$

- 5% glucose in water means 5 g glucose is present in (100 – 5) g = 95 g of water.

Therefore, Number of moles of glucose

$$= \frac{5}{180} \text{ mol}$$

$$= 0.0278 \text{ mol}$$

- Therefore, molality of the solution,

$$m = \frac{0.0278 \text{ mol}}{0.095 \text{ kg}}$$

$$= 0.2926 \text{ mol kg}^{-1}$$

- Applying the relation,

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

$$= 13.99 \text{ K kg mol}^{-1} \times 0.2926 \text{ mol kg}^{-1}$$

$$= 4.09 \text{ K (approximately)}$$

- Hence, the freezing point of 5% glucose solution is (273.15 – 4.09) K = 269.06 K.

UID : P1-C2-S3-Q20

21) Two elements A and B form compounds having formula AB_2 and AB_4. When dissolved in 20 g of benzene (C_6H_6), 1 g of AB_2 lowers the freezing point by 2.3 K whereas 1.0 g of AB_4 lowers it by 1.3 K. The molar depression constant for benzene is 5.1 K kg mol^{-1}. Calculate atomic masses of A and B. # [March-2020]

➠ We know that,

$$M_2 = \frac{1000 \times w_2 \times K_f}{\Delta T_f \times w_1}$$

Then, $M_{AB_2} = \frac{1000 \times 1 \times 5.1}{2.3 \times 20} = 110.87 \text{ g mol}^{-1}$

$M_{AB_4} = \frac{1000 \times 1 \times 5.1}{1.3 \times 20} = 196.15 \text{ g mol}^{-1}$

➠ Now, we have molar masses of AB_2 as 110.87 g mol^{-1} and 196.15 g mol^{-1} respectively.

Let the atomic masses of A and B x and y respectively.

Now, we can write :

$x + 2y = 110.87$ ...(i)

$x + 4y = 196.15$ ...(ii)

➠ Subtracting equation (i) from (ii), we have

$2y = 85.28$

$\therefore \quad y = 42.64$

➠ Putting the value of y in equation (1), we have

$x + 2 \times 42.64 = 110.87$

$\therefore \; x = 85.28$

➠ Hence, the atomic masses of A and B are 25.59 u and 42.64 u respectively.

22) At 27° C temperature, 36 gm glucose is in 1 litre aqueous solution has π = 4.98 bar. Find out concentration if π = 1.52 bar at same temperature.

➠ $\pi = iCRT = CRT$ ($\because$ i = 1 for glucose)

$4.98 = \frac{36}{180} \times RT$ .....(1)

$\pi = C \times RT$ .....(2)

Now, $\frac{\text{equation}(1)}{\text{equation}(2)} = \frac{4.98}{\pi} = \frac{36}{180} \times \frac{1}{C}$

$\therefore \; C = 0.061 \text{ mol L}^{-1}$

23) Suggest the most important type of intermolecular attractive interaction in the following pairs :

(i) n-hexane and n-octane

(ii) I_2 and CCl_4

(iii) $NaClO_4$ and water

(iv) Methanol and acetone

(v) Acetonitrile (CH_3CN) and acetone (C_3H_6O).

➠(i) Van der waal forces of attraction as both are non-polar.

➠(ii) Van der waal forces of attraction as they are non-polar.

➠(iii) Ion-diople interaction as $NaClO_4$ is ionic in nature.

➠(iv) Dipole-dipole interaction as they are polar.

➠(v) Dipole-dipole interaction as they are polar.

24) Based on solute-solvent interactions, arrange the following in order of increasing solubility in n-octane and explain. Cyclohexane, KCl, CH_3OH, CH_3CN.

➠ n-octane is a non-polar solvent. Therefore, the solubility of a non-polar solute is more than that of a polar solute in the n-octane as like dissolves in like.

➠ The order of increasing polarity is :

Cyclohexane < CH_3CN < CH_3OH < KCl

➠ Therefore, the order of increasing solubility is :

KCl < CH_3OH < CH_3CN < Cyclohexane

25) Amongst the following compounds, identify which are insoluble, partially soluble and highly soluble in water ?

(i) Phenol
(ii) Toluene
(iii) Formic acid
(iv) Ethylene glycol
(v) Chloroform
(vi) Pentanol.

➠(i) **Phenol :** (C_6H_5OH) has the polar group –OH and non-polar –C_6H_5 group.

Thus, phenol is partially soluble in water.

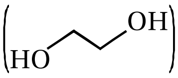
➠(ii) **Toluene :** ($C_6H_5 - CH_3$) has no polar groups.

Thus, toluene is insoluble in water.

➠(iii) **Formic acid :** (HCOOH) has the polar group –OH and can form H-bond with water.

Thus, formic acid is highly soluble in water.

\# UID : P1-C2-S3-Q21

➠(iv) **Ethylene glycol :**  has polar –OH group and can form H-bond.

Thus, it is highly soluble in water.

➠(v) **Chloroform :** is insoluble in water.

➠(vi) **Pentanol ($C_5H_{11}OH$) :** has polar -OH group, but it also contains a very bulky non-polar - C_5H_{11} group.

➠ Thus, pentanol is partially soluble in water.

26) If the density of some lake water 1.25g mol^{-1} is and contains 92g of Na^+ ions per kg of water, calculate the molality of Na^+ ions in the lake. #

➠ Number of moles present in 92 g of Na^+ ions

$= (92\ g)\ /\ (23\ g/mol)$

$= 4\ mol$

➠ Therefore, molality of Na^+ ions in the lake

$$= \frac{4\ mol}{1\ kg} = 4\ m$$

27) If the solubility product of CuS is 6×10^{-16}, calculate the maximum molarity of CuS in aqueous solution.

➠ Solubility product of CuS, $K_{sp} = 6 \times 10^{-16}$

Let us be the solubility of CuS in mol L^{-1}

$$CuS \leftrightarrow \underset{S}{Cu^{2+}} + \underset{S}{S^{2+}}$$

➠ Now, $K_{sp} = [Cu^{2+}][S^{2-}]$

$= S \times S$

$= S^2$

➠ Then, we have,

If $S^2 = 6 \times 10^{-16}$

$S = \sqrt{6 \times 10^{-16}}$

thus, $S = \sqrt{60 \times 10^{-16}}$

$= \sqrt{60} \times 10^{-8}$

$S = 2.45 \times 10^{-8}$ M

28) Calculate the mass percentage of aspirin ($C_9H_8O_4$) in acetonitrile (CH_3CN) when 6.5 g of ($C_9H_8O_4$) is dissolved in 450 g of :

➠ 6.5 g of $C_9H_8O_4$ is dissolved in 450 g of CH_3CN. Then, total mass of the solution

$= (6.5 + 45)$ g

$= 456.5$ g

➠ Therefore, mass percentage of $C_9H_8O_4$

$$= \frac{6.5}{456.5} \times 100$$

$= 1.424$ %

29) Nalorphene ($C_{19}H_{21}NO_3$), similar to morphine, is used to combat withdrawal symptoms in narcotic users. Dose of nalorphene generally given is 1.5 mg. Calculate the mass of 1.5×10^{-3} m aqueous solution required for the above dose.

➠ The molar mass of nalorphene $C_{19}H_{21}NO_3$ is given as :

$19 \times 12 + 21 \times 1 + 1 \times 14 + 3 \times 16$

$= 311\ g\ mol^{-1}$

➠ In 1.5×10^{-3} m aqueous solution of nalorphene, 1 kg (1000 g) of water contains

$= 1.5 \times 10^{-3}$ mol of nalorphene i.e.

$= 1.5 \times 10^{-3}$

$= 311$ g

$= 0.4665$ g of nalorphene

➠ Therefore, total mass of the solution

$= (1000 + 0.4665)$ g

$= 1000.4665$ g

➠ This implies that the mass of the solution containing 0.4665 g of nalorphene is 1000.4665 g.

➠ Therefore, mass of the solution containing 1.5 mg of nalorphene is :

$$= \frac{1000.4665 \times 1.5 \times 10^{-3}}{0.4665}$$

$= 3.22$ g

➠ Hence, the mass of aqueous solution required is 3.22 g.

30) Calculate the amount of benzoic acid (C_6H_5COOH) required for preparing 250 mL of 0.15 M solution in methanol.

➠ 0.15 M solution of benzoic acid in methanol means,

➠ 1000 mL of solution contains 0.15 mol of benzoic acid.

\# UID : P1-C2-S3-Q26

➠ Therefore, 250 mL of solution contains

$$= \frac{0.15 \times 250}{1000} \text{ mol of benzoic acid}$$

$= 0.0375$ mol of benzoic acid

➠ Molar mass of benzoic acid (C_6H_5COOH)

$= 7 \times 12 + 6 \times 1 + 2 \times 16$

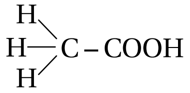
$= 122 \text{ g mol}^{-1}$

➠ Hence, required benzoic acid

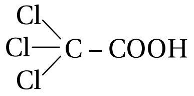
$= 0.0375 \text{ mol} \times 122 \text{ g mol}^{-1}$

$= 4.575$ g

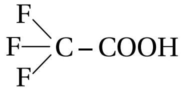
31) The depression in freezing point of water observed for the same amount of acetic acid, trichloroacetic acid and trifluoroacetic acid increases in the order given above. Explain briefly. #

➠ 

CH_3-COOH : Acetic acid



CCl_3-COOH : Trichloroacetic acid



CF_3-COOH : Trifluoroacetic acid

➠ Among H, Cl, and F, H is least electronegative while F is most electronegative. Then, F can withdraw electrons towards itself more than Cl and H. Thus, trifluoroacetic acid can easily lose H⁺ ions i.e., trifluoroacetic acid ionizes to the largest extent.

➠ Now, the more ions produced, the greater is the depression of the freezing point. Hence, the depression in the freezing point increases in the order : $CH_3COOH < CCl_3COOH < CF_3COOH$

32) Calculate the depression in the freezing point of water when 10 g of $CH_3CH_2CHCl\ COOH$ is added to 250 g of water. $K_a = 1.4 \times 10^{-3}$, $K_f = 1.86 \text{ K kg mol}^{-1}$. [August-2020]

➠ Molar mass of $CH_3CH_2CHClCOOH$

$= 15 + 14 + 13 + 35.5 + 12 + 16 + 16 + 1$

$= 122.5 \text{ g mol}^{-1}$

➠ Therefore, No. of moles present in 10 g $CH_3CH_2CHClCOOH$

$$= \frac{10 \text{ g}}{122.5 \text{ g mol}^{-1}}$$

$= 0.0.816$ mol

➠ It is given that 10 g of $CH_3CH_2CHClCOOH$ is added to 250 g of water.

Therefore, Molality of the solution,

$$= \frac{0.0186}{250} \times 1000$$

$= 32.64 \text{ mol kg}^{-1}$

➠ Let a be the degree of dissociation of $CH_3CH_2CHClCOOH$.

➠ $CH_3CH_2CHClCOOH$ undergoes dissociation according to the following equation :

$$CH_3CH_2CHClCOOH \rightleftharpoons CH_3CHClCOO^- + H^+$$

Initial conc.	C	O	O
At equilibrium	$C(1-\alpha)$	$C\alpha$	$C\alpha$

$$K_a = \frac{C^2x^2}{C(1-x)}$$

➠ Since x is very small with respect to 1 so x can be ignored, $1 - \alpha = 1$

Now,

$$K_a = \frac{Cx^2}{1}$$

$$x = \left(\frac{K_4}{C}\right)^{0.5}$$

$$= \sqrt{\frac{1.4 \times 10^{-3}}{0.3264}} \quad (\because K_a = 1.4 \times 10^{-3})$$

$= 0.0655$

➠ Again,

$$CH_3CH_2CHClCOOH \rightleftharpoons CH_3CHClCOO^- + H^+$$

initial	1 mol	0	0
equilibrium	$1 - x$	x	x

➠ i (Vant Hoff factor) $= 1 - x + x + x = 1 + x$

$= 1 + 0.0655$

$= 1.0655$

➠ Hence, the depression in the freezing point of water is given as :

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

$= 1.0655 \times 1.86 \text{ K kg mol}^{-1} \times 0.3264 \text{ mol kg}^{-1}$

$= 0.65$ K

UID : P1-C2-S3-Q31

33) 19.5 g of CH_2FCOOH is dissolved in 500 g of water. The depression in the freezing point of water observed is 1.0°C. Calculate the Van't Hoff factor and dissociation constant of fluoroacetic acid. #

➠ $w_1 = 500$ g $\qquad w_2 = 19.5$ g

$K_f = 1.86$ K kg mol^{-1} $\qquad \Delta T_f = 1$ K

➠ We known that :

$$M_2 = \frac{K_f \times w_B \times 1000}{\Delta K_f \times w_1}$$

$$= \frac{1.86 \text{ K kg mol}^{-1} \times 19.5 \text{ g} \times 1000 \text{ g kg}^{-1}}{500 \text{ g} \times 1 \text{ K}}$$

$$= 72.54 \text{ mol}^{-1}$$

➠ Therefore, observed molar mass of CH_2FCOOH, $(M_2)_{obs} = 72.54$ g mol

➠ The calculated mass of CH_2FCOOH is :

$$(M_2)_{cal} = 14 + 19 + 12 + 16 + 16 + 1$$

$$= 76 \text{ mol}^{-1}$$

➠ Therefore, Van't Hoff factor,

$$i = \frac{(M_2)_{cal}}{(M_2)_{obs}}$$

$$= \frac{78 \text{ g mol}^{-1}}{72.54 \text{ g mol}^{-1}} = 1.0753$$

➠ Let abe the degree of dissociation of

$$CH_2FCOOH \rightleftharpoons CH_2FCOO^- + H^+$$

initial	C mol L^{-1}	O	O
At equilibrium	$C(1-\alpha)$	$C\alpha$	$C\alpha$

Total $= C(1 - \alpha)$

$$i = \frac{C(1+\alpha)}{C} = 1 + \alpha$$

$$i = 1 + \alpha$$

$$\alpha = i - 1 = 1.0753 - 1$$

$$= 0.0753$$

➠ Now, the value of K_a is given as :

$$K_a = \frac{[CH_2FCOO^-][H^+]}{[CH_2FCOO]}$$

$$= \frac{C\alpha\, C\alpha}{C(1-\alpha)} = \frac{C\alpha^2}{1-\alpha}$$

➠ Taking the volume of the solution as 500 mL, we have the concentration :

$$C = \frac{\frac{19.5}{78}}{500} \times 1000 \text{ M}$$

$$= 0.5 \text{ M}$$

➠ Therefore,

$$K_a = \frac{C\alpha^2}{1-\alpha}$$

$$= \frac{(0.5)(0.0753)^2}{1 - 0.0753}$$

$$= \frac{0.5 \times 0.00567}{0.9247}$$

$$= 0.00307 \text{ (approximately)}$$

$$= 3.07 \times 10^{-3}$$

34) Vapour pressure of water at 293 K is 17.535 mm Hg. Calculate the vapour pressure of water at 293K when 25 g of glucose is dissolved in 450 g of water.

➠ Mass of glucose, $w_2 = 25$ g

Mass of water, $w_1 = 450$ g

➠ We know that,

Molar mass of glucose $(C_6H_{12}O_6)$

$M_2 = 6 \times 12 + 12 \times 1 + 6 \times 16$

$= 180$ g mol^{-1}

Molar mass of water $M_1 = 18$ g mol^{-1}

➠ Then, number of moles of glucose,

$$n_2 = \frac{25}{180 \text{ g mol}^{-1}} = 0.139 \text{ mol}$$

And, number of moles of water,

$$n_2 = \frac{450}{18 \text{ g mol}^{-1}} = 25 \text{ mol}$$

➠ We known that,

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{n_1}{n_2 + n_1}$$

$$\frac{17.535 - p_1}{17.535} = \frac{0.139}{0.139 + 25}$$

$$17.535 - p_1 = \frac{0.139 \times 17.535}{25.139} = 0.00552$$

$$17.535 - p_1 = 0.087$$

$$p_1 = 17.44 \text{ mm of Hg}$$

➠ Hence, the vapour pressure of water is 17.44 mm of Hg.

UID : P1-C2-S3-Q33

35) Henry's law constant for the molality of methane in benzene at 298 K is 4.27 × 10^5. Calculate the solubility of methane in benzene at 298 K under 760 mm Hg. #

➠ Here, $p = 760$ mm Hg

$K_H = 4.27 \times 10^5$ mm Hg

➠ According to Henry's law,

$$p = K_H \cdot x$$

$$x = \frac{p}{K_H}$$

$$= \frac{760 \text{ mm Hg}}{4.27 \times 10^5 \text{ mm Hg}}$$

$$= 1.77.99 \times 10^{-5}$$

$$= 1.78 \times 10^{-5} \text{ (approximately)}$$

➠ Hence, the mole fraction of methane in benzene is 1.78×10^{-5}

36) 100 g of liquid A (molar mass 140 g mol^{-1}) was dissolved in 1000 g of liquid B (molar mass 180 g mol^{-1}). The vapour pressure of pure liquid B was found to be 500 torr. Calculate the vapour pressure of pure liquid A and its vapour pressure in the solution if the total vapour pressure of the solution is 475 Torr.

➠ Number of moles of liquid A :

$$n_A = \frac{100}{140} = 0.7143 \text{ mol}$$

➠ Number of moles of liquid B :

$$n_B = \frac{1000}{180} = 5.556 \text{ mol}$$

➠ Then, mole fraction of A,

$$x_A = \frac{n_A}{n_A + n_B}$$

$$= \frac{0.714}{0.714 + 5.556} = 0.114$$

➠ And, mole fraction of B,

$$x_B = 1 - 0.114$$

$$= 0.8861$$

Vapour pressure of pure liquid B,

$$p_B^0 = 500 \text{ torr}$$

➠ Therefore, vapour pressure of liquid B in the solution,

$$p_B = p_B^0 \, x_B = 500 \times 0.886$$

$$= 443 \text{ torr}$$

➠ Total vapour pressure of the solution of liquid A in the solution,

$$p_A = p_{total} - p_B$$

$$= 475 - 443$$

$$= 32 \text{ torr}$$

➠ Now, $p_A^0 \, x_A$

$$p_A^0 = \frac{p_A}{x_A}$$

$$= \frac{32}{0.114} = 280.5 \text{ torr}$$

➠ Hence, the vapour pressure of pure liquid A is 280.7 torr.

37) Vapor pressure of pure acetone and chloroform at 328 K are 741.8 mm Hg and 632.8 mm Hg respectively. Assuming that they form ideal solution over the entire range of composition, plot P_{total}, $P_{chloroform}$, and $P_{acetone}$ as a function of $x_{acetone}$. The experimental data observed for different compositions of mixture is :

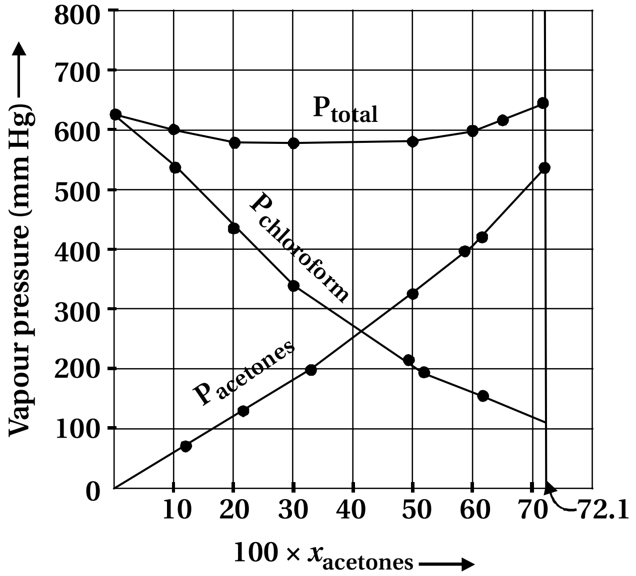
100 x $x_{acetone}$	**0**	**11.8**	**23.4**	**36.0**	**50.8**	**58.2**	**64.5**	**72.1**
$P_{acetone}$ / mm Hg	**0**	**54.9**	**110.1**	**202.4**	**322.7**	**405.9**	**454.1**	**521.1**
$P_{chloroform}$ / mm Hg	**632.8**	**548.1**	**469.4**	**359.7**	**257.7**	**193.6**	**161.2**	**120.7**

From the question, we have the following data

➠

$x_{acetone}$	0	0.118	0.234	0.360	0.508	0.582	0.645	0.721
$P_{acetone}$ / mm Hg	0	54.9	110.1	202.4	322.7	405.9	454.1	521.1
$P_{chloroform}$ / mm Hg	632.8	548.1	469.4	359.7	257.7	193.6	161.2	120.7
P_{total}	632.8	603.0	579.5	562.1	580.4	599.5	615.3	641.8

\# UID : P1-C2-S3-Q35



- It can be observed from the graph that the plot for the P_{total} of the solution curves downwards. Therefore, the solution shows negative deviation from the ideal behaviour.

38) Benzene and toluene form ideal solution over the entire range of composition. The vapour pressure of pure benzene and toluene at 300 K are 50.71 mm Hg and 32.06 mm Hg respectively. Calculate the mole fraction of benzene in vapour phase if 80 g of benzene is mixed with 100 g of toluene. #

- Molar mass of (C_6H_5)

$= 6 \times 12 + 6 \times 1$

$= 78 \text{ g mol}^{-1}$

- Molar mass of toluene ($C_6H_5CH_3$)

$= 7 \times 12 + 8 \times 1$

$= 92 \text{ g mol}^{-1}$

- Now, no. of moles present in 80 g of benzene

$= \frac{80}{78} = 1.026 \text{ mol}$

And, no. of moles present in 100 g of toluene

$= \frac{100}{92} = 1.086 \text{ moles}$

- Therefore, Mole fraction of benzene,

$$x_b = \frac{1.026}{1.026 + 1.087}$$

$= 0.486$

And, mole fraction of toluene,

$x_t = 1 - 0.486$

$= 0.514$

- It is given that vapour pressure of pure benzene,

$p_b^0 = 50.71 \text{ mm Hg}$

- Therefore, partial vapour pressure of benzene,

$p_b = x_b \times p_b$

$= 0.486 \times 50.71$

$= 24.645 \text{ mm Hg}$

And, partial vapour pressure of toluene,

$p_1 = x_t \times p_t$

$= 0.514 \times 32.06$

$= 16.479 \text{ mm Hg}$

- Hence, mole fraction of benzene in vapour phase is given by :

$$= \frac{p_b}{p_b + p_t}$$

$$= \frac{24.645}{24.645 + 16.479}$$

$$= \frac{24.645}{41.124}$$

$= 0.599$

$= 0.6$

39) The air is a mixture of a number of gases. The major components are oxygen and nitrogen with approximate proportion of 20% is to 79% by volume at 298 K. The water is in equilibrium with air at a pressure of 10 atm. At 298 K if the Henry's law constants for oxygen and nitrogen are 3.30×10^7 and 6.51×10^7 respectively, calculate the composition of these gases in water.

- Percentage of oxygen (O_2) in air = 20%

Percentage of nitrogen (N_2) in air = 79%

Also, it is given that water is in equilibrium with air at a total pressure of 10 atm, that is

(10 × 760) mm Hg = 7600 mm Hg

- Therefore,

Partial pressure of oxygen,

UID : P1-C2-S3-Q38

$$P_{O_2} = \frac{20}{100} \times 7600 \text{ mm Hg}$$

$= 1520$ mm Hg

➠ Partial pressure of nitrogen,

$$P_{N_2} = \frac{79}{100} \times 7600 \text{ mm Hg}$$

$= 6004$ mm Hg 79

$= 79 \times 760$ mm

➠ Now, according to Henry's law :

P $= K_H x$ for oxygen

$$P_{O_2} = KH \cdot x_{O_2}$$

$$x_{O_2} = \frac{P_{O_2}}{K_H}$$

$$= \frac{1520 \text{ mm Hg}}{3.30 \times 10^7 \text{ mm Hg}}$$

(Given $K_H = 330 \times 10^7$ mm Hg)

$= 461 \times 10^{-5}$

➠ For nitrogen :

$$P_{N_2} = KH \cdot x_{N_2}$$

$$x_{N_2} = \frac{P_{N_2}}{K_H}$$

$$= \frac{6004 \text{ mm Hg}}{6.51 \times 10^7 \text{ mm Hg}}$$

$= 9.22 \times 10^{-5}$

➠ Hence, the mole fractions of oxygen and nitrogen in water are 4.61×10^{-5} and 9.22×10^{-5} .

40) Determine the amount of $CaCl_2$ ($i = 2.47$) dissolved in 2.5 litre of water such that its osmotic pressure is 0.75 atm 27°C at. #

➠ $\pi = \frac{n}{V} RT$

$$\pi = i \frac{w}{MV} RT$$

$$k = \frac{\pi MV}{iRT}$$

$\pi = 0.75$ atm

V $= 2.5$ L

$i = 2.47$

T $= (27 + 273)$K

$= 300$ K

➠ Here,

R $= 0.0821$ atm K^{-1} mol^{-1}

M $= 1 \times 40 + 2 \times 35.5$

$= 111$ g mol^{-1}

➠ Therefore,

$$w = \frac{0.75 \times 111 \times 2.5}{2.47 \times 0.0821 \times 300}$$

$= 3.42$ gram

41) Determine the osmotic pressure of a solution prepared by dissolving 25 mg of K_2SO_4 in 2 liter of water at 25°C, assuming that it is completely dissociated.

➠ $K_2SO_4 \rightarrow 2K^+ + SO_4^{-2}$

Total number of ions produced = 3

Therefore, $i = 3$

Given,

w $= 25$ mg $= 0.025$ g

V $= 2$ L

T $= 250°C = (25 + 273)$K

$= 298$ K

Also, we know that :

R $= 0.0821$ L atm K^{-1} mol^{-1}

M $= (2 \times 39) + (1 \times 32) + (4 \times 16)$

$= 174$ mol^{-1}

➠ Appling the following relation,

$$\pi = i \frac{n}{V} RT$$

$$= i \frac{w}{M} \frac{1}{V} RT$$

$$= \frac{0.025}{174} \times \frac{1}{2} \times 0.0821 \times 298$$

$= 5.27 \times 10^{-3}$ atm

\# UID : P1-C2-S3-Q40

Section-4 NCERT Exemplar Solution

S4

Multiple Choice Questions (MCQs)

1) **Which of the following units is useful in relating concentration of solution with its vapour pressure ? #**

(A) Mole fraction (B) Parts per million

(C) Mass percentage (D) Molality

Ans. **(A)** Mole fraction

➠ **Explanation :** It is mole fraction (x) which is useful in relating concentration of solution with its vapour pressure. For example according to Rault's law in a binary solution of two volatile liquids, $p_1 = x_1 \, p_1^0$ where p_1 is vapour pressure of component I, and x_1 is its mole fraction in solution, p_1^0 denotes the vapour pressure of pure solvent.

2) **On dissolving sugar in water at room temperature solution feels cool to touch. Under which of the following cases dissolution of sugar will be most rapid ?**

(A) Sugar crystals in cold water.

(B) Sugar crystals in hot water.

(C) Powdered sugar in cold water.

(D) Powdered sugar in hot water.

Ans. **(D)** Powdered sugar in hot water

➠ **Explanation :** The solubility of a solute / sugar increases with increase in surface area of its particles Powdered sugar has higher surface area, therefore, powdered sugar will dissolve most rapidly.

3) **At equilibrium the rate of dissolution of a solid solute in a volatile liquid solvent is ....**

(A) Less than the rate of crystallisation

(B) Greater than the rate of crystallisation

(C) Equal to the rate of crystallisation

(D) Zero

Ans. **(C)** Equal to the rate of crystallisation

➠ **Explanation :** This happens as per conditions attained at equilibrium state; i.e. rate of forward reaction (dissolution) = rate of backward reaction (crystallisation).

4) **A beaker contains a solution of substance 'A'. Precipitation of substance 'A' takes place when small amount of 'A' is added to the solution. The solution is ....**

(A) Saturated (B) Super saturated

(C) Unsaturated (D) Concentrated

Ans. **(B)** Super saturated

➠ **Explanation :** A super saturated solution is a solution that contains lesser than maximum amount of solute per given amount of solvent at a particular temperature. If even a small amount of solute is added to such a solution it precipitates / crystallised rapidly. It should be noted that a super saturated solution differs from unsaturated solution in the sense that NO precipitation or crystallisation would occur by adding even a small amount of solute to it, rather it goes into solution and remains dissolved at a particular temperature.

5) **Maximum amount of a solid solute that can be dissolved in a specified amount of a given liquid solvent does not depend upon ....**

(A) Temperature (B) Nature of solute

(C) Pressure (D) Nature of solvent

Ans. **(C)** Pressure

➠ **Explanation :** Solubility of a solid in liquid does not depend upon pressure since solid and liquids are almost incompressible.

6) **Low concentration of oxygen in the blood and tissues of people living at high altitude is due to ....**

(A) Low temperature

(B) Low atmospheric pressure

(C) High atmospheric pressure

(D) Both low temperature and high atmospheric pressure

Ans. **(B)** low atmospheric pressure

➠ **Explanation :** At high altitude the atmospheric pressure is decreased &, due to low atmospheric pressure the solubility of oxygen in blood and tissues is reduced.

UID : P1-C2-S4-Q1

7) Considering the formation, breaking and strength of hydrogen bond, predict which of the following mixtures will show a positive deviation from Raoult's law ? #

(A) Methanol and acetone

(B) Chloroform and acetone

(C) Nitric acid and water

(D) Phenol and aniline

Ans. **(A)** Methanol and acetone

➠ **Explanation :** (A-A)* interaction is greater than the (A-B)** interaction. Intermolecular hydrogen bonding in methanol is more than methanol and acetone separately. So, methanol and acetone mixtures will show a positive deviation from Raoult's law.

➠ (A-A)* Interaction represents interaction between particles / molecules of acetone among which there is no hydrogen bonding.

➠ (A-B)** Interaction is the interaction between the particles / molecules of acetone and methanol.

8) Colligative properties depend on ....

(A) The nature of the solute particles dissolved in solution.

(B) The number of solute particles in solution.

(C) The physical properties of the solute particles dissolved in solution.

(D) The nature of solvent particles.

Ans. **(B)** The number of solute particles in solution.

9) Which of the following aqueous solutions should have the highest boiling point ?

(A) 1.0 M NaOH (B) 1.0 M Na_2SO_4

(C) 1.0 M NH_4NO_3 (D) 1.0 M KNO_3

Ans. **(B)** 1.0 M Na_2SO_4

➠ **Explanation :** In 1.0 M Na_2SO_4 solution Vant Hoff factor, $i > 1$ and is maximum when compared with the other three given electrolytes. So, the extent of dissociation in case of 1.0 M Na_2SO_4 would be highest yielding maximum no. of ions as compared to the other given electrolytes in their 1.0 M solutions.

10) The unit of ebulioscopic constant is ....

(A) K kg mol^{-1} or K $(molality)^{-1}$

(B) mol kg K^{-1} or K^{-1} (molality)

(C) kg mol^{-1} K^{-1} or K^{-1} $(molality)^{-1}$

(D) K mol kg^{-1} or K (molality)

Ans. **(A)** K kg mol^{-1} or K $(molality)^{-1}$

➠ $\Delta T_b = K_b \cdot m$

$$K_b = \frac{\Delta T_b}{m} = \frac{K}{\text{Molality}} = \frac{K}{\text{mol kg}^{-1}} = \text{K kg mol}^{-1}$$

11) In comparison to a 0.01 M solution of glucose, the depression in freezing point of a 0.01 M $MgCl_2$ solution is ....

(A) the same (B) about twice

(C) about three times (D) about six times

Ans. **(C)** about three times

➠ **Explanation :** Depression in freezing point is a colligative property. In case of $MgCl_2$ value of Van't. Hoff factor will be more.

➠ No. of ions yielded when a molecule of $MgCl_2$ gets dissociated in its aqueous solution is = 3. Thus one molecule of 0.01 M $MgCl_2$ gives out three particles / ions in solution, thereby increasing the number of particles present in its solution to three times.

➠ It is because of this that depression in freezing point of 0.01 M $MgCl_2$ will be three times as compared to that of 0.01 M glucose solution, where no dissociation of the molecule takes place.

12) An unripe mango placed in a concentrated salt solution to prepare pickle, shrivels because......

(A) it gains water due to osmosis.

(B) it loses water due to reverse osmosis.

(C) it gains water due to reverse osmosis.

(D) it loses water due to osmosis.

Ans. **(D)** it loses water due to osmosis.

13) At a given temperature, osmotic pressure of a concentrated solution of a substance ....

(A) is higher than that at a dilute solution.

(B) is lower than that of a dilute solution.

(C) is same as that of a dilute solution.

(D) cannot be compared with osmotic pressure of dilute solution.

Ans. **(A)** is higher than that at a dilute solution.

14) Which of the following statements is false ?

(i) Two different solutions of sucrose of same molality prepared in different solvents will have the same depression in freezing point.

UID : P1-C2-S4-Q7

(B) The osmotic pressure of a solution is given by the equation π = CRT (where C is the molarity of the solution).

(C) Decreasing order of osmotic pressure for 0.01 M aqueous solutions of barium chloride, potassium chloride, acetic acid and sucrose is

$BaCl_2 > KCl > CH_3COOH >$ sucrose.

(D) According to Raoult's law, the vapour pressure exerted by a volatile component of a solution is directly proportional to its mole fraction in the solution.

Ans. **(A)** Two different solutions of sucrose of same molality prepared in different solvents will have the same depression in freezing point.

➠ **Explanation :** $\Delta T_f = K_f$ m, Since K_f values depend upon the nature of solvent, the depression in freezing point of the solution would not be the same.

15) The values of Van't Hoff factors for KCl, NaCl and K_2SO_4, respectively, are .... #

(A) 2, 2 and 2　　(B) 2, 2 and 3

(C) 1, 1 and 2　　(D) 1, 1 and 1

Ans. **(B)** 2, 2 and 3

➠ **Explanation :** The values of Van't Hoff factor depend upon the extent of dissociation. KCl, NaCl and K_2SO_4 are strong electrolytes. The extent or degree of dissociation would be greatest with Na_2SO_4 as compared to that of KCl and NaCl.

16) Which of the following statements is false ?

(A) Units of atmospheric pressure and osmotic pressure are the same.

(B) In reverse osmosis, solvent molecules move through a semipermeable membrane from a region of lower concentration of solute to a region of higher concentration.

(C) The value of molal depression constant depends on nature of solvent.

(D) Relative lowering of vapour pressure, is a dimensionless quantity.

Ans. **(ii)** In reverse osmosis, solvent molecules move through a semipermeable membrane from a region of lower concentration of solute to a region of higher concentration.

➠ **Explanation :** In reverse osmosis solvent molecules move through a semipermeable membrane from a region of higher concentration of solute to a region of lower concentration, therefore the given statement at (ii) is false.

17) Value of Henry's constant K_H ....

(A) Increases with increase in temperature.

(B) Decreases with increase in temperature.

(C) Remains constant.

(D) First increases then decreases.

Ans. **(A)** Increases with increase in temperature.

18) The value of Henry's constant K_H is ....

(A) Greater for gases with higher solubility.

(B) Greater for gases with lower solubility.

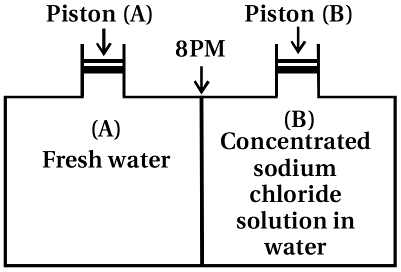
(C) Constant for all gases.

(D) Not related to the solubility of gases.

Ans. **(B)** greater for gases with lower solubility.

➠ **Explanation :** The value of Henry's constant K_H is greater for gases with lower solubility because of the mathematical relation - $p = K_H X$; $K_H = p/X$ where, K_H represents Henry's constant, p is partial pressure of the gas in vapour phase, and X denotes mole fraction of the gas in solution. Thus K_H is inversely proportional to mole fraction of gas in solution (representing its solubility)

19) Consider the Figure and mark the correct option.



(A) Water will move from side (A) to side (B) if a pressure lower than osmotic pressure is applied on piston (B).

(B) Water will move from side (B) to side (A) if a pressure greater than osmotic pressure is applied on piston (B).

(C) Water will move from side (B) to side (A) if a pressure equal to osmotic pressure is applied on piston (B).

UID : P1-C2-S4-Q15

(D) Water will move from side (A) to side (B) if pressure equal to osmotic pressure is applied on piston (A).

Ans. **(B)** water will move from side (B) to side (A) if a pressure greater than osmotic pressure is applied on piston (B).

➠ **Explanation :** Water will move from side (B) to side (A) if pressure greater than osmotic pressure is applied on piston (B) due to reverse osmosis.

20) We have three aqueous solutions of NaCl labelled as 'A', 'B' and 'C' with concentrations 0.1 M, 0.01 M and 0.001 M, respectively. The value of Van't Hoff factor for these solutions will be in the order .... #

(A) $i_A < i_B < i_C$

(B) $i_A > i_B > i_C$

(C) $i_A = i_B = i_C$

(D) $i_A < i_B > i_C$

Ans. **(A)** $i_A < i_B < i_C$

➠ **Explanation :** It is because the extent or degree of dissociation increases with increase in dilution of a solution. 0.001 M NaCl solution 'C' is most diluted as compared to the other two NaCl solutions. The Vant Hoff factor (A) depends on extent of dilution. This confirms answer at (A) $i_A < i_B < i_C$

21) On the basis of information given below mark the correct option. Information :

(i) In bromoethane and chloroethane mixture intermolecular interactions of A-A and B-B type are nearly same as A-B type interactions.

(ii) In ethanol and acetone mixture A-A or B-B type intermolecular interactions are stronger than A-B type interactions.

(iii) In chloroform and acetone mixture A-A or B-B type intermolecular interactions are weaker than A-B type interactions.

(A) Solution (ii) and (iii) will follow Raoult's law.

(B) Solution (i) will follow Raoult's law.

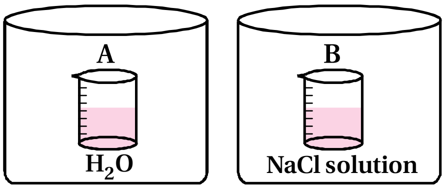
(C) Solution (ii) will show negative deviation from Raoult's law.

(D) Solution (iii) will show positive deviation from Raoult's law.

Ans. **(B)** Solution (i) will follow Raoult's law.

➠ **Explanation :** For an ideal solution A-A and B-B intermolecular interactions should be nearly same as A-B type interactions.

22) Two beakers of capacity 500 mL were taken. One of these beakers, labelled as "A", was filled with 400 mL water whereas the beaker labelled "B" was filled with 400 mL of 2 M solution of NaCl. At the same temperature both the beakers were placed in closed containers of same material and same capacity as shown in Fig. 2.2. At a given temperature, which of the following statement is correct about the vapour pressure of pure water and that of NaCl solution.



(A) Vapour pressure in container (A) is more than that in container (B).

(B) Vapour pressure in container (A) is less than that in container (B).

(C) Vapour pressure is equal in both the containers.

(D) Vapour pressure in container (B) is twice the vapour pressure in container (A).

Ans. **(A)** vapour pressure in container (A) is more than that in container (B).

➠ **Explanation :** The vapour pressure is built up due to escaping tendencies of water molecules from the surface of the liquid. More the number of molecules on the surface of liquid greater would be the vapour pressure.

➠ Since beaker A contains only water molecules at its surface it shows higher vapour pressure. But in beaker B containing NaCl solution, a fraction of surface area of the solution is occupied by NaCl molecules which are non - volatile in nature and have no escaping tendency.

➠ This results into a decrease in the number of water molecules present in NaCl solution, thereby reducing its vapour pressure.

23) If two liquids A and B form minimum boiling azeotrope at some specific composition then....

UID : P1-C2-S4-Q20

(A) A-B interactions are stronger than those between A-A or B-B.

(B) Vapour pressure of solution increases because more number of molecules of liquids A and B can escape from the solution.

(C) Vapour pressure of solution decreases because less number of molecules of only one of the liquids escape from the solution.

(D) A-B interactions are weaker than those between A-A or B-B.

Ans. **(D)** A-B interactions are weaker than those between A-A or B-B.

➠ **Explanation :** (i) The solutions which show large positive deviation from Rault's law form minimum boiling azeotrope at some specific composition.

(ii) In case of positive deviation from Rault's law A-B interactions are weaker than those between A-A or B-B.

24) 4 L of 0.02 M aqueous solution of NaCl was diluted by adding one litre of water. The molality of the resultant solution is .... #

(A) 0.004 (B) 0.008 (C) 0.012 (D) 0.016

Ans. **(D)** 0.016

➠ **Explanation :**

Apply the relation : $M_1V_1 = M_2V_2$

Given : $M_1 = 0.02$ M, $V_1 = 4$ L, $M_2 = ?$ $V_2 = 5$ L

Therefore, $0.02 \times 4 \text{ L} = M_2 \times 5 \text{ L}$

$M_2 = 0.08/5 = 0.016$ M

25) On the basis of information given below mark the correct option. Information : On adding acetone to methanol some of the hydrogen bonds between methanol molecules break.

(A) At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show positive deviation from Raoult's law.

(B) At specific composition methanol-acetone mixture forms maximum boiling azeotrope and will show positive deviation from Raoult's law.

(C) At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show negative deviation from Raoult's law.

(D) At specific composition methanol-acetone mixture will form maximum boiling azeotrope and will show negative deviation from Raoult's law.

Ans. **(A)** At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show positive deviation from Raoult's law.

➠ **Explanation :** (A) (A-A) or (B-B) interactions are stronger than the (A-B) interactions ; where, A is methanol molecule & B represents a molecule of acetone. It means that in this solution molecules of A (or B) will find it easier to escape. This will increase the vapour pressure and result into positive deviation from Rault's law. Further,

➠ (B) Due to this positive deviation the methanol - acetone mixture forms minimum boiling azeotrope.

26) K_H value for $Ar_{(g)}$, $CO_{2(g)}$, $HCHO_{(g)}$ and $CH_{4(g)}$ are 40.39, 1.67, 1.83 × 10-5 and 0.413 respectively. Arrange these gases in the order of their increasing solubility.

(A) $HCHO < CH_4 < CO_2 < Ar$

(B) $HCHO < CO_2 < CH_4 < Ar$

(C) $Ar < CO_2 < CH_4 < HCHO$

(D) $Ar < CH_4 < CO_2 < HCHO$

Ans. **(D)** $Ar < CO_2 < CH_4 < HCHO$

➠ **Explanation :** Higher the value of K_H lower will be the solubility of the gas at a given pressure, hence the solubility of given gases would increase with increase in K_H values.

Multiple Choice Questions MCQs (More than one options)

27) Which of the following factor(s) affect the solubility of a gaseous solute in the fixed volume of liquid solvent ?

(a) nature of solute

(b) temperature

(c) pressure

(A) (a) and (c) at constant T

(B) (a) and (b) at constant P

(C) (b) and (c) only

(D) (c) only

Ans. **(A) and (B)**

28) Intermolecular forces between two benzene molecules are nearly of same strength as those between two toluene molecules. For a mixture of benzene and toluene, which of the following are not true ?

UID : P1-C2-S4-Q24

(A) $\Delta_{mix}H$ = zero (B) $\Delta_{mix}V$ = zero

(C) These will form minimum boiling azeotrope.

(D) These will not form ideal solution.

Ans. **(B) and (D)**

➠ **Explanation :** In a mixture of benzene and toluene intermolecular forces between benzene and toluene molecules would be nearly of the same strength as those of two benzene molecules and two toluene molecules separately. The solution will, therefore, form an ideal solution & obey Raoult's law. So, the option (iii) & (iv) is not true.

29) Relative lowering of vapour pressure is a colligative property because .... #

(A) It depends on the concentration of a non-electrolyte solute in solution and does not depend on the nature of the solute molecules.

(B) It depends on number of particles of electrolyte solute in solution and does not depend on the nature of the solute particles.

(C) It depends on the concentration of a non-electrolyte solute in solution as well as on the nature of the solute molecules.

(D) It depends on the concentration of an electrolyte or non-electrolyte solute in solution as well as on the nature of solute molecules.

Ans. **(A) and (B)**

➠ **Explanation :** Colligative property depends on (A) the concentration of a nonelectrolyte solute in solution, (B) the number of particles of electrolyte solute in solution, & (C) It does not depend on the nature of solute molecules / particles.

30) Van't Hoff factor i is given by the expression ....

(A) $i = \dfrac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$

(B) $i = \dfrac{\text{Abormal molar mass}}{\text{Normal molar mass}}$

(C) $i = \dfrac{\text{Observed colligative property}}{\text{Calculated colligative property}}$

(D) $i = \dfrac{\text{Calculated colligative property}}{\text{Observed colligative property}}$

Ans. **(A) and (C)**

31) Isotonic solutions must have the same ....

(A) Solute

(B) Density

(C) Elevation in boiling point

(D) Depression in freezing point

Ans. **(C) and (D)**

32) Which of the following binary mixtures will have same composition in liquid and vapour phase ?

(A) Benzene - Toluene

(B) Water-Nitric acid

(C) Water-Ethanol

(D) n-Hexane - n-Heptane

Ans. **(B) and (C)**

➠ **Explanation :** At particular composition Water-Nitric acid and water-Ethanol form azeotropic mixture which have same composition in vapour phase and liquid phase.

33) In isotonic solutions ....

(A) Solute and solvent both are same.

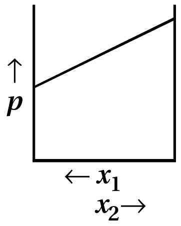
(B) Osmotic pressure is same.

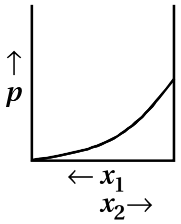
(C) Solute and solvent may or may not be same.

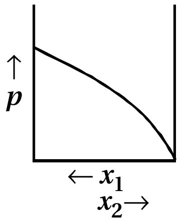
(D) Solute is always same solvent may be different.

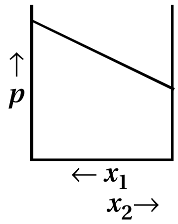
Ans. **(B) and (C)**

34) For a binary ideal liqid solution, the variation in total vapour pressure versus composition of solution is given by which of the curves ?

(A)


(B)


(C)


(D)


Ans. **(A) and (D)**

➠ **Explanation :** The slopes at (A) and (D) are straight lines, therefore they represent ideal behaviour of the solution.

UID : P1-C2-S4-Q29

35) Colligative properties are observed when..... #

(A) A nonvolatile solid is dissolved in a volatile liquid.

(B) A nonvolatile liquid is dissolved in an other volatile liquid.

(C) A gas is dissolved in nonvolatile liquid.

(D) A volatile liquid is dissolved in an other volatile liquid.

Ans. (A) and (B)

Short Answer Type Questions

36) Components of a binary mixture of two liquids A and B were being separated by distillation. After some time separation of components stopped and composition of vapour phase became same as that of liquid phase. Both the components started coming in the distillate. Explain why this happened.

➠ Since both the components are appearing in the distillate and composition of liquid and vapour is same, this shows that liquids have formed azeotropic mixture and hence cannot be separated at this stage by fractional distillation.

37) Explain why on addition of 1 mol of NaCl to 1 litre of water, the boiling point of water increases, while addition of 1 mol of methyl alcohol to one litre of water decreases its boiling point.

➠ Boiling point of a liquid depends on the vapor pressure of the liquid as compared to amspheric pressure. Lesser the vapour pressure higher would be the boiling point of a liquid or vice-versa, at a fixed atmospheric pressure. NaCl is a nonvolatile solute, therefore, addition of NaCl to water lowers the vapour pressure of water. As a result, boiling point of water increases. Methyl alcohol on the other hand is more volatile than water, therefore its addition increases, and the total vapour pressure over the solution and a decrease in boiling point of water results.

38) Explain the solubility rule "like dissolves like" in terms of inter-molecular forces that exist in solutions.

➠ The solubility rule "like dissolves like" is based on the inter-molecular forces of that exist in solution as follows : A substance (solute) dissolves in a solvent if the inter-molecular interactions are similar in both the components (i.e. solvent and solute particles or molecules). This commonly happens when polar solutes dissolve in polar solvents and non-polar solutes in non-polar solvents.

39) Concentration terms such as mass percentage, ppm, mole fraction and molality are independent of temperature, however molarity is a function of temperature. Explain.

➠ Molarity of a solution is a weight by volume relationship to represent its strength and defined as 'the number of moles of solute dissolved in one litre of solution'. Since volume depends on temperature and undergoes a change with change in temperature, the molarity will also change with change in temperature. On the other hand, the other concentration terms such as mass percentage, ppm, mole fraction and molality are based upon mass by mass relationship of solute and solvent present in a binary solution. Mass does not change with change in temperature, as a result these concentration terms remain unchanged with variation of temperature. According to the definition of all these terms, mass of the solvent used for making the solution is related to the mass of solute.

40) What is the significance of Henry's Law constant K_H ?

➠ Henry's law is expressed mathematically as, $p = K_H X$ (where, p is the partial pressure of the gas in vapour phase & X is the mole fraction of the gas in solution.)

➠ Thus it is significant from above equation that, "higher the value of Henry's law constant K_H at a given pressure, the lower is the solubility of the gas in the liquid".

41) Why are aquatic species more comfortable in cold water in comparison to warm water ?

➠ It is note worthy that the values of Henry's law constant (K_H) increase with decrease of temperature. It is due to this reason that at a given pressure the solubility of oxygen in water increases with decrease in temperature. Therefore, presence of more oxygen at lower temperature makes the aquatic species more comfortable in cold water in comparison to warm water.

UID : P1-C2-S4-Q35

42) (a) Explain the following phenomena with the help of Henry's law.

(i) Painful condition known as bends.

(ii) Feeling of weakness and discomfort in breathing at high altitude.

(b) Why soda water bottle kept at room temperature fizzes on opening ? #

➠(a) **(i)** According to Henry's law pressure of a gas is directly proportional to solubility. Scubadivers when come towards surface the air pressure gradually decreases. This reduced pressure releases the dissolved gases present in blood and leads to the formation of bubbles of nitrogen in the blood. This blocks capillaries and creates a medical condition known as bends, which is painful and dangerous to life.

(ii) At high altitude, partial pressure of oxygen is less than that of ground level. This leads to low concentrations of oxygen in blood and tissues of people living at high altitudes. Low blood oxygen causes weakness and discomfort.

➠(b) When a soda water bottle kept at room temperature is opened to air the partial pressure of CO_2 above the solution decreases suddenly, (as per Henry's law). This results into a decrease in solubility of carbon-di-oxide, hence CO_2 bubbles come out of the bottle with a fizz.

43) Why is the vapour pressure of an aqueous solution of glucose lower than that of water ?

➠ Vapour pressure of any solvent or water is caused due to escaping tendencies of the water molecules from the liquid level / surface. In pure water, only water molecules are present at its surface, but when a non-volatile solute like glucose is dissolved in it, certain number of non-volatile glucose molecules, with no escaping tendency are also present at the surface of aqueous solution. Thus the number of water molecules at the surface is correspondingly decreased, due to which relatively lesser number of molecules of water can escape out as vapours. This results in lowering * of vapour pressure of water in its glucose solution as compared to that of pure water / solvent. Such a relative lowering of vapour pressure is termed as its colligative property.

44) How does sprinkling of salt help in clearing the snow-covered roads in hilly areas ? Explain the phenomenon involved in the process.

➠ The phenomenon involved in clearing the snow-covered roads in hilly areas is 'Depression in freezing point of water when a non-volatile solute is dissolves in it'. Thus when salt is spread over snow covered roads, snow starts melting from the surface because of the depression in freezing point of water and it helps in clearing the roads.

45) What is "semi permeable membrane" ?

➠ Continuous sheets or films (natural or synthetic) which contain a network of sub microscopic holes or pores through which small solvent molecules like water can pass; but the passage of bigger molecules of solute is hindered, are known as semi permeable membrane. Diffusion taking place by this membrane is called Osmosis.

46) Give an example of a material used for making semipermeable membrane for carrying out reverse osmosis.

➠ Material used for making semipermeable membrane for carrying out reverse osmosis is - "a film of cellulose acetate placed over a suitable support."

Matching The Columns

47) Match the items given in Column-I and Column-II.

Column-I	Column-II
(A) Saturated solution	**(1) Solution having same osmotic pressure at a given temperature as that of given solution.**
(B) Binary solution	**(2) A solution whose osmotic pressure is less than that of another.**
(C) Isotonic solution	**(3) Solution with two components.**
(D) Hypotonic solution	**(4) A solution which contains maximum amount of solute that can be dissolved in a given amount of solvent at a given temperature.**
(E) Solid solution	**(5) A solution whose osmotic pressure is more than that of an other.**
(F) Hypertonic solution	**(6) A solution in solid phase.**

➠ (A – 4), (B – 3), (C – 1), (D – 2), (E – 6), (F – 5)

UID : P1-C2-S4-Q42

48) Match the items given in Column-I with the type of solutions given in Column-II. #

Column-I	Column-II
(A) Soda water	(1) A solution of gas in solid.
(B) Sugar solution	(2) A solution of gas in gas.
(C) German silver	(3) A solution of solid in liquid.
(D) Air	(4) A solution of solid in solid.
(E) Hydrogen gas in palladium	(5) A solution of gas in liquid
	(6) A solution of liquid in solid

➠ (A – 5), (B – 3), (C – 4), (D – 2), (E – 1)

49) Match the laws given in Column-I with express ions given in Column-II

Column-I	Column-II
(A) Raoult's law	(1) $\Delta T_f = K_f \cdot m$
(B) Henry's law	(2) $\pi = CRT$
(C) Elevation of boiling point	(3) $p = p_1^0 x_1 + p_2^0 x_2$
(D) Depression in freezing point	(4) $\Delta T_b = K_b \cdot m$
(E) Osmotic pressure	(5) $p = K_H \cdot x$

➠ (A – 3), (B – 5), (C – 4), (D – 1), (E – 2)

50) Match the terms given in Column-I with express ions given in Column-II.

Column-I	Column-II
(A) Mass percentage	(1) $\dfrac{\text{Number of moles the solute component}}{\text{Volume of solution in litre}}$
(B) Volume percentage	(2) $\dfrac{\text{Number of moles a component}}{\text{Total number all components}}$
(C) Mole fraction	(3) $\dfrac{\text{Volume of the solute in solution}}{\text{Total volume of solution}} \times 100$
(D) Molality	(4) $\dfrac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$
(E) Molarity	(5) $\dfrac{\text{Number of moles of the solute}}{\text{Mass of solvent in kilograms}}$

➠ (A – 4), (B – 3), (C – 2), (D – 5), (E – 1)

UID : P1-C2-S4-Q48

Assertion and Reason Type

❖ **In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct answer out of the following choices.**

(A) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(B) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(C) Assertion is correct statement but reason is wrong statement.

(D) Assertion and reason both are incorrect statements.

(E) Assertion is wrong statement but reason is correct statement.

51) Assertion : Molarity of a solution in liquid state changes with temperature.

Reason : The volume of a solution changes with change in temperature.

Ans. **(A)** Assertion and reason both are correct statements and reason is correct explanation for assertion.

➠ **Explanation :** (i) Strength of a solution in terms of 'Molarity (M)' is represents the number of moles of the solute dissolved per litre of solution, i.e.

$$\text{Molarity} = \frac{\text{No. of moles of solute component}}{\text{Volume of solution in litres}}$$

➠ (B) Since volume of a liquid varies with changes of temperature, the volume of solution would also change while the number of moles of solute present in it will remain the same (or unchanged). This, therefore, would affect the molarity of the solution.

52) Assertion : When methyl alcohol is added to water, boiling point of water increases.

Reason : When a volatile solute is added to a volatile solvent elevation in boiling point is observed.

Ans. **(D)** Assertion and reason both are incorrect statements.

➠ **Explanation :** (A) Methyl alcohol & water both are volatile liquids which when mixed together to form a binary solution, the vapour pressure of this solution becomes more as compared to individual pure components .This affects the boiling point of water with a decrease. Further, (B) When methyl alcohol is added to water A-B interaction < A-A or B-B interaction that is why it will show positive deviation from Raoult's law. Since a positive deviation from Rault's law indicates a rise in vapour pressure the boiling point decreases.

53) **Assertion : When NaCl is added to water a depression in freezing point is observed. Reason : The lowering of vapour pressure of a solution causes depression in the freezing point. #**

Ans. **(A)** Assertion and reason both are correct statements and reason is correct explanation for assertion.

➠ **Explanation :** On addition of nonvolatile solute (viz. NaCl) to water NaCl solution is formed. Due to relatively lesser number of water molecules at the surface of liquid, the solution exerts a lower vapour pressure as compared to that of pure water. It is because of this lowering of vapour pressure that a depression in freezing point of water is observed.

54) **Assertion : When a solution is separated from the pure solvent by a semipermeable membrane, the solvent molecules pass through it from pure solvent side to the solution side. Reason : Diffusion of solvent occurs from a region of high concentration solution to a region of low concentration solution.**

Ans. **(B)** Assertion and reason both are correct statements but reason is not correct explanation for assertion.

➠ **Explanation :** Assertion is correct statement but reason is a wrong statement because a semipermeable membrane permits solvent molecules to pass through a solution of lower concentration to that of higher concentration Flow of solvent molecule from solvent side to solution side through semipermeable membrane is called osmosis.

Long Answer Type Questions

55) **Define the following modes of expressing the concentration of a solution. Which of these modes are independent of temperature and why ?**

➠ **For answer see Section-A, Q. no.-3, 4, 5, 6, 7**

56) **Using Raoult's law explain how the total vapour pressure over the solution is related to mole fraction of components in the following solutions.**

(a) $CHCl_{3(l)}$ (b) $CH_2Cl_{2(l)}$

➠**(i)** **$CHCl_3$:** For a binary solution having both components as volatile liquids (viz. $CHCl_3$ and CH_2Cl_2), the total pressure will be

$$p = x_1 p_1^0 + x_2 p_2^0$$
$$= p_1^0 + 1 - x_2)p_2^0$$
$$= (p_1^0 - p_2^0)\, x_1 + p_2^0$$

p = total vapour pressure of the given mixture / binary solution of the given volatile liquids

p_1 =partial vapour pressure of component 1 (ie. $CHCl_3$)

p_2 =partial vapour pressure of component 2 (ie. CH_2Cl_2)

➠**(ii)** **$NaCl_{(s)}$ and $H_2O_{(l)}$:** For a solution containing non-volatile solute ie. $NaCl_{(s)}$ and $H_2O_{(l)}$, the Raoult's law is applicable only to vaporisable component (1) ie. $H_2O_{(l)}$ and total vapour pressure is written as $p = p_1 = x_1 p_1^0$ Where p_1^0 p_1 oreresents the vapour pressure of pure $H_2O_{(l)}$

57) **Explain the terms ideal and non-ideal solutions in the light of forces of interactions operating between molecules in liquid solutions.**

➠ **For answer see Section-A, Q. no.-14 and 15**

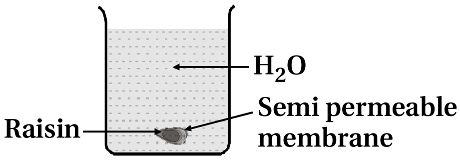
58) **Why is it not possible to obtain pure ethanol by fractional distillation ? What general name is given to binary mixtures which show deviation from Raoult's law and whose components cannot be separated by fractional distillation ? How many types of such mixtures are there ?**

➠ **For answer see Section-A, Q. no.-16**

UID : P1-C2-S4-Q53

59) When kept in water, raisin swells in size. Name and explain the phenomenon involved with the help of a diagram. Give three applications of the phenomenon. #

➠ When kept in water, raisin swells in size. It is because of a phenomenon known as 'Osmosis' The process is diagram matically represented in figure below. In this process a solution is separated from solvent by a semi permeable membrane which allows the passage of solvent molecules but does not permit solute particles to pass through.



➠ Osmosis is the process of flow of solvent molecules from pure solvent to the solution through semi permeable membrane. Three applications of osmosis are:

(i) Movement of water from soil into plant roots and subsequently into upper portion of the plant is partly due to osmosis.

(ii) Preservation of meat against bacterial action by adding salt.

(iii) Preservation of fruits against bacterial action by adding sugar. Bacterium in canned fruit loses water through the process of osmosis, shrivels and dies.

60) Discuss biological and industrial importance of osmosis.

➠ The process of osmosis is of immense biological and industrial importance as is evident from the following examples :

➠(A) **Biological Importance :**

(i) Movement of water from soil into plant roots and subsequently into upper portion of the plant is partly due to osmosis.

(ii) Preservation of meat against bacterial action by adding salt (i.e. salting).

(iii) Preservation of fruits against bacterial action by adding sugar. Bacterium in canned fruit loses water through the process of osmosis, shrivels and dies.

(iv) When placed in water containing less than 0.9% (mass by volume) salt blood cells collapse due to loss of water by osmosis. People taking lot of salt or salty food experience water retention in their tissue cells and in their intercellular spaces because of osmosis. This resulting puffiness or swelling has been identified as a disease called edema.

(v) Revival of wilted flowers when placed in fresh water.

➠(B) **Industrial importance :**

(iv) Reverse osmosis is used for desalination of sea water- when a pressure more than osmotic pressure is applied over sea water, pure water is squeezed out of the sea water through a semi-permeable membrane. A variety of semi-permeable membranes are available for this purpose.

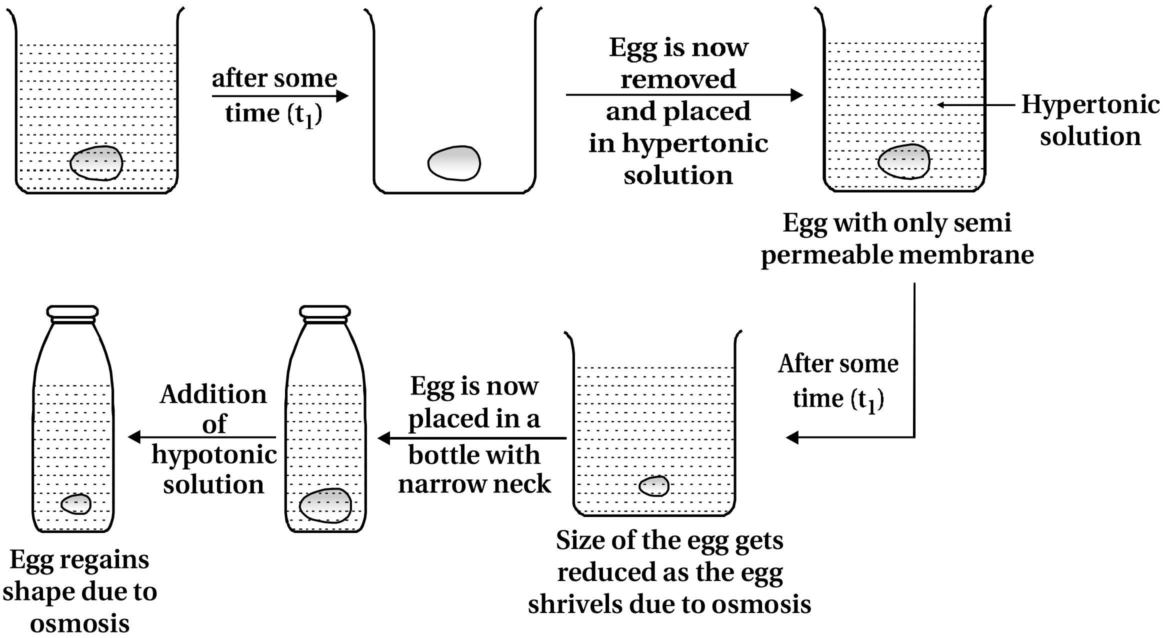
61) How can you remove the hard calcium carbonate layer of the egg without damaging its semi-permeable membrane ? Can this egg be inserted into a bottle with a narrow neck without distorting its shape ? Explain the process involved.

➠(i) When egg is placed in dilute mineral acid solution (preferably dilute HCl solution), the hard external $CaCO_3$ layer of the egg dissolves out / removed without damaging its semi-permeable membrane.

➠(ii) Yes, this egg can be inserted into a bottle with a narrow neck without distorting is shape. The process involved utilising phenomenon of osmosis is explained as below -Egg is placed in mineral acid solution - after some time egg is removed and placed in a hypertonic solution* - size of the egg gradually decreases after some time and it shrivels due to osmosis. Since the egg has shrivelled it can , now be inserted easily into a bottle with narrow mouth. The egg is, therefore, placed in a bottle with narrow neck & then a hypotonic solution is filled into this bottle. On adding hypotonic solution**, egg regains shape due to osmosis.

➠ Hypertonic solution - is a solution with higher salt concentration than that of the normal body cells so that the solvent /water is drawn out of the cell by osmosis; or any solution with higher osmotic pressure than another solution is called "Hypertonic solution".

UID : P1-C2-S4-Q59



➠ Hypotonic solution is a solution with lower salt concentration than that of the normal body cells so that water / solvent flows into the cell by osmosis; or - hypotonic solutionis a solution which has lower osmotic pressure than the other solution.

***62) Why is the mass determined by measuring a colligative property in case of some solutes abnormal ? Discuss it with the help of Van't Hoff factor. #**

➠ **For answer see Section-A, Q. no.-29 and 30**

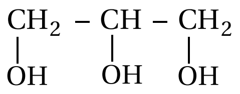
Section-5 Darpan's Exam Oriented MCQs S5

MCQs based on Textbook

1) Which of the following substance has highest solubility in water ?

(A) Ethanol (B) Ethylene glycol
(C) Glycerine (D) Propanol

Ans. **(C)** Glycerine

➠ 

$$\underset{OH}{CH_2} - \underset{OH}{CH} - \underset{OH}{CH_2}$$

As glycerine having more –OH group, it is highly soluble in water.

2) On increasing temperature, the value of Henry's constant ....

(A) decreases (B) increases
(C) remains constant (D) uncertain

Ans. **(B)** increases

➠ With increase in temp (T), K_H will also increase and solubility of gaseous solute decreases.

3) 0.5 M glucose solution is iso-osmotic with which of the following solutions ?

(A) 0.10 M NaCl (B) 0.05 NaCl
(C) 0.25 M NaCl (D) 1 M NaCl

Ans. **(C)** 0.25 M NaCl

4) The real vapour pressure for non ideal solution is .... than by Raoult's law.

(A) more (B) less
(C) equal (D) (A) and (B) both

Ans. **(D)** (A) and (B) both

5) The total pressure for volatile components A and B is 0.02 bar at equilibrium. If the mole fractions at component A is 0.2, then, what will be the partial pressure of component B ?

(A) 0.02 bar (B) 0.04 bar
(C) 0.016 bar (D) 0.2 bar

Ans. **(C)** 0.016 bar

➠ $X_A + X_B = 1$

$\therefore 0.2 + X_B = 1$ $\therefore X_B = 0.8$

$p_B = p \cdot X_B = (0.02)\ (0.8)$

$\therefore p_B = 0.016$ bar

UID : P1-C2-S4-Q62

6) **Soda water is of which type solution ? #**

(A) Solid solution (B) Liquid solution

(C) Gaseous solution (D) None of these

Ans. **(B)** Liquid solution

7) **Which of the following is non aqueous solvent ?**

(A) Benzene (B) Ether

(C) CCl_4 (D) All of these

Ans. **(D)** All of these

8) **Pickup the correct formula of potash alum.**

(A) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24\ H_2O$

(B) $K_2SO_4 \cdot Al_2(SO_4)_2 \cdot 24\ H_2O$

(C) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 12\ H_2O$

(D) $K_2SO_4 \cdot Al(SO_4)_3 \cdot 12\ H_2O$

Ans. **(A)** $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24\ H_2O$

9) **Formality unit is used in which scientific field ?**

(A) Pharmacy (B) Medical

(C) Agriculture (D) (A) and (B) both

Ans. **(D)** (A) and (B) both

10) **What is the nature of graph of mole fraction of gaseous solute and its partial pressure ?**

(A) Straight line (B) Perabola

(C) Zigzag line (D) None of these

Ans. **(A)** Straight line

11) **1 ppm = ... mass of solute in 1 liter solution.**

(A) 10^{-3} gram (B) 10^{-4} gram

(C) 10^{-6} gram (D) 10^{-2} gram

Ans. **(A)** 10^{-3} gram

12) **What is the use of Henry's law ?**

(A) In preparation of cold drinks

(B) In biochemical processes

(C) In the industry (D) All of these

Ans. **(D)** All of these

13) **Which of the following statement is wrong ?**

(A) K_H increase with increase in temperature.

(B) With increase in temperature, the solubility of gaseous solute in liquid decrease.

(C) K_H remains constant with change in temperature.

(D) $p \propto X$

Ans. **(C)** K_H remains constant with change in temperature.

14) **Which are the affecting factors on the vapour pressure ?**

(A) The nature of liquid (B) Temperature

(C) (A) and (B) both (D) None of these

Ans. **(C)** (A) and (B) both

15) **According to Raoult's law, for which system of solution, the vapour pressure of both i.e. solute and solvent will be proportional to their mole fraction ?**

(A) Both are volatile

(B) Solute is volatile, solvent is non volatile

(C) Both are nonvolatile

(D) Solute is nonvolatile, solvent is volatile

Ans. **(A)** Both are volatile

16) **Which of the following pair is of non ideal solution ?**

(A) $HCl + H_2O$ (B) $HNO_3 + H_2O$

(C) $C_6H_5OH + C_6H_5NH_2$ (D) All of these

Ans. **(D)** All of these

17) **The solution which do not obey the Raoult's law over the entire range of concentration is called which solution ?**

(A) Ideal (B) Non Ideal

(C) True Solution (D) (B) and (C) both

Ans. **(D)** (B) and (C) both

18) **Which is not a natural semi permeable membrane ?**

(A) Plant cellwall (B) Urinary bladder

(C) Cellophane paper (D) None of these

Ans. **(C)** Cellophane paper

19) **Which relation is true, if molecular weight of solute is x and its weight is y ?**

(A) $x = \left(\frac{y}{v}\right)\frac{RT}{\pi}$ (B) $y = \left(\frac{x}{y}\right)\frac{RT}{\pi}$

(C) $x = \left(\frac{v}{y}\right)\frac{RT}{\pi}$ (D) $x = \left(\frac{y}{v}\right)\frac{R\pi}{T}$

Ans. **(A)** $x = \left(\frac{y}{v}\right)\frac{RT}{\pi}$

UID : P1-C2-S5-Q6

20) To produce difference between freezing point and boiling point of a solution by 105.0°C, how much sucrose should be dissolved in 100 gm of water ? #

($K_f = 1.86°C.\ kg\ mol^{-1}$ and $K_b = 0.51°C\ kg\ mol^{-1}$)

(A) 72 gm (B) 34.2 gm (C) 342 gm (D) 460 gm

Ans. (A) 72 gm

➠ Boling point $(T_b) = 100 + \Delta T_b$

$= 100 + K_b \cdot m$

➠ Freezing point $(T_f) = 0 - \Delta T_f = K_f \cdot m$

$\therefore\ T_b - T_f = (100 + K_b \cdot m) - (-K_f \cdot m)$

$105 = 100 + 0.51\ m + 1.86\ m$

$2.37\ m = 5$

$$m = \frac{5}{2.37} = 2.11$$

➠ So, mass of sucrose to dissolve in 100 gm water is,

$$= \frac{2.11 \times 342 \times 100}{1000} = 72\ gm$$

21) At 273 K temperature, if 10 gm glucose (p_1), 10 gm urea (p_2) and 10 gm sucrose (p_3) is dissolved in 250 mL of water, then what is the correct relation of osmotic pressure for them ?

(A) $p_1 > p_2 > p_3$ (B) $p_3 > p_2 > p_1$

(C) $p_2 > p_1 > p_3$ (D) $p_2 > p_3 > p_1$

Ans. (C) $p_2 > p_1 > p_3$

➠ $p = \frac{wRT}{MV}$ Where, $\frac{wRT}{V}$ is constant and so, $p \propto \frac{1}{M}$

So, $p_2 > p_1 > p_3$

22) If osmotic pressure of an aqueous solution of sucrose having concentration of 34.2 gm/liter at 17° C is 2.38 atmosphere, then …….. gm/mL glucose is isotonic with this solution.

(A) 34.2 (B) 17.1 (C) 36.0 (D) 18.0

Ans. (D) 18.0

➠ For isotonic solutions, concentration should be same, so concentration of sucrose solution at 34.2 gm/liter is 0.1 M.

➠ So concentration 18.0 gm/liter glucose is 0.1 M.

23) To prepare solution of certain substance, 300 gm is used for 25% solution and 400 gm for 40% solution, then what is the mass percentage of solute present in this solution mixture ?

(A) 33.57 (B) 66.43 (C) 87.23 (D) 19.24

Ans. (A) 33.57

➠ In solution-1, mass of solute $= \frac{25}{100} \times 300 = 75$ gm

In solution-2, mass of solute $= \frac{40}{100} \times 400 = 160$ gm

➠ So, total mass of solute on mixing two solution is = 235 gm

So, total mass of solution = 700 gm

So, % solute present in final solution

$$= \frac{235}{700} \times 100 = 33.57\%$$

24) 20% aqueous $FeCl_3$ solution has density of 1.1 gm/mL then molar concentration of this solution is………

(A) 0.028 (B) 1.357 (C) 0.163 (D) 1.47

Ans. (B) 1.357

➠ 20% $FeCl_3$ solution means 20 gm $FeCl_3$ is present in 100 gm of solution.

$\therefore$ Volume of 100 gm solution $= \frac{100}{1.1} = 90.91$ mL

Moles of 20 gm $FeCl_3$ solution $= \frac{20}{162} = 0.1234$ mol

So, molar concentration of solution

$$= \frac{0.1234 \times 1000}{90.91} = 1.357\ M$$

25) Give mole fraction of solute present in 1.00 m aqueous solution.

(A) 0.177 (B) 0.00177 (C) 0.0177 (D) 0.034

Ans. (C) 0.0177

26) Find out molarity of NO_3^- ions in solution when mixing 2 litre 3 M $AgNO_3$ solution with 3 litre 1 M $BaCl_2$ solution.

(A) 1.2 M (B) 0.1 M (C) 0.5 M (D) 0.4 M

Ans. (A) 1.2 M

➠ 2 litre of 3M $AgNO_3$ solution has 3 moles of $AgNO_3$.

3 litre of 1M $BaCl_2$ solution has 3 moles of $BaCl_2$.

$$2AgNO_3 + BaCl_2 \longrightarrow Ba(NO_3)_2 + 2AgCl$$

➠ From above reaction, it is clear that 6 moles of $AgNO_3$ is reacted with 3 moles of $BaCl_2$ and produce 3 moles of $Ba(NO_3)_2$.

➠ So in 5 litre solution total 6 moles of NO_3^- ions is produced.

$\therefore$ Molarity of NO_3^- ions $= \frac{6}{5} = 1.2$

\# UID : P1-C2-S5-Q20

27) Which equimolal concentrated solution has highest freezing point ? #

(A) Glucose (B) La $(NO_3)_3$

(C) Ca $(NO_3)_2$ (D) Vinegar

Ans. **(A)** Glucose

28) Brass is mixture of .... metals.

(A) Zn, Ni (B) Cu, Sn

(C) Cu, Zn (D) Cu, Zn, Ni

Ans. **(C)** Cu, Zn

29) Bronze is mixture of .... metals.

(A) Cu, Sn (B) Cu, Zn (C) Zn, Sn (D) Cu, Pb

Ans. **(A)** Cu, Sn

30) .... ppm of F^- ion in water can stop decay of teeth.

(A) 1.5 (B) 1 (C) 0.5 (D) 2

Ans. **(B)** 1

31) German silver is a alloy of .... metal.

(A) Zn, Sn, Ni (B) Cu, Sn, Ni

(C) Zn, Cu, Pb (D) Cu, Zn, Ni

Ans. **(D)** Cu, Zn, Ni

32) .... ppm concentration of flouride ion causes a stain of teeth.

(A) 1.5 (B) 1 (C) 0.5 (D) 2

Ans. **(A)** 1.5

33) At certain temperature, vapour pressure of pure element A and B has 108 and 36 torr respectively. If solution has equal mole of A and B elements, then vapour pressure of solution is....

(A) 144 torr (B) 72 torr

(C) 90 torr (D) 125 torr

Ans. **(B)** 72 torr

34) Four solution of K_2SO_4 possess concentration of 0.1 m, 0.01 m, 0.001 m and 0.0001 m respectively. So among which solution has highest van't hoff factor ?

(A) 0.0001 m (B) 0.001 m

(C) 0.01 m (D) 0.1 m

Ans. **(A)** 0.0001 m

35) Osmotic pressure of aqueous solution of urea is 500 mm at 283 K. If its temperature is maintained at 298 K, then on how much dilution its osmotic pressure would be 105.3 mm ?

(A) 10 times (B) 5 times

(C) 2.5 times (D) 4 times

Ans. **(B)** 5 times

➠ $$\frac{\pi_1}{\pi_2} = \frac{T_1}{V_1} \times \frac{V_2}{T_2}$$

$$\therefore \frac{500/760}{105.3/760} = \frac{283 \times V_2}{V_1 \times 298} \qquad \therefore \frac{V_2}{V_1} = 5$$

36) Which of the following aqueous solution has same osmotic pressure ?

(i) 0.1 M NaCl solution

(ii) 0.1 M glucose solution

(iii) 0.6 gm urea in 100 mL solution

(iv) 1.0 gm non-volatile solute (*x*) in 50 mL solution. (Molecular Mass of *x* = 200)

(A) (i), (ii), (iii) (B) (ii), (iii), (iv)

(C) (i), (ii), (iv) (D) (i), (iii), (iv)

Ans. **(B)** (ii), (iii), (iv)

➠ (ii) 0.1 M glucose = π = 0.1 RT

(iii) $$\pi = \frac{n}{V} RT = \frac{\frac{0.6}{60} \times 1000}{100} RT = 0.1\ RT$$

(iv) $$\pi = \frac{\frac{0.1}{200}}{50} \times 1000\ RT = 0.1\ RT$$

37) .... solution has highest freezing point.

(A) 1 m $K_4[Fe(CN)_6]$ (B) 1 m NaCl

(C) 1 m glucose (D) 1 m KCl

Ans. **(C)** 1 m glucose

38) If non ideal solution is prepared by mixing 30 mL $CHCl_3$ and 50 mL Acetone, then volume of solution is....

(A) > 80 mL (B) < 80 mL

(C) = 80 mL (D) ≥ 80 mL

Ans. **(B)** < 80 mL

➠ Due to formation of H-bond between $CHCl_3$ and acetone A-B attraction is more than A-A and B-B, so this solution shows negative deviation from Raoult's law.

Means, $\Delta V_{mix} = -ve$, $\Delta H_{mix} = -ve$

So, total volume = < 80 mL

39) Density of solution prepared by dissolving 120 gm urea in 1000 gm water is 1.15 gm/mL. then find out molarity of solution is....

(A) 0.50 M (B) 1.78 M (C) 1.02 M (D) 2.05 M

Ans. **(D)** 2.05 M

UID : P1-C2-S5-Q27

40) If 25 gram of Na_2SO_4 is dissolved in 10^3 kilogram solution, then concentration will be… #

(A) 25 ppm (B) 0.25 ppm
(C) 250 ppm (D) 2.5 ppm

Ans. **(A)** 25 ppm

➠ $$\text{ppm} = \frac{0.025}{10^3} \times 10^6 = 25 \text{ ppm}$$

41) How much gram of acid should be present in 100 mL volume of solution to obtain decimolar solution having 200 gm / mole molecular mass of diabasic acid ?

(A) 20 gm (B) 1 gm (C) 2 gm (D) 10 gm

Ans. **(C)** 2 gm

➠ Decimolar means 0.1 M

$$M = \frac{\text{Mole}}{\text{Liter}} = \frac{w}{200} \times \frac{1}{100} \times 1000 = 0.1$$

$$\therefore 0.1 = \frac{w}{20} \qquad \therefore w = 2 \text{ gm}$$

42) If 6.022×10^{20} molecules are present in 100 mL urea solution, then find out the concentration of urea solution.

(A) 0.01 M (B) 0.001 M (C) 0.2 M (D) 0.1 M

Ans. **(A)** 0.01 M

➠ Mole = 10^{-3}

6.022×10^{23} molecule urea = 1 mole urea

6.022×10^{20} molecule urea = (?)

$$\therefore M = \frac{10^{-3}}{0.1 \text{ (liter)}} = 0.01 M$$

43) Find out molarity of solution on addition of 200 mL of water in 500 mL of 0.2 M solution.

(A) 0.501 M (B) 0.02847 M
(C) 0.709 M (D) 0.1428 M

Ans. **(D)** 0.1428 M

➠ Milimole = 500 × 0.2 = 100

$$\therefore M = \frac{100}{700} = 0.1428 \text{ M}$$

44) Increase in boiling point in solution …….. prepared by dissolving 13.44 gm $CuCl_2$ in 1 kg of water. (K_b = 0.52 K kg mol^{-1} and molecular mass of $CuCl_2$ = 134.4 gm/mole)

(A) 0.05 (B) 0.1 (C) 0.16 (D) 0.92

Ans. **(C)** 0.16

➠ $$\Delta T_b = i\, K_b \cdot m$$

$$= 3 \times 0.52 \times \frac{13.44}{134.4} = 0.16$$

UID : P1-C2-S5-Q40

Assertion and Reason Type

❖ **In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the following choices.**

(A) Assertion and reason both are correct statement and reason is correct explanation for assertion.

(B) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(C) Assertion is correct statement but reason is wrong statement.

(D) Assertion is wrong statement but reason is correct statement.

(E) Both assertion and reason are false.

45) Assertion (A) : For ideal solution ΔH_{mix} and ΔV_{mix} are always zero.

Reason (R) : Intermolecular attractive forces in solution is same as liquid.

Ans. **(A)** Assertion and reason both are correct statement and reason is correct explanation for assertion.

46) Assertion (A) : As the pressure on water increased it's freezing point decreases.

Reason (R) : Density of water at 273 K is maximum.

Ans. **(C)** Assertion is correct statement but reason is wrong statement.

47) Assertion (A) : Pressure cooker reduces time for cooking.

Reason (R) : In pressure cooker boiling point get increased.

Ans. **(B)** Assertion and reason both are correct statements but reason is not correct explanation for assertion.

48) Assertion (A) : 0.1 M urea solution is iso-osmotic with 0.1 M NaCl solution.

Reason (R) : Urea and NaCl had same concentration.

Ans. **(E)** Both assertion and reason are false.

49) Assertion (A) : NaCl is used for removing snow from roads.

Reason (R) : NaCl decreases the freezing point of water.

Ans. **(A)** Assertion and reason both are correct statement and reason is correct explanation for assertion.

Section-6 MCQs aksed in Various Exams S6

MCQs asked in Competitive Exam

1) **The molal depreesion constant of water is 1.86^o C/m. Then find out the freezing point of 0.1 m NaCl solution. # [MLNR – 1994]**

(A) -1.86^o C (B) 0.372^o C

(C) -0.372^o C (D) -0.186^o C

Ans. **(C)** -0.372^o C

➠ For NaCl, $i = 2$

$\Delta T_f = 2K_f \cdot m$

$= 2 \times 1.86 \times 0.1 = 0.372$

➠ $T_s = T - \Delta T_f = 0 - 0.372 = -0.372^o$ C

2) **What will be equal for the isotonic solution at constant temperature ? [A.F.M.C. – 1994]**

(A) Density (B) Normality

(C) Molar concentration (D) Volume

Ans. **(C)** Molar concentration

3) **The solution of 6.8 gram non-ionic substance in 100 gram water is freezed at -0.93 ^{o}C. What is the molar mass of unknown substance ? ($K_f = 1.86$) [P.M.T. - 1994]**

(A) 34 (B) 136 (C) 68 (D) 13.6

Ans. **(B)** 136

➠ $$M = \frac{K_f \times w \times 1000}{\Delta T_f \times w_A} = \frac{1.86 \times 6.8 \times 1000}{0.93 \times 100}$$

$= 136$ gram/mole

4) **The solution of 1 gram urea boils at 100.25 ^{o}C, At what temperature the same volume solution of 3 gram glucose will boil ? [B.H.U - 1994]**

(A) 100^o C (B) 100.5^o C

(C) 100.25^o C (D) 100.75^o C

Ans. **(C)** 100.25^o C

➠ Mole of urea $= \frac{1}{60}$

Mole of glucose $= \frac{3}{180} = \frac{1}{60}$

∴ Concentration is same and hence boiling point also same.

5) **What is the concentration of NO_3^- ion on mixing equal volume solution of 0.1 M $AgNO_3$ and 0.2 M NaCl ? [P.M.T. – 1994, B.H.U.–1994]**

(A) 0.1 M (B) 0.15 M (C) 0.2 M (D) 0.05 M

Ans. **(D)** 0.05 M

➠ 0.1 M $AgNO_3$ and 0.2 M NaCl are mixed

So total volume = 2 litre

So concentration will be halved.

∴ Concentration of $AgNO_3 = \frac{0.1}{2} = 0.05$ M

6) **Which of the following having maximum boiling point ? [Pb. P.M.T. - 1994]**

(A) 1.1 M glucose solution

(B) 1.1 M Na_2SO_4 solution

(C) 1.1 M KCl solution

(D) 1.1 M $C_6H_{12}O_6$ solution

Ans. **(B)** 1.1 M Na_2SO_4 solution

7) **How much methanol should be added to water, to make 150 mL. 2 M solution of CH_3OH ? [C.B.S.E-1994]**

(A) 9.6 gram (B) 2.4 gram

(C) 9.6×10^3 gram (D) 4.3×10^2 gram

Ans. **(A)** 9.6 gram

➠ 1000 mL 1 M CH_3OH = 32 gram

∴ 150 mL 2M CH_3OH = **?**

$= \frac{32 \times 150 \times 2}{1000} = 9.6$ gram

8) **Which of the following having same Van't Hoff factor as that of $K_3[Fe(CN)_6]$? [C.B.S.E.–1994]**

(A) $Al_2(SO_4)_3$ (B) K_2SO_4

(C) $Al(NO_3)_3$ (D) KCl

Ans. **(C)** $Al(NO_3)_3$

➠ $K_3[Fe(CN)_6] \rightarrow 3K^+ + [Fe(CN)_6]^{-3}$

$Al(NO_3)_3 \rightarrow Al^{+3} + 3NO_3^-$

➠ Total no. of ions in both are same.

9) **What will be the Van't Hoff factor *i* for the 0.1 M ideal solution ? [C.E.T.-1994]**

(A) 0.1 (B) Zero (C) 10 (D) 1

Ans. **(D)** 1

10) **Which of the following having same Van't Hoff factor as $K_4[Fe(CN)_6]$? [C.B.S.E.-1994]**

(A) $Al_2(SO_4)_3$ (B) NaCl

(C) $Al(NO_3)_3$ (D) Na_2SO_4

Ans. **(A)** $Al_2(SO_4)_3$

\# UID : P1-C2-S6-Q1

11) What is the mole fraction of NaCl, when solution is prepared by dissolving 5.85 gram NaCl in 90 gram of water ? # [M.P.CET - 1994]

(A) 0.2 (B) 0.1 (C) 0.01 (D) 0.0196

Ans. **(D)** 0.0196

➠ $$X_{NaCl} = \frac{5.85/58.5}{\frac{90}{18} + \frac{5.85}{58.5}} = \frac{0.1}{5.1} = 0.0196$$

12) The concentration of an aqueous solution of glucose is 10 % W/V. How much solution is required to dissolve 1 mole glucose ? [A.I.M.S.-1994]

(A) 18 litre (B) 9 litre (C) 0.9 litre (D) 1.8 litre

Ans. **(D)** 1.8 litre

➠ $$10\%\ W/V = \frac{180 \times 100}{x}$$

$x = 1800$ mL $= 1.8$ litre

13) What will be the same in the isotonic solution at same temperature ? [A.F.M.C.-1994, 95]

(A) Size (B) N

(C) M (D) Mole fraction

Ans. **(C, D)**

14) What will be the osmotic pressure of 5 % W/V sugar solution of 150°C temperature ? [B.H.U.-1995]

(A) 5.07 atmosphere (B) 5.70 atmosphere

(C) 7.5 atmosphere (D) 3.55 atmosphere

Ans. **(A)** 5.07 atmosphere

➠ $$\pi = \frac{5 \times 0.082 \times 423}{342 \times 0.1} = 5.07 \text{ atm.}$$

15) The boiling point of water at 760 mm pressure is 373 K. The vapour pressure of water at 298K is 23mm. If the vaporisation enthalpy is 40.656 KJ/mole, then what will be boiling point of water at 23 mm. pressure ? [C.B.S.E.-1995]

(A) 250 K (B) 298 K (C) 51.6 K (D) 12.5 K

Ans. **(B)** 298 K

➠ Boiling point is the temperature at which the vapour pressure will be equal to the atmospheric pressure.

16) What is the molarity of a solution prepared by dissolving 7.1 gram Na_2SO_4 in 100 mL. water ? [C.P.M.T.-1995]

(A) 0.5M (B) 2M (C) 0.2M (D) 0.05M

Ans. **(A)** 0.5M

➠ $$M = \frac{w \times 1000}{\text{Molecular weight} \times \text{volume}}$$

$$= \frac{7.1 \times 1000}{142 \times 100} = 0.5 \text{ M}$$

17) What is the vapour pressure of the solution prepared by dissolving 0.5 gram substance (Molecular weight 65) in 100 mL CCl_4 ? The vapour pressure of CCl_4 is 143 mm. density of CCl_4 is 1.58. [C.B.S.E. - 1996]

(A) 143.99 mm (B) 94.39 mm

(C) 141.97 mm (D) 199.34 mm

Ans. **(C)** 141.97 mm

➠ $w_B = 0.5$ gram

$w_A =$ volume × density

$= 100 \times 1.58 = 158$ gram CCl_4

$M_B = 65$ gram/volume

$M_A = 154$ gram/volume

$$\frac{p^o - p}{p^o} = \frac{w_B \cdot M_A}{w_A \cdot M_B} = \frac{0.5 \times 154}{158 \times 65}$$

$\therefore$ p = 141.97 gram

18) Show the relation between the osmotic pressure of the solutions prepared in 1 liter water by dissolving 10 gram glucose (P_1), 10 gram urea (P_2) and 10 gram Sucrose, (P_3) respectively. [C.B.S.E.-1996]

(A) $P_2 > P_1 > P_3$ (B) $P_2 > P_3 > P_1$

(C) $P_1 > P_2 > P_3$ (D) $P_3 > P_2 > P_1$

Ans. **(A)** $P_2 > P_1 > P_3$

➠ In equal volume of solution = mole = $\frac{W}{\text{molecular weight}}$ so, as the molecular weight less, the no. of mole is more and hence osmotic pressure is also more.

19) 5% sucrose solution is isotonic with 1% 'X' solution. What will be the molecular weight of 'X' ? [C.B.S.E.-1998]

(A) 342 gram/mole (B) 180 gram/mole

(C) 68.4 gram/mole (D) 171 gram/mole

Ans. **(C)** 68.4 gram/mole

➠ For the 5% solution $\frac{5}{M_1}$ and 1% solution = $\frac{1}{M_2}$

$$\therefore \frac{5}{342} = \frac{1}{M_2}$$

$\therefore M_2 = 68.4$ gram/mole

UID : P1-C2-S6-Q11

20) **The mole fraction of solute is 0.2 at that time the decrease in vapour pressure is 10mm. If the decrease in vapour pressure is 20mm, then what will be the mole fraction of solute ? #** **[C.B.S.E.-1998]**

(A) 0.2 (B) 0.4 (C) 0.6 (D) 0.8

Ans. **(B)** 0.4

➠ $$\frac{p^o - p}{p^o} = \frac{n}{n+N}$$

$$\frac{\Delta p}{p^o} = 0.2 \text{ (given)}$$

$$\frac{10}{p^o} = 0.2 \qquad \therefore\ p^o = 50$$

$$\text{Now } \frac{p^o - p}{p^o} = \frac{n}{n+N}$$

$$\therefore\ \frac{20}{50} = x \qquad \therefore\ x = 0.4$$

21) **How much water should be added to 2% W/V, 5 liter NaOH solution so as to make its concentration to 0.5 N ?** **[C.B.S.E.-1999]**

(A) 5 lit (B) 2.5 lit

(C) 1 lit (D) No need to add water

Ans. **(D)** No need to add water

➠ 2% W/W

i.e. 100 mL → 2 gram NaOH

1000 mL → 20 gram NaOH

To get 0.5 N solution,

W = Normality × eq. weight × volume

= 0.5 × 40 × 1 = 20 gram

$\therefore$ There is no need to add water.

MCQs asked in JEE / NEET / AIEEE

22) **What will be the osmotic pressure of the solution prepared by dissolving 1.75 gram sucrose in 50 mL. solution at 17 °C temperature ?** **[AIEEE - 2002]**

(A) 0.406 (B) 8.12 (C) 0.822 (D) 0.0406

Ans. **(C)** 0.822

➠ T = 17^oC = 293 K , w = 1.75g, V = 0.15 l

$$\pi = \frac{WRT}{MV}$$

$$= \frac{1.75 \times 0.08314 \times 293}{342 \times 0.15} = 0.822 \text{ bar}$$

23) **25 mL $Ba(OH)_2$ solution is neutralized by 35 mL 0.1 M HCl, what will be molarity of $Ba(OH)_2$ solution ?** **[AIEEE - 2003]**

(A) 0.42 (B) 0.21 (C) 0.07 (D) 0.14

Ans. **(C)** 0.07

24) **35 mL 0.1 M HCl solution is required to neutralise 25 mL. *x* M $Ba(OH)_2$ solution. What is the molarity of $Ba(OH)_2$ solution ?** **[AIEEE - 2003]**

(A) 0.14 (B) 0.28 (C) 0.35 (D) 0.07

Ans. **(D)** 0.07

➠ $$\frac{M_1V_1}{1} = \frac{M_2V_2}{2}$$

$$M_1 \times 25 = \frac{0.1 \times 35}{2} = 0.07$$

25) **The degree of ionization of 0.2 m weak acid HX is 0.3. If the K_f for water = 1.85. What will be the freezing point of solution ?** **[AIEEE-2003]**

(A) –0.360° C (B) –0.206° C

(C) +0.480° C (D) –0.480° C

Ans. **(D)** –0.480° C

➠

	HX	$\rightleftharpoons$	H^+	+	X^-
Initial mole	1 mole		0		0
Final mole	(1 – 0.3)		0.3		0.3

Total mole = (1 – 0.3) + 0.3 + 0.3 = 1.3

$$i = \frac{1.3}{1} = 1.3$$

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

$$= 1.3 \times 1.85 \times 0.2$$

$$= 0.480^o\ C$$

$\therefore$ Freezing point = 0^o C – 0.480^o C

= -0.480^o C

26) **Which of the following having the highest boiling point ?** **[AIEEE-2004]**

(A) 0.01 M Na_2SO_4 (B) 0.015 M Sucrose

(C) 0.015 M Glucose (D) 0.01 M $NaNO_3$

Ans. **(A)** 0.01 M Na_2SO_4

27) **The partial pressure ratio $P^o{}_A : P^o{}_B$ for the two volatile liquid A and B and $P^o{}_A : P^o{}_B$ = 1 : 2 and mole ratio is $X_A : X_B$ = 1 : 2. What is the mole fraction of A ?** **[PMT-2005]**

(A) 0.33 (B) 0.25 (C) 0.20 (D) 0.52

Ans. **(C)** 0.20

UID : P1-C2-S6-Q20

➠ $p_A = x \cdot p$; $p_B = x \cdot p$

$p_A = x_p$; $p_B = 2x \cdot 2p$

Total pressure $p = p_A + p_B$

$p = xp + 4xp = 5xp$

∴ Mole fraction of,

$$A\ (X_A) = \frac{p_A}{p} = \frac{xp}{5xp} = \frac{1}{5} = 0.2$$

28) The vapour pressure of benzene is 75 mm and that of toluene is 22 mm at 20 °C tempreture. The solution prepared by mixing 78 gram benzene and 46 gram toluene then, what will be the partial pressure of benzene in the mixture ? # [AIEEE-2005]

(A) 25 (B) 50 (C) 100 (D) 75

Ans. (B) 50

➠ $p_1^0 = 75$ mm , $p_2^0 = 22$ mm

$w_1 = 78$ g , $w_2 = 56$ g

$n_1 = 1$ mole , $n_2 = 0.5$ mole

$$X_1 = \frac{1}{1.5} \quad , \quad X_2 = \frac{0.5}{1.5}$$

➠ Partial pressure of benzene,

$$P = P_1^0 X_1 = \frac{75}{1.5} = 50 \text{ mm}$$

29) What is the molality of 2.05 molar aqueous solution of acetic acid ? The density of solution is 1.02 gram/mL. [AIEEE-2006]

(A) 1.14 M (B) 3.28 M (C) 2.28 M (D) 0.44 M

Ans. (C) 2.28 m

➠ $M = 2.05$ M , $d = 1.02$, $M_1 = 60$ g / mol

$$m = \frac{1000\ M}{1000d - MM_1} = \frac{1000 \times 2.05}{1000 \times 1.02 - (2.05 \times 60)}$$

$= 2.28$ M

30) The freezing point of 5% W/W solution of sucrose is 271 K. The freezing point of pure water is 273.15 K. What will be the freezing point of 5% W/W Glucose solution ? [AIIMS-2006]

(A) 271.22 K (B) 273.15 K

(C) 269.07 K (D) 277.23 K

Ans. (C) 269.07 K

➠ $\Delta T_f = K_f \times m$

$$2.15 = \frac{1000 \times 5}{95 \times 342} \times K_f$$

$K_f = 13.9707$

$$\Delta T_f = \frac{13.97 \times 1000 \times 5}{95 \times 180}$$

$= 4.084 = 269.07$ K

31) What will be the vapour pressure of solution prepared by dissolving 18 gram Glucose to 178.2 gram water ? [AIEEE-2006]

(A) 759.00 mm (B) 7.60 mm

(C) 76.00 mm (D) 752.40 mm

Ans. (D) 752.40 mm

➠ $$\frac{P^o - P}{p^o} = \frac{n}{n + N} = \frac{n}{N} \text{ for solvent } p^\circ = 760 \text{ mm}$$

$$\therefore \frac{P^o - P}{p^o} = \frac{W \times M_0}{M \times W_0}$$

32) What will be the vapour pressure of the solution of 18 gram glucose dissolve in 178.2 gram water at 100 °C temp. ? [AIEEE - 2006]

(A) 706.4 mm (B) 752.4 mm

(C) 750 mm (D) 760 mm

Ans. (B) 752.4 mm

➠ $$\text{Mole of water (N)} = \frac{178.2}{18} = 9.9$$

$$\text{Mole of Glucose (n)} = \frac{18}{180} = 0.1$$

$$\therefore \frac{p^o - p}{p^o} = \frac{n}{n + N} \quad \therefore p = 752.4 \text{ mm}$$

33) How much H_2SO_4 is required to prepare 0.1 M 1 liter H_2SO_4 solution ? The density of 98% W/W H_2SO_4 is 1.80 gm/mL. [PMT-2007]

(A) 22.20 mL (B) 5.55 mL

(C) 11.10 mL (D) 16.65 mL

Ans. (B) 5.55 mL

➠ $$M = \frac{\% \text{ of solute} \times 10 \times \text{density}}{\text{molecular weight}}$$

$$M = \frac{98 \times 1.80 \times 10}{98} = 18 \text{ M}$$

$$M_1V_1 = M_2V_2$$

$$18 \times V_1 = 0.1 \times 1000$$

$$V_1 = \frac{0.1 \times 1000}{18} = 5.55 \text{ mL}$$

34) 1.5% Urea solution and 5.25% unknown substance's solutions are isotonic. The density of both the solutions are 1 gm/cm^3 then what is the molecular weight of unknown substance ? [AIEEE - 2007]

(A) 90.0 gram/mole (B) 115.0 gram/mole

(C) 105.0 gram/mole (D) 210.0 gram/mole

UID : P1-C2-S6-Q28

Ans. **(D)** 210.0 gram/mole

➠ For isotonic solution $\frac{W_{unknown}}{M_{unknown}} = \frac{W_{urea}}{M_{urea}}$

$M_{unknown} = \frac{5.25 \times 60}{1.5} = 210$ gram/mole

35) The vapour pressure of mixture of ethanol and propanol is 290 mm at 300 K temp. If the vapour pressure of propanol is 200 mm at 300 K temp. and the mole fraction of ethanol is 0.6, then what will be the vapour pressure of ethanol at 300 K temp. ? # [AIEEE-2007]

(A) 350 mm (B) 300 mm

(C) 700 mm (D) 360 mm

Ans. **(A)** 350 mm

➠ $P = P^o_A \cdot X_A + P^o_B \cdot X_B$

$290 = 200 \times 0.4 + P^o_B \times 0.6$

$P^o_B = 350$ mm

36) The two solutions, 1.5% urea and 5.25% unknown substance are isotonic. The density of both the solution is 1 gram/Cm^3. What will be the molar mass of the unknown substance ? [AIEEE-2007]

(A) 104 (B) 210 (C) 88 (D) 120

Ans. **(B)** 210

➠ $C_1 = C_2$

$\therefore \frac{1.5 \times 1000}{100 \times 60} = \frac{5.25 \times 1000}{100 \times M}$

$\therefore$ M = 210 g/mol

37) A 5.25 % solution of a substance is isotonic with a 1.5% solution of urea (molar mass = 60 g.mol^1) in the same solvent. If the densities of both the solutions are assumed to be equal to 1.0 g cm^{-3}, then molar mass of the substance will be [AIEEE-2007]

(A) 90 g mol^{-1} (B) 115 g mol^{-1}

(C) 105 g mol^{-1} (D) 210 g mol^{-1}

Ans. **(D)** 210 g mol^{-1}

38) When 20 g of naphthoic acid ($C_{11}H_8O_2$) is dissolved in 50 g of benzene (K_f = 1.72 K m^{-1}), a freezing point depression of 2 K is observed. The Van't Hoff factor is .... [IIT JEE-2007]

(A) 0.5 (B) 1 (C) 2 (D) 3

Ans. **(A)** 0.5

39) A mixture of ethanal and propanal has a vapour pressure of 290 mm at 300 K. The vapour pressure of propanal is 200 mm. If the mole fraction of ethanal is 0.6, its vapour pressure (in mm) at the same temperature will be.... [AIEEE-2007]

(A) 350 mm (B) 300 mm

(C) 700 mm (D) 360 mm

Ans. **(A)** 350 mm

40) The vapour pressure of pure liquid A and B are 520 mm and 1000 mm respectively at 80°C temp. If the solution of A and B is boil at 80°C temp. and 1 at pressure, what will be the % of A in the mixture ? [AIEEE-2008]

(A) 52 % (B) 34 % (C) 48 % (D) 50 %

Ans. **(D)** 50 %

➠ $P = P^o x_A + P^o x_B$

$760 = (520 \times x_A) + [1000\ (1 - x_A)]$

$= 520 \times x_A + 1000 - 1000x_A$

$\therefore x_A = 0.5$

$\therefore$ % mole = 0.5 × 100

= 50%

41) At 353 K, the vapour pressure of pure liquid A and B are 520 mm and 1000 mm respectively. If a mixture of solutions of A and B boils at 353 K and 1 bar pressure, the mole percent of A in mixture is ...... (1 bar = 760 mm) [AIEEE-2008]

(A) 52 % (B) 34 % (C) 48 % (D) 50 %

Ans. **(D)** 50 %

42) The freezing point of 0.01 M KCl solution is –2°C. If BaCl$_2$ is completely ionized, what is the freezing point of 0.01 M BaCl$_2$ solution ? [AIIMS - 2008]

(A) –3° C (B) +3° C (C) –2° C (D) –4° C

Ans. **(A)** –3° C

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

$2 = K_f \times 0.01 \times 2$

$K_f = 100^o$ C kg mol^{-1}

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

$= 100 \times 0.01 \times 3$

$= 3^o$ C

$T_f = -3^o$ C

UID : P1-C2-S6-Q35

43) The vapour pressure of water is 17.5 mm at 20°C temp. what is the vapour pressure of solution 20°C prepared by dissolving 18 gram glucose in to 178.2 gram water at 20°C temp. ? #

[AIEEE - 2008]

(A) 17.675 mm (B) 15.750 mm

(C) 16.500 mm (D) 17.325 mm

Ans. (D) 17.325 mm

➠ $P_1^0 = 17.5$ mm , $P_1 = ?$

$$\frac{P_1^o - P_1}{P_1^o} = \frac{M_1 w_2}{M_2 w_1}$$

$$\frac{17.5 - P_1}{17.5} = \frac{18 \times 18}{180 \times 178.2}$$

$$P_1 = 17.325 \text{ mm}$$

44) Two liquid A and B form an ideal solution on mixing. The vapour pressure of solution having 1 mole A and 3 mole B is 550 mm at 300 K temp. The vapour pressure will increased by 10 mm on addition of 1 mole B to the solution. What will be the vapour pressure of A and B individually ? [AIEEE-2009]

(A) 500 and 600 (B) 200 and 300

(C) 300 and 400 (D) 400 and 600

Ans. (D) 400 and 600

➠ Suppose X = A and Y = B

$$P_A^0 X_A + P_B^0 X_B = P_{TOT}$$

$$\therefore \; P_A^0\left(\frac{1}{1+3}\right) + P_B^0\left(\frac{3}{1+3}\right) = 550 \text{ mm}$$

$\therefore$ 0.25 P_A^0 + 0.75 P_B^0 = 550 mm ....(1)

➠ Now add 1 mole B to mixture

0.20 P_A^0 + 0.80 P_B^0 = 560 mm ....(2)

multiply (1) by 4 | $\therefore$ $P_A^0 + 4\,P_B^0 = 2800$

$\therefore$ $P_A^0 + 3\,P_B^0 = 2200$ | $\therefore$ $P_A^0 = 400$ mm $= P_X^0$

multiply (2) by 5 | $P_A^0 = 600$ mm $= P_Y^0$

45) Identify the correct order of solubility in aqueous medium : [NEET-2013]

(A) $Na_2S > ZnS > CuS$ (B) $CuS > ZnS > Na_2S$

(C) $ZnS > Na_2S > CuS$ (D) $Na_2S > CuS > ZnS$

Ans. (A) $Na_2S > ZnS > CuS$

46) Consider separate solutions of 0.500 M $C_2H_5OH_{(aq)}$, 0.100 M $Mg_3(PO_4)_{2(aq)}$, 0.250 M $KBr_{(aq)}$ and 0.125 M $Na_3PO_{4(aq)}$ at 25°C. Which statement is true about these solutions, assuming all salts to be strong electrolytes ?

[JEE-2014]

(A) 0.125 M $Na_3PO_{4(aq)}$ has the highest osmotic pressure.

(B) 0.500 M $C_2H_5OH_{(aq)}$ has the highest osmotic pressure.

(C) They all have the same osmotic pressure.

(D) 0.100 M $Mg_3(PO_4)_{2(aq)}$ has the highest osmotic pressure.

Ans. (C) They all have the same osmotic pressure.

47) Of the following 0.10 m aqueous solutions, which one will exhibit the largest freezing point depression ? [NEET-2014]

(A) KCl (B) $C_6H_{12}O_6$

(C) $Al_2(SO_4)_3$ (D) K_2SO_4

Ans. (C) $Al_2(SO_4)_3$

➠ $\Delta T_f = ik_f m$

i is highest for $Al_2(SO_4)_3$

48) Which of the following electrolytes has the same value of Van't Hoff's factor (i) as that of $Al_2(SO_4)_3$ (if all are 100% ionised) ?

[NEET-May : 2015]

(A) K_2SO_4 (B) $K_3[Fe(CN)_6]$

(C) $Al(NO_3)_3$ (D) $K_4[Fe(CN)_6]$

Ans. (D) $K_4[Fe(CN)_6]$

➠ Van't Hoff factor of

$$Al_2(SO_4)_3 \rightarrow 2Al^{+3} + 3SO_4^{-2}$$

so n = 5

➠ $K_4[Fe(CN)_6] \rightarrow 4K^+ + [Fe(CN)_6]^{-4}$

so n = 5 ⇒ i = n = 5

49) The boiling point of 0.2 mol kg^{-1} solution of X in water is greater than equimolal solution of Y in water. Which one of the following statements is true in this case ?

[NEET-May : 2015]

UID : P1-C2-S6-Q43

(A) X is undergoing dissociation in water.

(B) Molecular mass of X is greater than the molecular mass of Y.

(C) Molecular mass of X is less than the molecular mass of Y.

(D) Y is undergoing dissociation in water while X undergoes no change.

Ans. **(A)** X is undergoing dissociation in water.

➠ $(\Delta T_b)_x > (\Delta T_b)_y$

same solvent so, K_b is same

m is same (given)

$i_x \cdot K_b \cdot m > i_y \cdot K_b \cdot m \Rightarrow i_x > i_y$

➠ so, X is undergoing dissociation in water.

50) Which one is not equal to zero for an ideal solution ? # [NEET-May : 2015]

(A) ΔH_{mix} (B) ΔS_{mix}

(C) ΔV_{mix} (D) $\Delta P = P_{observed} - P_{Raoult}$

Ans. **(B)** ΔS_{mix}

➠ For an ideal solution $\Delta S_{mix} > 0$

51) What is the mole fraction of the solute in a 1.00m aqueous solution ? [NEET-July : 2015]

(A) 0.0354 (B) 0.0177 (C) 0.177 (D) 1.770

Ans. **(B)** 0.0177

➠ 1.00 m solution means 1 mole solute is present in 1000 g water.

$$n_{H_2O} = \frac{1000}{18} = 55.5 \text{ mol } H_2O$$

$$X_{solute} = \frac{n_{solute}}{n_{solute} + n_{H_2O}} = \frac{1}{1+55.5} = 0.0177$$

52) 18 g glucose ($C_6H_{12}O_6$) is added to 178.2 g water. The vapour pressure of water (in torr) for this aqueous solution is : [JEE-2016]

(A) 759.0 (B) 7.6 (C) 76.0 (D) 752.4

Ans. **(D)**

➠ From Roult's law

$$\frac{P_O - P_S}{P_O} = X_{solute}$$

$$\therefore \frac{P_O - P_S}{P_O} = \frac{n_{solute}}{n_{solute} + N_{solvent}}$$

$$\Rightarrow \frac{P_O - P_S}{P_O} = \frac{0.1}{\frac{178.2}{18} + 0.1}$$

$\because P_o$ = 760 torr (100°C)

∴ Vapour pressure of H_2O in solution = 752.3 torr

53) At 100°C the vapour pressure of a solution of 6.5 gm of a solute in 100 g water is 732 mm. If K_b = 0.52, the boiling point of this solution will be : [NEET-May : 2016]

(A) 100°C (B) 102°C. (C) 103° C (D) 101° C

Ans. **(D)** 101° C

➠ $$\frac{P_1^0 - P_1}{P_1^0} = \frac{n_2}{n_1}$$

$$\frac{760-732}{760} = \frac{6.5 \times 18}{M_2 \times 100} \qquad \therefore M_2 = 31.6$$

$$\Delta T_b = \frac{0.52 \times 6.5 \times 1000}{31.6 \times 100} = 1.07$$

∴ Vapour pressure = 100 + 1.07

= 101.07° C

≈ 101° C

54) Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct ? Assume that the temperature is constant at 25° C. (Given, Vapour' Pressure Data at 25°C, benzene = 12.8 kPa toluene = 3.85 kPa) [NEET-May : 2016]

(A) The vapour will contain a higher percentage of toluene.

(B) The vapour will contain equal amounts of benzene and toluene.

(C) Not enough information is given to make a prediction.

(D) The vapour will contain a higher percentage of benzene.

Ans. **(D)** The vapour will contain a higher percentage of benzene.

➠ In composition of Benzene of vapour pressure is more hence its proportion of percentage is more in mixture.

55) The Van't Hoff factor (i) for a dilute aqueous solution of the strong electrolyte barium hydroxide is [NEET-July : 2016]

(A) 2 (B) 3 (C) 0 (D) 1

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Ans. **(B)** 3

➠ $Ba(OH)_2$ is strong electrolyte, so its 100% dissociation occurs in solution

$$Ba(OH)_2 \longrightarrow Ba^{+2} + 2OH^-_{(aq)}$$

➠ Van't Hoff factor = total number of ions present in solution $i = 3$

56) Which one of the following is incorrect for ideal solution ? # [NEET-July : 2016]

(A) $\Delta P = Pobs - P_{\text{calculated by Raoult's law}} = 0$

(B) $\Delta G_{mix} = 0$

(C) $\Delta H_{mix} = 0$ (D) $\Delta U_{mix} = 0$

Ans. **(B)** $\Delta G_{mix} = 0$

➠ For an ideal solution $\Delta H_{mix} = 0$

$\Delta U_{mix} = 0$

$\Delta S_{mix} \neq 0$

➠ According to $\Delta G_{mix} = \Delta H_{mix} - T\Delta S_{mix}$

$\Rightarrow \Delta G_{mix} \neq 0$

Incorrect answer, is $\Delta G_{mix} = 0$

57) The freezing point of benzene decreases by 0.45° C when 0.2 g of acetic acid is added to 20 g of benzene. If acetic acid associates to form a dimer in benzene, percentage association of acetic acid in benzene will be.....

(K_f for benzene = 5.12 K kg mol^{-1}) [JEE-2017]

(A) 64.6 % (B) 80.4 % (C) 74.6 % (D) 94.6 %

Ans. **(D)** 94.6 %

➠ $\Delta T_f = 0.45$

$$m = \frac{\left(\frac{0.2}{60}\right) \times 1000}{20} = \frac{1}{6}$$

$K_f = 5.12$ K kg / mol

$$i = 1 + \left(\frac{1}{n} - 1\right)x \qquad (n = 2)$$

$$= 1 - \frac{x}{2}$$

➠ Now, $\Delta T_f = iK_f m$

$$0.45 = \left(1 - \frac{x}{2}\right)(5.12)\left(\frac{1}{6}\right)$$

$x = 0.94$

$\therefore$ Percentage of ≈ 94%

58) For 1 molal aqueous solution of the following compounds, which one will show the highest freezing point ? [JEE-2018]

(A) $[Co(H_2O)_6]\ Cl_3$

(B) $[Co(H_2O)_5Cl]\ Cl_2 \cdot H_2O$

(C) $[Co(H_2O)_4Cl_2]\ Cl \cdot 2H_2O$

(D) $[Co(H_2O)_3Cl_3] \cdot 3H_2O$

Ans. **(D)** $[Co(H_2O)_3Cl_3] \cdot 3H_2O$

➠ As the value of *i* increases the freezing point decreases.

Aqueous solution	***i***
$[Co(H_2O)_6]Cl_3$	$\rightarrow 4$
$[Co(H_2O)_5Cl]Cl_2 \cdot H_2O$	$\rightarrow 3$
$[Co(H_2O)_4Cl_2]\ Cl \cdot 2H_2O$	$\rightarrow 2$
$[Co(H_2O)_3Cl_3] \cdot 3H_2O$	$\rightarrow 1$

59) If increase in boiling point of 1 molal glucose solution is 2K and increase in freezing point of 2 molal glucose solution is also 2K. Then state the relationship of K_b and K_f.

[JEE (January)-2019]

(A) $K_b = 1.5\ K_f$ (B) $K_b = 0.5\ K_f$

(C) $K_b = 2K_f$ (D) $K_b = K_f$

Ans. **(C)** $K_b = 2K_f$

➠ $$\frac{\Delta T_b}{\Delta T_f} = \frac{i \times m \times K_b}{i \times m \times K_f}$$

$$\therefore \frac{2}{2} = \frac{1 \times 1 \times K_b}{1 \times 2 \times K_f}$$

$\therefore K_b = 2K_f$

60) The mixture that forms maximum boiling azeotrope is : [NEET-2019]

(A) Heptane + Octane

(B) Water + Nitric acid

(C) Ethanol + Water

(D) Acetone + Carbon disulphide

Ans. **(B)** Water + Nitric acid

➠ Negative deviated mixtures from ideal behaviour can form maximum boiling azeotrope.

➠ Water + Nitric acid shows negative deviation.

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61) **At 35 °C the vapour pressure of CS_2 is 512 mm of Hg and that of acetone is 344 mm of Hg. A solution of CS_2 in acetone has a total vapour pressure of 600 mm of Hg. The false statement among the following is : # [JEE-2020]**

(A) CS_2 and acetone are less attracted to each other than themselves.

(B) Heat must be absorbed in order to produce the solution at 35° C.

(C) Raoult's law is not obeyed by this system.

(D) A mixture of 100 mL CS_2 and 100 mL acetone has a volume less than 200 mL.

Ans. **(D)** A mixture of 100 mL CS_2 and 100 mL acetone has a volume less than 200 mL.

➠ $p_{total} = p^{o}{}_{A}x_{A} + p^{o}{}_{B}x_{B}$

➠ Maximum value of X_A is 1, so p_{total} has maximum value of 512 mm, which is less value than observed 600 mm value, so positive deviation would be observed. In which interaction between A – A and B – B is more than A – B interaction.

➠ So, for the system which does not follow Raoult's law and shows positive deviation,

$$\Delta V_{mix} > 0,\ \Delta H_{mix} > 0$$

62) **The molarity of HNO_3 in a sample which has density 1.4 g/mL and mass percentage of 63% is...... [JEE-2020]**

(A) 14 (B) 12 (C) 8 (D) 6

Ans. **(A)** 14

➠ Where, $\%\frac{w}{w} = 63\%$

$\rho = 1.4$ g/mL

➠ $M = \dfrac{(\%\frac{w}{w} \times \rho \times 10)}{MM}$

$M = \dfrac{(63 \times 1.4 \times 10)}{63}$

M = 14 mol/L

63) **At 300 K, the vapour pressure of a solution containing 1 mole of n-hexane and 3 moles of n-heptane is 550 mm of Hg. At the same temperature, if one more mole of n-heptane is added to this solution, the vapour pressure of the solution increases by 10 mm of Hg. What is the vapour pressure in mm Hg of n-heptane in its pure state ? [JEE (September)-2020]**

➠ $P_{total} = P^0_{hexane} \cdot X_{hexane} + P^0_{heptane} \cdot X_{heptane}$

Case-1 :

$$550 = P^0_{hexane}\left(\frac{1}{4}\right) + P^0_{heptane}\left(\frac{3}{4}\right) \quad \text{....(i)}$$

Case-2 : After mixing 1 mole n-heptane

$$560 = P^0_{hexane}\left(\frac{1}{5}\right) + P^0_{heptane}\left(\frac{4}{5}\right) \quad \text{....(ii)}$$

➠ On solving eq. (i) and (ii)

$$\begin{array}{rcl} 2200 &=& P^0_{hexane} + 3P^0_{heptane} \\ 2800 &=& P^0_{hexane} + 4P^0_{heptane} \\ - && -\qquad\quad - \\ \hline -600 &=& -P^0_{heptane} \end{array}$$

$\therefore\ P^0_{heptane} = 600$ mm Hg

64) **A mixture of N_2 and Ar gases in a cylinder contains 7 g of N_2 and 8 g of Ar. If the total pressure of the mixture of the gases in the cylinder is 27 bar, the partial pressure of N_2 is : [Use atomic masses (in g mol^{-1}) : N = 14, Ar = 40] [NEET-2020]**

(A) 15 bar (B) 18 bar (C) 9 bar (D) 12 bar

Ans. **(A)** 15 bar

➠ Total moles of $N_2 = \dfrac{7}{28} = \dfrac{1}{4}$ mol,

Total moles of Ar $= \dfrac{8}{40} = \dfrac{1}{5}$ mol

Mole fraction of N_2, $y_1 = \dfrac{\frac{1}{4}}{\frac{1}{4}+\frac{1}{5}} = \dfrac{5}{9}$

Partial Pressure of $N_2 = y_1 \cdot p_{total}$

$= \dfrac{5}{9} \times 27 = 15$ bar

65) **The freezing point depression constant (K_f) of benzene is 5.12 K kg mol^{-1}. The freezing point depression for the solution of molality 0.078 m containing a non-electrolyte solute in benzene is (rounded off upto two decimal places) : [NEET-2020]**

(A) 0.40 K (B) 0.60 K (C) 0.20 K (D) 0.80 K

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Ans. **(A)** 0.40 K

➠ $\Delta T_f = K_f \cdot M$

$= 5.12 \times 0.078$

$= 0.40$ K

66) The mixture which shows positive deviation from Raoult's law is : # [NEET-2020]

(A) Acetone + Chloroform

(B) Chloroethane + Bromoethane

(C) Ethanol + Acetone

(D) Benzene + Toluene

Ans. **(C)** Ethanol + Acetone

➠ Pure ethanol has intermolecular H-bonding. The acetone when added to the ethanol, the acetone occupies the space in between the molecules of ethanol by breaking the H-bonds. This results in the rise in vapour pressure. Hence,the mixture shows the positive deviation from Raoult's Law.

67) The following solutions were prepared by dissolving 10 g of glucose ($C_6H_{12}O_6$) in 250 ml of water (P_1), 10 g of urea (CH_4N_2O) in 250 ml of water (P_2) and 10 g of sucrose ($C_{12}H_{22}O_{11}$) in 250 ml of water (P_3). The right option for the decreasing order of osmotic pressure of these solutions is : [NEET-2021]

(A) $P_2 > P_3 > P_1$ (B) $P_3 > P_1 > P_2$

(C) $P_2 > P_1 > P_3$ (D) $P_1 > P_2 > P_3$

Ans **(C)** $P_2 > P_1 > P_3$

➠ Osmotic pressure $= \pi = \dfrac{inRT}{V}$

$\pi \propto \text{Mole} \quad \text{and} \quad \text{Mole} \propto \dfrac{1}{\text{Molecular mass}}$

Molecular mass of Glucose = 180 g mole^{-1}

Molecular mass of urea = 60 g mole^{-1}

Molecular Mass of Sucrose = 342 g mole^{-1}

➠ Thus as molar mass increases, no of mole decreases, so osmotic pressure will decrease. Sucrose has minimum osmotic pressure whereas urea has maximum osmotic pressure.

MCQ's asked in GUJCET Exam

68) Which of the following is change with temperature ? [GUJCET-2006]

(A) Molality (B) %W/W

(C) Formality (D) Mole fraction

Ans. **(C)** Formality

➠ Formality is volume dependent and volume is change with change in temp.

69) Which pair is isotonic at same temperature ? [GUJCET-2006]

(A) 0.1 M urea and 0.1 M KCl

(B) 0.1 M $Ba(NO_3)_2$ and 0.1 M Na_2SO_4

(C) 0.2 M NaCl and 0.2 M Na_2SO_4

(D) 0.2 M $BaCl_2$ and 0.2 M Sucrose

Ans. **(B)** 0.1 M $Ba(NO_3)_2$ and 0.1 M Na_2SO_4

70) What is the normality of 0.04 M H_2SO_4 ? [GUJCET-2006]

(A) 0.04 N (B) 0.012 N (C) 0.08 N (D) 0.02 N

Ans. **(C)** 0.08 N

➠ $\text{Molarity} = \dfrac{\text{Normality} \times \text{equivalent weight}}{\text{Molecular weight}}$

$0.04 = \dfrac{\text{Normality} \times 49}{98}$

$\therefore$ Normality = 0.08 N

71) Freezing point of urea solution is -0.6^0 C. How much urea is required to be dissolved in 3 kg water ?

[M(urea) = 60 g mol^{-1}, $K_f = 1.5^0\text{C Kg mol}^{-1}$]

[GUJCET-2007]

(A) 2.4 g (B) 3.6 g (C) 6.0 g (D) 72 g

Ans. **(D)** 72 g

72) Which of the following is the best semi permeable membrane ? [GUJCET-2007]

(A) Cell wall of plants (B) Cellophane

(C) Parchment paper

(D) Copper ferrocynide

Ans. **(D)** Copper ferrocynide ($Cu_2[Fe(CN)_6]$)

UID : P1-C2-S6-Q66

73) The freezing point of the aqueous solution of urea is –0.6°C. How much urea should be added to 3 kg water to get such solution ? (K_f = 1.5° C Kg. mol^{-1}) # [GUJCET-2007]

(A) 72 gram (B) 6.0 gram

(C) 3.6 gram (D) 2.4 gram

Ans. (A) 72 gram

➠ $\Delta T = K_f \cdot m = K_f \times \left(\frac{1000 \times W}{M \times W_o}\right)$

$$W = \frac{\Delta T \times M \times W_o}{K_f \times 1000}$$

$$\therefore \quad W = \frac{0.6 \times 60 \times 3000}{1.5 \times 1000} = 72 \text{ gram}$$

74) Calculate the osmotic pressure of 0.25 M urea solution at 27°C temp. (R = 0.082 lit.at./mole K, R = 1.987 K cal.) [GUJCET-2008]

(A) 0.0615 atmosphere (B) 61.5 atmosphere

(C) 6.15 atmosphere (D) 0.615 atmosphere

Ans. (C) 6.15 atmosphere

➠ Osmotic pressure $\pi = \frac{WRT}{MV}$

$$= \frac{W}{MV} \times RT$$

$$= C \times RT$$

$$= 0.25 \times 0.082 \times 300$$

$$= 6.15 \text{ atmosphere}$$

75) Find out normality of the solution prepared by dissolving 9.8 gram H_2SO_4 to 500 mL solution ? [GUJCET-2008]

(A) 4.0 (B) 0.8 (C) 0.2 (D) 0.4

Ans. (D) 0.4

➠ V = 500 mL

W = 9.8 gram

M = 98 gram/mole

$$E = \frac{49 \text{ gram}}{\text{eq. wt.}}$$

➠ Normality (N) $= \frac{1000 \times W}{E \times V}$

$$= \frac{1000 \times 9.8}{49 \times 500} = 0.4 \text{ N}$$

76) The elevation in boiling point of the solution prepared by dissolving 0.6 gram urea to 200 gram water is 0.50°C. What will be the molal elevation constant ? [GUJCET-2009]

(A) 10 K kg mole (B) 10 K kg mole^{-1}

(C) 1.0 K kg mole (D) 100 K kg mole^{-1}

Ans. (B) 10 K kg mole^{-1}

➠ $K_b = \frac{\Delta T \times M \times W_0}{1000 \times W} = \frac{0.5 \times 60 \times 200}{1000 \times 0.6}$

$$= 10 \text{ K kg mole}^{-1}$$

77) How much NaOH is required to prepare 10% w/w 500 gram solution of NaOH ? [GUJCET-2009]

(A) 0.5 gram (B) 100 gram

(C) 5.0 gram (D) 50 gram

Ans. (D) 50 gram

➠ $\%\frac{w}{w} = \frac{100 \times \text{mass of solute}}{\text{mass of solution}}$

$$\therefore \quad 10 = \frac{100 \times \text{mass of solute}}{500}$$

$$\therefore \quad \text{Mass of solute} = \frac{10 \times 500}{100} = 50 \text{ gram}$$

78) The increase in boiling point of a solution containing 0.6 g urea in 200 g water is 0.50° C, find the molal elevation constant. [GUJCET-2009]

(A) 1.0 K kg mol^{-1} (B) 10 K kg mol^{-1}

(C) 10 K kg mol^{-1} (D) 10 K kg mol

Ans. (C) 10 K kg mol^{-1}

79) How many grams of NaOH will be required to prepare 500 gram solution containing 10% W/W NaOH solution ? [GUJCET-2009]

(A) 5 g (B) 50 g (C) 100 g (D) 0.5 g

Ans. (B) 50 g

80) If osmotic pressure of a solution at 27° C is 0.82 bar, what will be molarity of solution ? [GUJCET-2009]

(A) 0.33M (B) 0.033M (C) 3.3M (D) 0.066M

Ans. (B) 0.033M

UID : P1-C2-S6-Q73

81) Which of the following aqueous solutions will have maximum osmotic pressure at constant temperature ? # [GUJCET-2010]

(A) 1m $H_2SO_{4(aq)}$ (B) 1m $NaCl_{(aq)}$

(C) 1M $H_2SO_{4(aq)}$ (D) 1M $NaCl_{(aq)}$

Ans. (C) 1M $H_2SO_{4(aq)}$

82) The $[H_3O^+]$ cocentration in the 200 mL. H_2SO_4 solution is 1 M. How much H_2SO_4 is dissolved in the solution ? [GUJCET - 2011]

[H = 1, O = 16, S = 32 gram/mole]

(A) 4.9 g (B) 19.6 g (C) 9.8 g (D) 0.98 g

Ans. (C) 9.8 g

➠ $H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$

$2 \times x = 1$

$x = 0.5$ M

$\therefore\ 0.5 = \dfrac{x \times 1000}{98 \times 200}$

$\therefore\ x = 9.8$ g

83) What happened when concentration of salt solution will increase ? [GUJCET - 2011]

(A) Boiling point increase and vapour pressure decreases.

(B) Boiling point decrease and vapour pressure increases.

(C) Freezing point decrease and vapour pressure increases.

(D) Freezing point increases and vapour pressure decreases.

Ans. (A) Boiling point increase and vapour pressure decreases.

84) What is the normality of 250 mL. H_2SO_4 having pH = 0.0 ? [GUJCET-2010, 2012]

(A) 0.50 N (B) 0.25 N (C) 2 N (D)1 N

Ans. (D) 1 N

➠ pH = 0 $\quad$ l0g$[H^+]$ = 0 $\quad$ $[H^+]$ = 1

Molarity = 0.5 M

Normality = 1 N

85) When gas is dissolve in liquid solvent and form solution, then according to Raoult's law its vapour pressure will be.... [GUJCET-2012]

(A) $\dfrac{P^o - P}{P^o} = \dfrac{n}{n+N}$ (B) $P = K \cdot \dfrac{N}{n+N}$

(C) $P = K_H \cdot X_A$ (D) $P = P_A + P_B$

Ans. (A) $\dfrac{P^o - P}{P^o} = \dfrac{n}{n+N}$

86) Which of the following solution having same vapour pressure as 0.3 M glucose solution ?

[GUJCET-2012]

(A) 0.1 M $[Co(H_2O)_3(NO_2)_3]$

(B) 0.1 M $Na_2[Co(H_2O)(NO_2)_5]$

(C) 0.1 M $Na[Co(H_2O)_2(NO_2)_4]$

(D) 0.1 M $Na_3[Co(NO_2)_6]$

Ans. (B) 0.1 M $Na_2[Co(H_2O)(NO_2)_5]$

➠ $Na_2[Co(H_2O)(NO_2)_5] \rightarrow 2Na^+ + [Co(H_2O)(NO_2)_5]$

Total no. of ions are 3.

So = 3 × 0.1 = 0.3 M

87) What will be the normality of 0.2 M H_3PO_3 soution ? [GUJCET-2012]

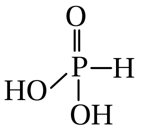
(A) 0.1 N (B) 0.2 N (C) 0.6 N (D) 0.4 N

Ans. (D) 0.4 N

➠ Normality = M × basicity

= 0.2 × 2

Normality = 0.4 N



88) Which of the following aqueous solution will have maximum vapour pressure at constant temperature ? [GUJCET-2013]

(A) 0.1 M NaCl (B) 0.1 M $FeCl_3$

(C) 0.1 M $BaCl_2$ (D) 0.1 M Glucose

Ans. (D) 0.1 M Glucose

➠ The number of particles of solute in solution $\propto \dfrac{1}{\text{Vapour pressure}}$

➠ The number of particles are the least in the solution of 0.1 M glucose due to dissociation does not take place in it.

UID : P1-C2-S6-Q81

89) What will be the normality of resulting solution obtained by mixing 4 mL 0.05 M $H_2SO_{4(aq)}$ solution and 6 mL 0.3 M $H_2SO_{4(aq)}$? #

[GUJCET-2013]

(A) 0.175 N (B) 0.35 N (C) 0.4 N (D) 0.2 N

Ans. (C) 0.4 N

➠ $$M = \frac{N_1V_1 + N_2V_2}{(V_1 + V_2)}$$

$$= \frac{0.05 \times 4 + 0.3 \times 6}{4 + 6} = \frac{0.2 + 1.8}{10} = 0.2$$

Now, N = M × 2 = 0.2 × 2 = 0.4

90) Which of the following mixture is the ideal solution ? [GUJCET-2013]

(A) Chloroform and acetone

(B) Benzene and toluene

(C) Phenol and aniline

(D) HCl and H_2O

Ans. (B) Benzene and toluene

91) What will be the value of molality for an aqueous solution of 10% w/w NaOH ?

(Na = 23, O = 16, H = 1) [GUJCET-2014]

(A) 2.778 (B) 5 (C) 10 (D) 2.5

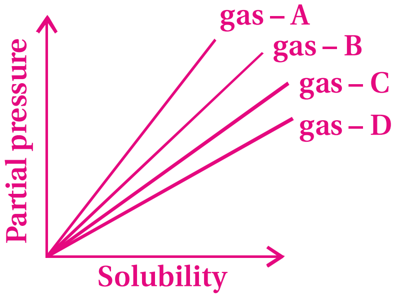
Ans. (A) 2.778

➠ $$m = \frac{\text{mass of solute} \times 1000}{\text{atomic weight} \times \text{mass of solvent}}$$

$$= \frac{10 \times 1000}{40 \times 90} = 2.778$$

92) From the given graph at constant temperature, which gas has the least solubility ?

[GUJCET-2014]



(A) gas – D (B) gas – B

(C) gas – A (D) gas – C

Ans. (C) gas – A

93) If 10 mL of 0.1 M aqueous solution of NaCl is divided in to 1000 drops of equal volume, what will be the concentration of one drop ?

[GUJCET-2014]

(A) 0.01 M (B) 0.10 M

(C) 0.001 M (D) 0.0001 M

Ans. (B) 0.10 M

94) The boiling points for aqueous solutions of sucrose and urea are same at constant temperature. If 3 gm of urea is dissolved in its 1 litre solution, what is the weight of sucrose dissolved in its 1 litre solution ?

[Urea - 60 gm/mole, sucrose = 342 gm/mole]

[GUJCET-2015]

(A) 3.0 gram (B) 17.1 gram

(C) 6.0 gram (D) 34.2 gram

Ans. (B) 17.1 gram

95) Which option is inconsistant for Raoult's law ?

[GUJCET-2015]

(A) Volume of liquid solvent + volume of liquid solute = volume of solution.

(B) The change in heat of dilution for solution = 0.

(C) Solute does not undergo association in solution.

(D) Solute undergoes dissociation in solution.

Ans. (D) Solute undergoes dissociation in solution.

96) Which colligative property is more useful to determine the molecular weight of the substances like proteins and polymers ?

[GUJCET-2015]

(A) Lowering of vapour pressure.

(B) Elevation in boiling point.

(C) Depression of freezing point.

(D) Osmotic pressure.

Ans. (D) Osmotic pressure.

97) At given temperature and pressure adsorption of which gas of the following will take place the most ? [GUJCET-2015]

(A) Di hydrogen (B) Di oxygen

(C) Ammonia (D) Di nitrogen

Ans. (C) Ammonia

UID : P1-C2-S6-Q89

98) Which solution has the highest vapour pressure in identical condition ? # [GUJCET-2016]

(A) 0.1 M $FeCl_3$ (B) 0.1 M $BaCl_2$

(C) 0.1 M NaCl (D) 0.1 M Urea

Ans. **(D)** 0.1 M Urea

99) In which of the following solutions, the solubility of solute decreases on heating the solution ? [GUJCET-2016]

(A) Aqueous solution of ethylene glycol

(B) Chlorine water

(C) Aqueous solution of sugar

(D) Zn-Hg amalgam

Ans. **(B)** Chlorine water

100) The proportion of CaF_2 in a sample of water is 156 ppm. What will be its molarity ?

[Mole. mass of CaF_2 is 78 gm/mol.]

[GUJCET-2016]

(A) 0.01 M (B) 0.02 M

(C) 0.002 M (D) 0.001 M

Ans. **(C)** 0.002 M

101) At certain temperature 1.6% solution of an unknown substance is isotonic with 2.4% solution of Urea. If both the solutions have the same solvent and both the solutions have same density 1 gm/cm^3, what will be the molecular mass of unknown substance in gm/mol.

[Mole. mass of urea = 60 gm/mol]

[GUJCET-2017]

(A) 40 (B) 90 (C) 80 (D) 30

Ans. **(A)** 40

➠ For, isotonic solution

$$\left(\frac{\%\,w/V}{M}\right)_{urea} = \left(\frac{\%\,w/V}{M}\right)_{unknown}$$

$$\frac{2.4}{60} = \frac{1.6}{M}$$

$$\therefore \quad M = \frac{1.6 \times 60}{2.4} = 40 \text{ gram/mole}$$

102) Which of the following aqueous solution will have the boiling point 102.2°C ? The molar elevation constant for water is 2.2 K kg mol^{-1}.

[GUJCET-2017]

(A) 1m NaCl (B) 1m glucose

(C) 1M NaCl (D) 1m CH_3COOH

Ans. **(B)** 1m glucose

➠ $m = 1$; $\Delta T_b = 2.2$ K ; $K_b = 2.2$ K kg mol^{-1}

$\Delta T_b = i \cdot K_b \cdot m$

$2.2 = i \times 2.2 \times 1$

$\therefore\ i = 1$ For glucose, $i = 1$

103) Maximum amount of a solid solute that can be dissolved in a specified amount of a given liquid solvent does not depend upon ....

(i) Temperature (ii) Nature of solute

(iii) Pressure (iv) Nature of solvent

[GUJCET-2020]

(A) (i) and (iii) (B) Only (ii)

(C) (ii) and (iv) (D) Only (iii)

Ans. **(D)** Only (iii)

➠ Solids are non-compressible. Thus, there will be no effect of pressure on its solubility.

104) The molality of aqueous solution of any solute having mole fraction 0.25 is ....

[GUJCET-2020]

(A) 18.52 m (B) 16.67 m

(C) 33.33 m (D) 9.26 m

Ans. **(A)** 18.52 m

➠ The relation between the mole fraction and molality can be written as :

$$\frac{x_{solute}}{x_{water}} = \frac{m \times \text{Molar mass of solvent}}{1000}$$

$$= \frac{0.25}{0.75} = \frac{m \times 18}{1000}$$

$$\therefore\ m = 18.52 \text{ m}$$

105) The osmotic pressure of 0.5 M aqueous solution of CH_3COOH having 2pH at temperature T is .... [GUJCET-2020]

(A) 0.051 RT (B) 1.02 RT

(C) 0.51 RT (D) 0.102 RT

Ans. **(C)** 0.51 RT

➠ $\pi = iCRT$ Where, i = Van't Hoff Factor

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

For $[H^+]$ and dissociation fraction α

$[H^+] = C \cdot \alpha$

C = Concentration

R = Gas constant

T = Temperature

UID : P1-C2-S6-Q98

$\therefore \quad \alpha = \dfrac{[H^+]}{C}$

pH = 2

$-\log [H^+] = 2$

$\log [H^+] = -2$

$[H^+] = 10^{-2} = 0.01$

$\therefore \quad \alpha = \dfrac{0.01}{0.5} = 0.02$

$\therefore \quad i = 1 + \alpha = 1 + 0.02 = 1.02$

➠ $\pi = iCRT$

$= 1.02 \times 0.5\ RT = 0.51\ RT$

106) Which of the following aqueous solutions should have the minimum boiling point ? # **[GUJCET-2021]**

(A) 0.1 M Urea (B) 0.1 M NaCl

(C) 0.1 M K_2SO_4 (D) 0.1 M $FeCl_3$

Ans. (A) 0.1 M Urea

➠ For urea, $i = 1$, hence, its boiling point is minimum.

107) 3.0 gram ethanoic acid in 50 gram benzene having .... molality.

(Atomic weights : H = 1, C = 12, O = 16)

[GUJCET-2021]

(A) 0.1 (B) 0.6 (C) 1.0 (D) 0.06

Ans. (C) 1.0

➠ Mass of benzene = 50 g

Mass of ethanoic acid (CH_3COOH) = 3 g

Molecular mass of ethanoic acid is

= 2(12) + 4(1) + 2(16)

= 24 + 4 + 32

= 60 gram mol^{-1}

Moles of ethanoic acid $= \dfrac{3}{60} = 0.05$ mol

$$M = \frac{\text{Moles of solute}}{\text{Mass of solvent (kg)}} = \frac{0.05}{\frac{50}{1000}}$$

m = 1 M

108) Which method is used to remove salts from sea water ? **[GUJCET-2021]**

(A) Hydraulic washing (B) Reverse osmosis

(C) Leaching (D) Froth floatation

Ans. (B) Reverse osmosis

MCQ's asked in Board Exam

109) The depression in freezing points is 0.69 K when 2g phenol is dissolved in 100g benzene. If it is associated as dimeric then find its degree of association. The molal depression constant for solvent is 5.12 K kg mol^{-1}

(C = 12, H = 1, O = 16g/mol) **[October-2012]**

(A) 0.633 (B) 0.743 (C) 0.367 (D) 0.734

Ans. (C) 0.367

➠ $\Delta T_f = 0.69$ K, $w_2 = 2g$, $w_1 = 100g$,

$M_2 = 94$, $n = 2$, $K_f = 5.12$

$$\Delta T_f = \frac{K_f \times 1000 \times w_2 \times i}{M_2 \times w_1}$$

$$i = \frac{0.69 \times 94 \times 100}{1000 \times 2 \times 5.12} = 0.633$$

$$\alpha = (1 - i)\frac{n}{n-1} = (1 - 0.633) \times 2 = 0.733$$

110) What are the molecular and formula mass of Potash alumn respectively ? **[October-2012]**

(A) 950, 480 (B) 948, 474

(C) 474, 948 (D) 480, 950

Ans. (B) 948, 474

111) Who suggested that the solute in the dilute solution behaves like a gas ? **[October-2012]**

(A) Van't - Hoff and Pfeiffer

(B) Boyle and Van't - Hoff

(C) Gay - Lussac and Van't - Hoff

(D) Avogadro and Van't - Hoff

Ans. (A) Van't - Hoff and Pfeiffer

112) Which of the following factors affect the colligative properties of solution ?

(A) Nature of solute **[October-2012]**

(B) Nature of solvent

(C) Number of solvent molecules

(D) Number of solute particles

Ans. (D) Number of solute particles

113) Opening and closing of flower is controlled by.... **[October-2012]**

(A) capillary action (B) hydrolysis

(C) diffusion (D) osmosis

Ans. (D) osmosis

UID : P1-C2-S6-Q106

114) If a solution is prepared by adding common salt to pure water, which of the following statements is true ? # [October-2012]

(A) Both freezing point and boiling point of solution will decrease.

(B) The freezing point of solution will increase but boiling point will decrease.

(C) Both freezing point and boiling point of solution will increase.

(D) The freezing point of solution will decrease but boiling point will increase.

Ans. **(D)** The freezing point of solution will decrease but boiling point will increase.

115) Which of the following is / are the method(s) of determining the molecular mass ?

(A) Using Henry's law [October-2012]

(B) Using Raoult's law

(C) Osmotic pressure measurement method

(D) Both (B) and (C)

Ans. **(D)** Both (B) and (C)

116) What is the diameter of molecular particles of homogeneous mixture ? [October-2012]

(A) 10^{-9}m (B) 10^{-8}m (C) 10^{-10}m (D) 10^{-12}m

Ans. **(A)** 10^{-9}m

117) 2m urea solution is diluted from 2 kg to 5 kg by addition of water. Calculate molality of diluted solution.

(Molecular weight of urea = 60g/mol)

[October-2012]

(A) 0.4 m (B) 1.2 m (C) 0.6 m (D) 0.8 M

Ans. **(D)** 0.8 M

➠ $M = 2 = \frac{x \times 1}{2 \times 60} = 240$ gm

$\therefore M = \frac{240 \times 1}{5 \times 60} = 0.8\,M$

118) At 300K temperature, Beaker A containing 0.02M solution of urea and Beaker B containing 0.002M solution of sugar are separated by semipermiable membrane with respect to water. On which beaker how much pressure should be applied to prevent osmosis ? Molecular weight of urea = 60 g/mol and molecular weight of sugar = 342 g/mol.

[R = 0.082 L atm. mol^{-1} k^{-1}] [October-2012]

(A) 0.4428 atm. on beaker B

(B) 0.4920 atm. on beaker A

(C) 0.4920 atm. on beaker B

(D) None of the above

Ans. **(D)** None of the above

➠ $\pi = CRT$

$= 0.02 \times 0.082 \times 300$

$=$ 0492 atm. on beaker A

119) Which of the following is a formula to calculate degree of dissociation ? [Oct.-2013]

(A) $\alpha n - \alpha = i$ (B) $\alpha n - \alpha + 1 = i$

(C) $\alpha i - \alpha + 1 = n$ (D) $\alpha - \alpha n - 1 = i$

Ans. **(B)** $\alpha n - \alpha + 1 = i$

120) What will be the normality of 500 mL solution of 0.5 M Na_2SO_4 when diluted to 5 litre volume by addition of water ? [October-2013]

(A) 0.1 N (B) 0.01 N (C) 10 N (D) 1N

Ans. **(A)** 0.1 N

121) Homogeneous mixture of camphor in N_2 is an example of [October-2013]

(A) Gas solute - Solid solvent

(B) Solid solute - Liquid solvent

(C) Solid solute - Gas Solvent

(D) Liquid solute - Solid solvent

Ans. **(C)** Solid solute - Gas Solvent

122) Which of the following statement is correct for an ideal solution ? [October-2013]

(A) The value of ΔH and ΔV will not be zero.

(B) Vapour pressure of such solution is either higher or lower than predicted by Raoult's law.

(C) Mixture of Phenol and Aniline is an example of an ideal solution.

(D) The value of ΔH and ΔV will be zero.

Ans. **(D)** The value of ΔH and ΔV will be zero.

123) The relative lowering in vapour pressure and mole fraction of a solvent in a 1.5 molal aqueous solution obeying Raoult's law for non volatile solute and volatile solvent. [Oct.-2013]

(A) 0.26 bar, 0.74 (B) 2.6 bar, 0.99

(C) 0.026 bar, 0.97 (D) 0.96 bar, 0.98

Ans. **(C)** 0.026 bar, 0.97

UID : P1-C2-S6-Q114

124) **Match the following two Column-I and Column-II : #** [October-2013]

Column-I	Column-II
(U) Raoult's law for volatile solute and volatile solvent	(i) $P_A = p_A^0 \cdot X_A$
(V) Raoult's law for gaseous solute and liquid solvent	(ii) $P_A = p_A^0 + \left(p_B^0 + p_A^0\right)X_B$
(W) Raoult's law for non-volatile solute and volatile solvent	(iii) $\frac{p_1^0 - p_1}{p_1^0} = \frac{n_2}{n_1 + n_2}$

(A) U → (iii), V → (i), W → (ii) (B) U → (iii), V → (ii), W → (i)

(C) U → (i), V → (ii), W → (iii) (D) U → (ii), V → (i), W → (iii)

Ans. **(D)** U → (ii), V → (i), W → (iii)

125) **Match the following Columns :** [October-2013]

Column-I	Column-II
(m) $Zn_{(s)} \rightarrow Zn^{+2}_{(aq)} + 2e^-$	(i) Lead storage cell
(n) $Zn(Hg) + 2OH^-_{(aq)} \rightarrow ZnO_{(s)} + H_2O + 2e^-$	(ii) Leclanche cell
(o) $Pb_{(s)} + SO^{-2}_{4(aq)} \rightarrow PbSO_4 + 2e^-$	(iii) Mercury cell
(p) $2H_{2(q)} + 4OH^-_{(aq)} \rightarrow 4H_2O + 4e^-$	(iv) Fuel cell of H_2
	(v) Ni-Cd cell

(A) m → (v), n → (iii), o → (i), p → (ii) (B) m → (ii), n → (iii), o → (i), p → (iv)

(C) m → (ii), n → (iii), o → (v), p → (i) (D) m → (iv), n → (ii), o → (iii), p → (iv)

Ans. **(B)** m → (ii), n → (iii), o → (i), p → (iv)

126) **Which of the following solution, where physical state of solute and solvent is liquid and solid, respectively ?** [October-2014]

(A) Air containing moisture

(B) Zinc dissolved in mercury

(C) Solution of naphthalene in benzene

(D) Sugar solution

Ans. **(B)** Zinc dissolved in mercury

127) **Due to which reason, O_2 gas librates from the blood of tissues of animal bodies ?** [Oct.-2014]

(A) partial pressure of oxygen gas is less in tissues.

(B) partial pressure of oxygen is more in tissues.

(C) partial pressure of carbon dioxide is less in tissues.

(D) less temperature of tissues.

Ans. **(A)** partial pressure of oxygen gas is less in tissues.

128) **At 300 K temperature 2.5 gram unknown substance is dissolved in solvent and made the volume 4 liter of the solution. Its osmotic pressure is found to be 0.2 bar. Calculate the molar mass of unknown substance.** [Oct.-2014]

(A) 19.95 gms/mole (B) 77.94 gms/mole

(C) 199.5 gms/mole (D) 779.4 gms/mole

Ans. **(B)** 77.94 gms/mole

129) **...... will be formality of solution in which 948 gram potash alum is dissolved in 5 liter solution.** [October-2014]

(Potash alum – $K_2SO_4 \cdot Al_2(SO_4)_3\ 24H_2O$ Mol. wt. is 948 gms/mole)

(A) 0.1 F (B) 0.8 F (C) 0.2 F (D) 0.4 F

Ans. **(D)** 0.4 F

130) **The depression in freezing point is 0.69 K when 2 gram phenol is dissolved in 100 gram benzene if it is associated as dimeric then find its degree of association. The molal depression constant for solvent is 5.12 K kg mole^{-1}.** [October-2014]

(A) X = 0.950 (B) X = 0.704

(C) X = 0.473 (D) X = 0.734

Ans. **(D)** X = 0.734

UID : P1-C2-S6-Q124

131) Calculate the solubility in water in term of mole fraction in partial pressure of CO_2 is 2×10^{-3} bar at 298 K temperature, the K_a value for CO_2 is 6.02×10^{-4} bar. # [October-2015]

(A) 3.322×10^{-3} (B) 3.011×10^{-3}

(C) 3.322×10^{-4} (D) 3.011×10^{-6}

Ans. **(C)** 3.322×10^{-4}

➠ According to Henry's law = KH × CO_2

$$Xco_3 = \frac{Pco_3}{KH} = \frac{2 \times 10^{-8}\ \text{bar}}{6.02 \times 10^{-4}\ \text{bar}}$$

$$= 3.332 \times 10^{-4}$$

132) 12 gm of urea is dissolved in 2 liter solution at 300 K temperature. How many gram of NaCl should be dissolved in 10 liter solution so that it becomes iso-osmotic with urea solution ?

[At. wt. of Na = 23, Cl = 35.5 gm/mole]

[October-2015]

(A) 29.25 gm (B) 7.31 gm

(C) 5.85 gm (D) 19.5 gm

Ans. **(A)** 29.25 gm

➠ $$\frac{\text{mole of urea}}{\text{volume of urea}} = \frac{\text{mole of NaCl}}{\text{volume of NaCl}}$$

$$\therefore \frac{0.2}{2} = \frac{\text{mole of NaCl}}{10}$$

$\therefore$ mole of NaCl = 1 mole

But total No. of particles of NaCl = 2

so $\frac{1\ \text{mole}}{2} = 0.5$ mole

weight of NaCl = mole × weight

= 0.5 × 58.5 = 29.25 gram

133) Whose elevation in boiling point will be the same as for 0.1 m KNO_3 ? [October-2015]

(A) 0.1 m Urea

(B) 0.1 m Potassium sulphate

(C) 0.1 m Sodium chloride

(D) 0.1 m Aluminium nitrate

Ans. **(C)** 0.1 m Sodium chloride

134) If 'n' is the number of ions given by 1 mole of electrolyte, the degree of dissociation 'α' of electrolyte is – [October-2015]

(A) $\frac{i-1}{n+1}$ (B) $\frac{i-1}{n-1}$ (C) $\frac{n-1}{i-1}$ (D) $\frac{n+1}{i-1}$

Ans. **(B)** $\frac{i-1}{n-1}$

135) The Van't Hof factor for 0.1m $Ba(NO_3)_2$ solution is 2.74 percentage of dissociation is.....

[October-2016]

(A) 91.3% (B) 100% (C) 87% (D) 74%

Ans. **(C)** 87%

➠ $Ba(NO_3)_2$ ionises as ....

$$Ba(NO_3)_2 \rightarrow Ba^{2+} + 2NO_3^-$$

No of ions fomed = (1) + (2)

$\therefore$ n = 3 and i = 2.74

➠ Degree of dissociation,

$$\alpha = \frac{i-1}{n-1}$$

$$= \frac{2.74-1}{3-1}$$

$$= \frac{1.74}{2} = 0.87 = 87\%$$

136) 45 grams of ethylene glycol ($C_2H_6O_2$) is mixed with 600 grams of water. What is the depression in freezing point (K_f for water = 1.86 kg $mole^{-1}$) (C = 12, O = 16, H = 1 g/mol).

[October-2016]

(A) 2.25 K (B) 22.5 K

(C) 3.25 K (D) 32.5 K

Ans. **(A)** 2.25 K

➠ M. F = $C_2H_6O_2$

M.*wt* = 2(12) + 6 (1) + 2 (16)

= 62 g mol^{-1} = M_2

Weight of ethylene glycol = 45 g = W_2

Weight of solvent (water) = 600 g = W_1

K_f (water) = 1.86 kg mol^{-1}

➠ $\Delta T = K_f\ m$

$$= \frac{K_f \times W_2 \times 1000}{M_2 \times W_1}$$

$$= \frac{1.86 \times 45\,\text{gram} \times 1000}{62\,\text{g mol}^{-1} \times 600\ \text{gram}}$$

= 2.25 K

137) The percentage composition (by weight) of a solution is 45% X, 15% Y 40% Z. Calculate the mole fraction of each component of the solution. [October-2016]

\# UID : P1-C2-S6-Q131

(Mol. wt. of X = 18, Y = 60, Z = 60 gms/mole)

(A) X = 0.2 Y = 0.61 Z = 0.194

(B) X = 0.73 Y = 0.073 Z = 0.194

(C) X = 0.73 Y = 0.25 Z = 0.194

(D) X = 0.3 Y = 0.2 Z = 0.5

Ans. **(B)** X = 0.73, Y = 0.073, Z = 0.194

➠ **Element**	**X**	**Y**	**Z**
% Proportion	45	15	40
Molecular weight g mol^{-1}	18	60	60
Mole = Weight / Molecular weight	$\frac{45}{1.8}$ = 2.5	$\frac{15}{60}$ = 0.25	$\frac{40}{60}$ 0.667
Mole fraction = Mole / Total mole	$\frac{2.5}{3.4117}$ = 0.7316 ≈ 0.73	$\frac{0.25}{3.417}$ = 0.0731 ≈ 0.073	$\frac{0.667}{3.417}$ = 0.195 ≈ 0.194

138) The addition of 3 gms of a substance to 100 gms CCl_4 (M.w. = 154gm/mole) raises the boiling point of CCl_4 by 0.60°C. If K_b of CCl_4 is 5.03K Kg $mole^{-1}$ then find out the relative lowering of vapour pressure. # [October-2016]

(A) 0.0181 (B) 0.0224

(C) 0.204 (D) 0.192

Ans. **(A)** 0.0181

➠ Substance = 3 gms = W_2

Mol. wt. of sub = M_2 = ?

Solvent = CCl_4 = 100 gms = W_1

Molal of solvent CCl_4 = 154 gm $mole^{-1}$ = M_1

Increase of B.P. = ΔT_b = 0.6° C

K_b of solvent CCl_4 = 5.03 K kg $mole^{-1}$

$$M_2 = \frac{K_b \times W_2 \times 100}{\Delta T_b \times W_1}$$

$$\therefore \quad M_2 = \frac{5.03 \times 3 \times 1000}{0.6 \times 100}$$

$$= 251.5 \text{ gm mol}^{-1}$$

➠ Relative depression of vapour pressure

$$= \frac{p^\circ - p}{p^\circ} = X_2$$

$$= \frac{n_2}{n_1 + n_2}$$

➠ Where n_2 = mole of solvent

$$= \frac{W_2}{M_2} = \frac{3}{251.5}$$

= 0.0119 mole substance

➠ n_1 = mole of solvent

$$= \frac{W_1}{M_1} = \frac{100}{154}$$

= 0.6494 mole solvent CCl_4

➠ Total mole = 0.6494 + 0.0119 = 0.6613

$$X_2 = \frac{0.0119}{0.6613}$$

= 0.01799 ≈ 0.0181

139) Which of the following is not a colligative property ? [October-2016]

(A) Depression in freezing point

(B) Elevation in boiling point

(C) Boiling point

(D) Relative lowering in vapour pressure

Ans. **(B)** Boiling point

140) Which of the following pairs show an ideal solution ? [October-2016]

(A) Water – Nitric acid

(B) Benzene – Toluene

(C) Acetone – Chloroform

(D) Phenol – Aniline

Ans. **(C)** Benzene – Toluene

➠ Because in the binary solution of (A) benzene and tolune (B) the intermolecular attractive forces between A – A and B – B nearly equal to the intermolecular attraction forces between A – B for the solution.

141) What is the value of Van't Hoff factor for dilute Ferrous sulphate (aqueous) solution ? [October-2016]

(A) < 1 (B) Zero (C) > 1 (D) 1

Ans. **(C)** > 1

➠ $$FeSO_4 \xrightarrow{\text{Water}} \underbrace{Fe^{2+}_{(aq)} + SO^{-2}_{4(aq)}}_{\text{Total 2 ions}}$$

$\therefore$ i = Van't Hoff factor > 1

\# UID : P1-C2-S6-Q138

142) Which of the following aqueous solution has the highest boiling point having concentration 0.03 m ? # [October-2016]

(A) $Urea_{(aq)}$ (B) Sodium $sulphate_{(aq)}$ (C) Aluminium $sulphate_{(aq)}$ (D) Sodium $nitrate_{(aq)}$

Ans. **(C)** Aluminium $Sulphate_{(aq)}$

Substance	Insolution	Total Particles
(A) Urea : $NH_2CONH_{2(s)}$	$\xrightarrow{H_2O} NH_2CONH_{2(aq)}$	1 and 0.03 m
(B) Sodium sulphate : Na_2SO_4	$\xrightarrow{H_2O} 2Na^+_{(aq)} + SO^{2-}_{4(aq)}$	3 and (3 × 0.03) = 0.09 m
(C) Aluminium sulphate : $Al_2(SO_4)_3$	$\xrightarrow{H_2O} 2Al^{3+}_{(aq)} + 3SO^{2-}_{4(aq)}$	5 and (5 × 0.03) = 0.15 m
(D) Sodium Nitrate : $NaNO_3$	$\xrightarrow{H_2O} Na^+_{(aq)} + NO^-_{3(aq)}$	2 and (2 × 0.03) = 0.06 m

➠ Boiling point ∝ (number of particles) ∝ concentration

∴ Aluminium sulphate has highest boiling point.

143) Which of the following aqueous solution has highest boiling point ? [March-2019]

(A) 0.01 m Na_3PO_4 (B) 0.2 m $Ba(NO_3)_2$

(C) 0.1 m NaCl (D) 0.03 m KNO_3

Ans. **(B)** 0.2 m $Ba(NO_3)_2$

➠	Salt	Ions	Total ions
(A)	Na_3PO_4 0.01 m	= $3Na^+ + PO_4^{3-}$ → [3(0.01) + 0.01)]m	0.04 m
(B)	$Ba(NO_3)_2$ 0.2 m	= $Ba^{2+} + 2NO_3^-$ → 0.2 m + 2(0.2m)	0.6 m
(C)	NaCl 0.1 m	= $Na^+ + Cl^-$ → 0.1 m 0.1 m	0.2 m
(D)	KNO_3 0.03 m	= $K^+ + NO_3^-$ → 0.03 m 0.03 m	0.06 m

➠ Elevation of boiling point is a colligative property. (B) in a solution of 0.2 m $Ba(NO_3)_2$ maximum concentration of ions is 0.6 m. So, elevation of boling point and boiling points of solution are maximum.

144) What is the weight to volume ppm of 0.05 % w/v $CaCl_2$ aqueous solution ? [March-2019]

(A) 50 (B) 0.05 (C) 500 (D) 5

Ans. **(C)** 500

➠ 0.05% w/v solution = 0.05 gm solutes are present in 100 mL.

∴ 0.05 g solutes are present in 10^2 mL.

So, 0.05 g solute is in 10^2 mL.

$$\therefore \text{Mass of solute in } 10^6 \text{ mL} = \frac{10^6 \times 0.05}{10^2}$$

$$= 10^4 \times 0.05 = 500 \text{ ppm}$$

➠ ppm means mass of solute present in 10^6 volume.

145) Which of the following is appropriate for the solution made by mixing acetone and carbon-disuiphide ? [March-2019]

(A) $\Delta V_{mix} > 0$ (B) $\Delta H_{mix} < 0$

(C) Negative deviation from Raoult's law

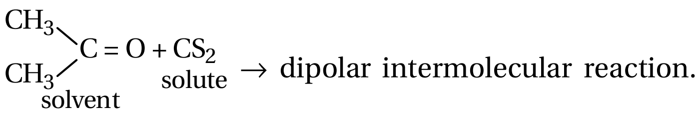
(D) Obey Raoult's law

Ans. **(A)** $\Delta V_{mix} > 0$

➠ (Acetone + carbon disulfied)

(Polar solvent + non polar solvent) this solution ins not an ideal solution.

➠ Nature of these two solvents are different. So, this two solvents remain immiscible. so, volume of mixture of acetone and carbon disulfied increases and $\Delta V_{mix} > 0$.



$$\underset{\text{solvent}}{(CH_3)_2C=O} + \underset{\text{solute}}{CS_2} \rightarrow \text{dipolar intermolecular reaction.}$$

➠ So positive deviation is observed. and so Roult's law is not followed.

146) Which of the following is an example of a solid solution in which the solute is a gas ? [March-2020]

(A) Amalgam of mercury with sodium

(B) Camphor in nitrogen gas

(C) Solution of hydrogen in palladium

(D) Oxygen dissolved in water

Ans. **(C)** Solution of hydrogen in palladium

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147) We have three aqueous solutions of NaCl labelled 'A', 'B' and 'C' with concentrations 0.1 M, 0.01 M and 0.01 M respectively. The value or Van't Hoff factor for these solutions will be in the order .... # [March-2020]

(A) $i_C = i_B = i_A$ (B) $i_C > i_B > i_A$

(C) $i_A > i_C > i_B$ (D) $i_B > i_A > i_C$

Ans. **(B)** $i_C > i_B > i_A$

➠ As concentration is more, Van't Hoff factor (i) is more. on incomplete dissociation, i value of solution is maximum. $i_C > i_B > i_A$

148) Molality 30% w/w aqueous solution of NaOH is .... [March-2020]

(A) 10.71 m (B) 8.32 m (C) 7.5 m (D) 9.17 m

Ans. **(A)** 10.71 m

➠ 30% w/w → 30 gm NaOH, 70 gm water

$$m = \frac{\text{Mass of solute} \times 1000}{\text{Molecular mass of solute} \times \text{Mass of solvent}}$$

$$= \frac{30 \times 1000}{40 \times 70} = 10.71 \text{ m}$$

149) Calculate Molarity (M) for the solution of 0.1 molal (m) NaOH solution whose density is 1.25 g mL^{-1}. [August-2020]

(A) 0.135 M (B) 0.129 M

(C) 0.125 M (D) 0.100 M

Ans. **(C)** 0.125 M

➠ 0.1 molal NaOH means 0.1 mol of NaOH in 1000 g of solvent.

Mass of NaOH = Moles × Mol.

Mass = 0.1 × 40 = 4 g

Mass of solvent = 1000 g

➠ Total mass of the solution

= Mass of solvent + Mass of solute

= 1000 + 4 = 1004 g

$$\therefore \text{Volume of solution} = \frac{\text{Mass of solution} \times 1000}{\text{Density of solution}}$$

$$= \frac{1004}{1.25} = 803.2 \text{ mL}$$

➠ The molarity of the solution is calculated as :

$$\text{Molarity} = \frac{\text{Moles of solute} \times 1000}{\text{Volume of solution in mL}}$$

$$\therefore \text{Molarity} = \frac{0.1 \times 1000}{803.2}$$

$$= 0.1245 \text{ M} \approx 0.125 \text{ M}$$

150) Which of the following is an example of ideal solution ? [August-2020]

(A) Chloroform - Acetone

(B) Ethanol - Water

(C) Water - Nitric acid

(D) Benzene - Toluene

Ans. **(D)** Benzene - Toluene

151) K_H value for $Ar_{(g)}$, $CO_{2(g)}$, $HCHO_{(g)}$ and $CH_{4(g)}$ are 40.39, 1.67, 1.82 × 10^{-5} and 0.413 respectively. Arrange these gases in the order of their increasing solubility. [August-2020]

(A) $HCHO < CH_4 < CO_2 < Ar$

(B) $Ar < CO_2 < CH_4 < HCHO$

(C) $HCHO < CO_2 < CH_4 < Ar$

(D) $Ar < CH_4 < CO_2 < HCHO$

Ans. **(B)** $Ar < CO_2 < CH_4 < HCHO$

➠ According to Henry's Law :

$p = K_H \times x$ (x = mole fraction of gas)

$$\therefore \quad x \propto \frac{1}{K_H}$$

➠ Thus, the gas with high values of Henry's Law constant will have the lower solubility in water. Thus, the solubility order of the gases is :

$$Ar < CO_2 < CH_4 < HCHO$$

152) If 22 g benzene C_6H_6) is dissolved in 222 g carbon tetra chloride (CCl_4), then concentration W/W is .... [May-2021]

(A) 90 % (B) 0.9 % (C) 9 % (D) 0.09 %

Ans. **(C)** 9%

➠ $$\%W/W = \frac{\text{Mass of Benzene}}{\text{Total mass}} \times 100$$

$$= \frac{22}{22+222} \times 100$$

$$= 9.01\% \approx 9\%$$

153) 1.00 g of a non electrolyte solute dissolved in 50 g of benzene lowered the freezing point of benzene by 0.40 K. The freezing point depression constant of benzene is 5.12 K kg mol^{-1}. Find the molar mass of the solute. [May-2021]

(A) 356 g mol^{-1} (B) 562 g mol^{-1}

(C) 280 g mol^{-1} (D) 256 g mol^{-1}

Ans. **(D)** 256 g mol^{-1}

➠ $w_2 = 1$ g, $w_1 = 50$ g,

$\Delta T_f = 0.40$ K, $K_f = 5.12$ kg mol^{-1}

$$M_2 = \frac{K_b \times w_2 \times 1000}{\Delta T_b \times w_1}$$

$$M_2 = \frac{5.12 \times 1 \times 1000}{0.40 \times 50}$$

$$M_2 = 256 \text{ g mol}^{-1}$$

154) The pressure required for the reverse osmosis is quite high. For this .... membrane is used. # **[May-2021]**

(A) Parchment	(B) Cellulose acetate
(C) Cellophane	(D) Pig's bladder

Ans. **(C)** Cellophane

155) If 5 gm NaOH is dissolved in 450 ml solution, molarity of solution is ....
(Na = 23, O = 16, H = 1 g mol^{-1}) [May-2021]

(A) 0.278 M	(B) 2.78 M
(C) 27.8 M	(D) 278 M

Ans. **(A)** 0.278 M

➠ Molar mass of NaOH = 23 + 16 + 1

= 40 g mol^{-1}

Moles of NaOH (n) = $\frac{5}{40}$ = 0.125 mol

Molarity of NaOH = $\frac{0.125}{\frac{450}{1000}} = \frac{0.125 \times 100}{450}$

= 0.278 M

❖ ❖ ❖

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