## CASE BASED QUESTIONS (4 MARKS)

**Read the passage given below and answer the following case-based questions:**

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|---|---|
| **Q1**. | Boiling point or freezing point of liquid solution would be affected by the dissolved solids in the liquid phase. A soluble solid in solution has the effect of raising its boiling point and depressing its freezing point. The addition of non-volatile substances to a solvent decreases the vapor pressure and the added solute particles affect the formation of pure solvent crystals. According to many researches the decrease in freezing point directly correlated to the concentration of solutes dissolved in the solvent. This phenomenon is expressed as freezing point depression and it is useful for several applications such as freeze concentration of liquid food and to find the molar mass of an unknown solute in the solution. Freeze concentration is a high-quality liquid food concentration method where water is removed by forming ice crystals. This is done by cooling the liquid food below the freezing point of the solution. The freezing point depression is referred as a colligative property and it is proportional to the molar concentration of the solution (m), along with vapor pressure relative lowering, boiling point elevation, and osmotic pressure. These are physical characteristics of solutions that depend only on the identity of the solvent and the concentration of the solute. The characters are not depending on the solute's identity.<br>(Jayawardena, J. A. E. C., Vanniarachchi, M. P. G., & Wansapala, M. A. J. (2017). Freezing point depression of different Sucrose solutions and coconut water.) |
| **a** | What is the relation between vapour pressure of solid and liquid states at freezing point? |
| **b** | Why freezing point of 0.1m solution of acetic acid in benzene is less than freezing point of 0.01m solution? |
| **c** | Out of the following 0.10 m aqueous solutions, which one will exhibit the largest freezing point depression? KCl , $C_6H_{12}O_6$ , $Al_2(SO_4)_3$ , $K_2SO_4$ |
| | **OR** |
| **c** | If $K_f$ for water is 1.86 $^oC/m$, explain why 1m NaCl in water does not have a freezing point equal to a) -1.86 $^oC$ b) -3.72$^oC$ |
| **ANS Q1** | |
| **a** | Equal |
| **b** | Depression in FP in 0.1m solution is more than 0.01 solution so FP of first is less. |
| **c** | $C_6H_{12}O_6$<br>**OR** |
| **c** | a) as there are 2 moles of ions per mol of NaCl<br>b) degree of ionisation is not 100% at freezing point due to stronger interactions for 1m solution. |
| **Q2** | 1. Henna is investigating the melting point of different salt solutions. She makes a salt solution using 10 mL of water with a known mass of NaCl salt. She puts the salt solution into a freezer and leaves it to freeze. She takes the frozen salt solution |

| S.No | Mass of the salt used in g | Melting point in $^0C$ | |
|---|---|---|---|
| | | Readings Set 1 | Reading Set 2 |
| 1 | 0.3 | -1.9 | -1.9 |
| 2 | 0.4 | -2.5 | -2.6 |
| 3 | 0.5 | -3.0 | -5.5 |
| 4 | 0.6 | -3.8 | -3.8 |
| 5 | 0.8 | -5.1 | -5.0 |
| 6 | 1.0 | -6.4 | -6.3 |

| | |
|---|---|
| | out of the freezer and measures the temperature when the frozen salt solution melts. She repeats each experiment.<br>Assuming the melting point of pure water as 0°C, answer the following questions:<br>(a) One temperature in the second set of results does not fit in the pattern. Which temperature is that? Justify your answer. 1<br>(b) Why did Henna collect two sets of results? 1<br>(c) In place of NaCl, if Henna had used glucose, what would have been the melting point of the solution with 0.6 g glucose in it? 2<br>**OR**<br>(c) What is the predicted melting point if 1.2 g of salt is added to 10 mL of water? Justify your answer. |
| **Ans-Q2** | a) 3rd reading for 0.5 g there has to be an increase in depression of freezing point and therefore decrease in freezing point so also decrease in melting point when amount of salt is increased but the trend is not followed in this case.<br>b) Two sets of reading help to avoid error in data collection and give more objective data.<br>c.) $\Delta T_f$ (glucose) = 1 x $K_f$ x 0.6 x 1000 /180x 10 ........... (1)<br>$\Delta T_f$ (NaCl) = 2 x $K_f$ x 0.6 x 1000 / 58.5x10<br>3.8 = 2 x $K_f$ x 0.6 x 1000 /58.5x 10 ................ (2)<br>Divide equation 1 by 2<br>$\Delta T_f$ (glucose)/ 3.8 = 58.5/ 2 x 180<br>$\Delta T_f$ (glucose) = 0.62<br>Freezing point or Melting point = - 0.62 °C<br>OR<br>depression in freezing point is directly proportional to molality (mass of solute when<br>the amount of solvent remains same)<br>0.3 g depression is 1.9 °C<br>0.6 g depression is 3.8 °C<br>1.2 g depression will be 3.8 x2 = 7.6 °C |
| **Q3** | Aarav Sharma is very fond of a special drink made by his grandmother using different fruits available in their hometown. It has an outstanding taste and also provides great health benefits of natural fruits. He thought of utilizing his grandmother recipe to create a new product in the beverage market that provide health benefits and also contain fizziness of various soft drinks available in the market. Based on your understanding of solutions chapter, help Aarav Sharma to accomplish his idea by answering following:<br>(a) How he can add fizz to the special drink made by his grandmother? 1<br>(b) What is the law stated in the chapter that can help Aarav to make his drink fizzy? 1<br>(c) What precautions he should take while bottling so that his product does not lose fizz during storage and handling across long distances? 2<br>OR |

(c)The mole fraction of helium in a saturated solution at 20°C is $1.2 \times 10^{-6}$. Find the pressure of helium above the solution. Given Henry's constant at 20°C is 144.97 kbar.

**Ans-Q3**

a) Carbon dioxide is a gas which provides fizz and tangy flavour. He can dissolve Carbon dioxide gas in the drink.

b) Henry's law which states that solubility of a gas in liquid is directly proportional to partial pressure of the gas.

(c) Bottles should be sealed under high pressure of CO and capping should be done perfectly to avoid leakage of $CO_2$ as any loss of partial pressure will result into decrease in solubility.

**OR**

(c) $p_{He} = K_H \times X_{He}$

$= (144.97 \times 10^3 \text{bar})(1.2 \times 10^{-6})$
$= 0.174$ bar

**Q4**

Observe the table in which azeotropic mixtures are given along with their boiling points of pure Components and azeotropes and answer the questions that follow.

| Some Azeotropic Mixtures | | | | | |
|---|---|---|---|---|---|
| A | B | Minimum Boiling Azeotropes | Boiling Points | | |
| | | | A | B | Mixture Azeotropes |
| $H_2O$ | $C_2H_5OH$ | 95.37% | 373K | 351.3K | 351.15 |
| $H_2O$ | $C_3H_7OH$ | 71.69% | 373K | 370.19K | 350.72 |
| $CH_3COCH_3$ | $CS_2$ | 67% | 329.25K | 319.25K | 312.30 |
| A | B | Maximum Boiling Azeotropes | A | B | Mixture Azeotropes |
| $H_2O$ | HCl | 20.3% | 373K | 188K | 383K |
| $H_2O$ | $HNO_3$ | 68.0% | 373K | 359K | 393.5K |
| $H_2O$ | $HClO_4$ | 71.6% | 373K | 383K | 476K |

(a) What type of deviation is shown by minimum boiling azeotropes? 1

**OR**

(a) Why does $H_2O$ and HCl mixture form maximum boiling azeotropes? 1

(b) What are azeotropes?

(c) Give one example of ideal solution. What type of liquids form ideal solutions? 2

**Ans-Q4**

(a) Positive deviation from Raoult's law.

**OR**

(a) It is because force of attraction between $H_2O$ and HCl is more than $H_2O$-$H_2O$ and HCl-HCl.

(b) Azeotropes- Binary mixtures having same composition in liquid and vapour phase and boil at a constant temperature.

(c) Hexane and heptane form ideal solution. Those compounds of same family having similar forces of attraction form ideal solution.

**Q5**

Boiling point or freezing point of liquid solution would be affected by the dissolved solids in the liquid phase. A soluble solid in solution has the effect of raising its boiling point and depressing its freezing point. The addition of non-volatile substances to a solvent decreases the vapor pressure and the added solute particles affect the formation of pure solvent crystals According to many researches the decrease in freezing point directly correlated to the concentration of solutes dissolved in the solvent. This phenomenon is expressed as freezing point depression

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| | and it is useful for several applications such as freeze concentration of liquid food and to find the molar mass of an unknown solute in the solution.<br>Freeze concentration is a high-quality liquid food concentration method where water is removed by forming ice crystals, this is done by cooling the liquid food below the freezing point of the solution. The freezing point depression is referred as a colligative property and it is proportional to the molar concentration of the solution (m), along with vapour pressure lowering boiling point elevation, and osmotic pressure. These are physical characteristics of solutions that depend only on the identity of the solvent and the concentration of the solute. The characters are not depending on the solute's identity.<br>*(Source: Jayawardena, J. A. E. C., Vanniarachchi, M. P. G., & Wansapala, M. A. J. (2017). Freezing point depression of different Sucrose solutions and coconut water)*<br>**a.** Four samples $BaCl_2$, NaCl, $ZnCl_2$ and $AICI_3$ of 0.5 M are being boiled Which of the among will show highest elevation in boiling point?<br>**b.** How does sprinkling of salt help in clearing the snow-covered roads in hilly areas?<br>**c.** The freezing point of nitrobenzene is 278.8 K. When 2.8 g of an unknown substance is dissolved in 100 g of nitrobenzene, the freezing point of solution is found 276.8 K. If the freezing point depression of nitrobenzene is 8.0 K kg $mol^{-1}$, what is the molar mass of unknown substance? [ $K_f$=8 $KKgmol^{-1}$for nitrobenzene]<br>**OR**<br>C.A solution prepared by dissolving 2g of oil of wintergreen (methyl salicylate) in 100.0 g of benzene has a boiling point of 80. 31° C. Determine the molar mass of this compound. (B.P. of benzene - 80.10°C and $K_b$ for benzene $2.52^0$ C kg $mol^{-1}$) |
| **Ans Q5** | a. $AlCl_3$<br>b. By depression of freezing point (it lowers freezing point of water less than 0 C)<br>c. $\Delta T_f = i\ k_f\ m$<br>$2=1x\ 8\ x\ (2.8/M_b\ )x1000/100 =8x2.8x10/M_b$<br>$M_b$=8x28/2=8x14=112g/mol<br>**OR**<br>$\Delta T_b = i\ k_b\ m$<br>$0.21= 1x\ 2.52x2x1000/100xM_b$<br>$M_b$= 2.52x2x10/0.21=240 g/mol |