## WORKSHEET- 1

### SOME IMPORTANT FORMULAS

**1.** **Mole fraction (X)**

If the number of moles of A and B are $n_A$ and $n_B$ respectively, the mole fractions of A and B will be

$$X_A = \frac{n_A}{n_A + n_B} \text{ and } X_B = \frac{n_B}{n_A + n_B}$$

$$X_A + X_B = 1$$

**2.** **Molarity (M) =** $\dfrac{\text{Moles of solute}}{\text{Volume of solution in litres}} \text{ mol L}^{-1}$

**3.** **Molality (*m*) =** $\dfrac{\text{Moles of solute}}{\text{Mass of solvent in kilograms}} \text{ mol kg}^{-1}$

**4.** **Parts per million (ppm)**

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

**5.** **Raoult's law for a solution of volatile solute in volatile solvent :**

$$p_A = p_A^{\ 0} X_A$$

$$p_B = p_B^{\ 0} X_B$$

Where $p_A$ and $p_B$ are partial vapour pressures of component 'A' and component 'B' respectively in solution. $p_A^{\ 0}$ and $p_B^{\ 0}$ are vapour pressures of pure components 'A' and 'B' respectively.

**6.** **Raoult's law for a solution of non-volatile solute and volatile solvent :**

$$\frac{p_A^{\ 0} - p_A}{p_A^{\ 0}} = iX_B = i\frac{n_B}{n_A} = i\frac{W_B \times M_A}{W_A \times M_B} \text{ (for dilute solutions)}$$

Where $X_B$ is mole fraction of solute, *i* is van't Hoff factor and $\dfrac{p_A^{\ 0} - p_A}{p_A^{\ 0}}$ is relative lowering of vapour pressure.

**7.** **Elevation in boiling point ($\Delta T_b$) :**

$$\Delta T_b = i.K_b\, m$$

Where $\Delta T_b = T_b - T_b^{\ 0}$

$K_b$ = molal boiling point elevation constant

$m$ = molality of solution

$T_b$ = Boiling point of solution

$T_b^0$ = Boiling point of solvent

## 8. Depression in freezing point ($\Delta T_f$) :

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

Where $\quad \Delta T_f = T_f^0 - T_f$

$K_f$ = molal freezing point depression constant

$m$ = molality of solution

$T_f^0$ = Freezing point of solvent

$T_f$ = Freezing point of solution

## 9. Osmotic pressure ($\pi$) of a solution :

$$\pi V = i\,nRT \quad \text{or} \quad \pi = i\,CRT$$

where $\quad \pi$ = osmotic pressure in bar or atm

$V$ = volume in litres

$i$ = van't Hoff factor

$C$ = molar concentration in moles per litres

$n$ = number of moles of solute

$T$ = Temperature on Kelvin scale

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

$R = 0.0821$ L atm $mol^{-1}$ $K^{-1}$

## 10. Van't Hoff factor ($i$)

$$= \frac{\text{Number of particles in solution after association or dissociation}}{\text{Number of particles actually dissolved in solution}}$$

$$i = \frac{\text{Observed colligative property}}{\text{Theoretically calculated colligative property}}$$

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

$i > 1$ For dissociation of solute

$i < 1$ For association of solute

$i = 1$ For ideal solution undergoing no association or dissociation

## MULTIPLE CHOICE QUESTIONS

1. **The molality of 98% $H_2SO_4$ (density = 1.8 g/mL) by weight is:**
   - (a) 6 m
   - (b) 18 m
   - (c) 10 m
   - (d) 4 m

2. **Which of the following does not show positive deviation from Raoult's law?**
   - (a) benzone + chlorofor
   - (b) benzene + acetone
   - (c) benzene + ethanol
   - (d) benzene + $CCl_4$

3. **Which solution will have least vapour pressure?**
   - (a) 0.1 M $BaCl_2$
   - (b) 0.1 M Uxa
   - (c) 0.1 M $Na_2SO_4$
   - (d) 0.1 M $Na_3PO_4$

4. **Which condition is not satisfied by an ideal solution?**
   - (a) $\Delta H_{mix} = 0$
   - (b) $\Delta V_{mix} = 0$
   - (c) $\Delta P_{mix} = 0$
   - (d) $\Delta S_{mix} = 0$

5. **Azeotrope mixture are:**
   - (a) mixture of two solids
   - (b) those will boil at different temperature
   - (c) those which can be fractionally distilled
   - (d) constant boiling mixtures

6. **If $K_f$ value of $H_2O$ is 1.86. The value of $\Delta T_f$ for 0.1 m solution of non-volatile solute is**
   - (a) 18.6
   - (b) 0.186
   - (c) 1.86
   - (d) 0.0186

7. **Solute when dissolve in water**
   - (a) increases the vapour pressure of water
   - (b) decreases the boiling point of water
   - (c) decrease the freezing point of water
   - (d) All of the above

8. **The plant cell will shrink when placed in:**
   - (a) water
   - (b) A hypotonic solution
   - (c) a hypertonic solution
   - (d) an siotonic solution

9. **The freezing point of 11% aquous solution of calcium nitrate will be:**
   - (a) 0°C
   - (b) above 0°C
   - (c) 1°C
   - (d) below 0°C

10. **The Van't Hoff factor for 0.1 M $Ba(NO_3)_2$ solution is 2.74. The degree of dissociation is:**

    (a) 91.3%                          (b) 87%

    (c) 100%                           (d) 74%

11. **Which of the following solutions would have the highest osmotic pressure:**

    (a) $\dfrac{M}{10}$ NaCl          (b) $\dfrac{M}{10}$ Urea

    (c) $\dfrac{M}{10}$ $BaCl_2$      (d) $\dfrac{M}{10}$ Glucose

12. **0.5 M aquous solution of Glucose is isotonic with:**

    (a) 0.5 M KCl solution            (b) 0.5 M $CaCl_2$ solution

    (c) 0.5 M Urea solution           (d) 1 M solution of sucrose

13. **Which of the following is true for Henry's constant**

    (a) It decreases with temperature    (b) It increases with temperature

    (c) Independent on temperature       (d) It do not depend on nature of gases.

14. **Which one is the best colligative property for determination of molecular mass of polymer?**

    (a) osmotic pressure              (b) elevation in boiling point

    (c) depression in freezing point  (d) osmosis

15. **Which of the following do not depend on temperature?**

    (a) % W/V (weight/volume)          (b) molality

    (c) molarity                       (d) normality

16. **Henry's law constant K of $CO_2$ in water at 25°C is $3 \times 10^{-2}$ mol/L atm$^{-1}$. Calculation the mass of $CO_2$ present in 100 L of soft drink bottled with a partial pressure of $CO_2$ of 4 atm at the same temperatrue.**

    (a) 5.28 g                         (b) 12.0 g

    (c) 428 g                          (d) 528 g

17. **Mixing of $HNO_3$ and HCl is reaction:**

    (a) endothermic reaction          (b) exothermic reaction

    (c) both exothermic and endothermic (d) depend on entropy of reaction

18. **The most likely on ideal solution is:**

    (a) $NaCl$—$H_2O$                 (b) $C_2H_5OH$—$C_6H_6$

    (c) $C_7H_{16}$—$H_2O$            (d) $C_7H_{16}$—$C_8H_{18}$

19. **Van't Hoff factor for a dilute solution of a $K_2[HgI4]$ is:**

    (a) 2                              (b) 1

    (c) 3                              (d) zero

20. **Benzoic acid dissolved in benzene shows a molecular weight of:**
    (a) 122                          (b) 61
    (c) 244                          (d) 366

21. **6% (W/V) solution of urea will be isotonic with:**
    (a) 18% (W/V) solution of glucose     (b) 0.5 M solution of NaCl
    (c) 1 M solution of $CH_3COOH$        (d) 6% (W/V) solution of sucrose.

22. **Solution showing (+) ve deviation from Raoult's law include:**
    (a) acetone + $CS_2$             (b) acetone + $C_2H_5OH$
    (c) acetone + Benzene            (d) acetone + aniline

### Fill in the blanks type:

23. The property which depends on number of particles of solute is called .............

24. Azeotrope mixture cannot be separate by .............

25. Match the column and choose correct option

| **Vant'Hoff factor** | **Behaviour of compound** |
| --- | --- |
| (A) i = 1 | P. Impossible |
| (B) i > 1 | Q. Association is the solution |
| (C) i < 1 | R. Dissociation in the solution |
| (D) i = 0 | S. No dissociation or association |

    (a) A–S, B–R, C–P, D–Q        (b) A–R, B–S, C–Q, D–P
    (c) A–S, B–P, C–R, D–Q        (d) A–S, B–R, C–Q, D–P

### Assertion Reason Type

26. **Statement 1:** Azeotropemixture are formed by only non-ideal solution

    **Statement 2:** Azeotrope mixture can't be separated by fractional distillation.

## ANSWERS

**1.** (b)   **2.** (a)   **3.** (d)   **4.** (d)   **5.** (d)   **6.** (b)   **7.** (d)   **8.** (c)   **9.** (d)   **10.** (b)

**11.** (c)   **12.** (c)   **13.** (d)   **14.** (a)   **15.** (b)   **16.** (d)   **17.** (b)   **18.** (d)   **19.** (c)   **20.** (c)

**21.** (a, b, c)      **22.** (a, b)         **23.** Colligative property   **24.** Fractional distillation

**25.** (d)   **26.** (b)

# VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

**Q. 1. What is Van't Hoff factor ?**

**Ans.** It is the ratio of normal molecular mass to observed molecular mass. It is denoted as *i*.

> $i$ = normal molecular mass/observed molecular mass
>
> = no. of particles after association or dissociation/no. of particles before dissociation or association

**Q. 2. What is the Van't Hoff factor in $K_4[Fe(CN)_6]$ and $BaCl_2$ ?**

**Ans.** 5 and 3

**Q. 3. Why the molecular mass becomes abnormal ?**

**Ans.** Due to association or dissociation of solute in given solvent.

**Q. 4. What role does the molecular interaction play in the solution of alcohol and water ?**

**Ans.** Positive deviation from ideal behaviour.

**Q. 5. What is van't Hoff factor ? How is it related with :**

    **(a) degree of dissociation**        **(b) degree of association**

**Ans.** (a)  $\alpha = i - 1/n - 1$        (b)  $\alpha = i - 1/1/n - 1$

**Q. 6. Why NaCl is used to clear snow from roads ?**

**Ans.** It lowers freezing point of water.

**Q. 7. Why the boiling point of solution is higher than pure liquid ?**

**Ans.** Due to lowering in vapour pressure.

**Q. 8. Henry law constant for two gases are 21.5 and 49.5 atm, which gas is more soluble ?**

**Ans.** $K_H$ is inversely proportional to solubility.

**Q.9.** Define azeotrope. Give an example of maximum boiling azeotrope.

**Q.10.** Calculate the volume of 75% of $H_2SO_4$ by weight ($d$ = 1.8 gm/ml) required to prepare 1 L of 0.2 M solution.

    *Hint:*        $M_1 = \dfrac{\text{Mass}\,\% \times d \times 10}{98}$

                $M_1 V_1 = M_2 V_2$

                       = 14.5 ml

**Q.11.** **Why water cannot be completely separated from aqueous solution of ethyl alcohol ?**

**Ans.** Due to formation of azeotrope at (95.4%).

**Q.12.** **Why anhydrous salts like NaCl or $CaCl_2$ are used to clear snow from roads on hills ?**

*Hint :* They depress freezing point of water.

**Q.13.** **What is the effect on boiling and freezing point of a solution on addition of NaCl ?**

*Hint :* Boiling point increases and freezing point decreases.

**Q.14.** **Why osmotic pressure is considered as colligative property ?**

*Hint :* It depends upon number of moles of solute present in solution.

**Q.15.** **Liquid A and B on mixing produce a warm solution. Which type of deviation does this solution show ?**

*Hint :* – ve deviations

**Q.16.** **Give an example of a compound in which hydrogen bonding results in the formation of a dimer.**

*Hint :* Carboxylic acids or other example

**Q.17.** **What role does the molecular interaction play in solution containing chloroform and acetone ?**

*Hint :* H-bonding formed, results in negative deviation from Raoult's law.

## SHORT ANSWER TYPE QUESTIONS (2 Marks)

**Q. 1.** Out of the following three solutions, which has the highest freezing point and why ?

    (a)  0.1 M urea        (b)    0.1M $BaCl_2$      (c)    0.1M $Na_2SO_4$

**Q. 2.** Which of the following solutions have highest boiling point and why ?

    (a)  1M glucose       (b)   1M KCl       (c)   1M aluminium nitrate

**Q. 3.** Equal moles of liquid P and Q are mixed. What is the ratio of their moles in the vapour phase ? Given that $P_P^0 = 2 \times P_Q^0$.

**Q. 4.** On mixing liquid X and Y, volume of the resulting solution decreases. What type of deviation from Raoult's law is shown by the resulting solution ? What change in temperature would you observe after mixing liquids X and Y ?

**Q. 5.** Explain the significance of Henry's constant ($K_H$). At the same temperature, hydrogen is more soluble in water than helium. Which of them will have higher value of $K_H$ and why ?

**Q. 6. How many grams of KCl should be added to 1 kg of water to lower its freezing point to – 8.0°C ? ($K_f$ = 1.86 K kg/mol)**

**Ans.** Since KCl dissociate in water completely, $i = 2$.

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

$$m = \frac{\Delta T_f}{iK_f}$$

$$m = \frac{8}{2 \times 1.86}$$

$$= 2.15 \text{ mol/kg}$$

Grams of KCl = 2.15 × 74. = 160.2 g/kg

**Q. 7** With the help of diagram, show the elevation in boiling point colligative properties ?

**Q. 8.** What do you mean by colligative properties ? Which colligative property is used to determine molar mass of polymer and why ?

**Q.9. Define reverse osmosis. Write its one use.**

**Ans.** Desalination of water.

**Q.10.** Why does an azeotropic mixture distills without any change in composition ?

*Hint :* It has same composition of components in liquid and vapour phase.

**Q.11.** Under what condition Van't Hoff factor is :

(a) equal to 1 ?  (b) less than 1 ?  (c) more than 1 ?

**Q.12.** An aqueous solution of 2% non-volatile exerts a pressure of 1.004 Bar at the normal boiling point of the solvent. What is the molar mass of the solute ?

*Hint :*  $$\frac{P^0_A - P_A}{P^0_A} = \frac{w_B \times m_A}{m_B \times w_A}$$

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

$$m_B = 41.35 \text{ gm/mol}$$

**Q.13.** Why is it advised to add ethylene glycol to water in a car radiator in hill station ?

*Hint :* Anti-freeze.

**Q.14. Calculate the molarity of pure water ($d = 1$ g mL$^{-1}$).**

**Ans.** Desity of water $= 1$ g mL$^{-1}$

Mass of 1000 ml of water $= V \times d$

$$= 1000 \text{ mL} \times 1 \text{ gm}^{-1}$$

$$= 1000 \text{ g}$$

Moles of water $= \dfrac{1000}{18} = 55.55$ mol

Now, mole of $H_2O$ present in 1000 mL or 1 L of water.

So, molarity $= 55.55$M

**Q.15.** Define Henry's law. Give their two application.

**Q.16. The dissolution of ammonium chloride in water is endothermic process. What is the effect of temperature on its solubility ?**

**Ans.** Since dissolution of $NH_4Cl$ in water is endothermic process, its solubility increases with rise in temperature (*i.e.,* Le-Chatelier process).

**Q.17. Two liquids A and B boil at 145ºC and 190ºC respectively. Which of them has higher vapour pressure at 80ºC ?**

**Ans.** Lower the boiling point more volatile is the respective compound. Therefore, liquid A will have higher vapour pressure at 80ºC.

**Q.18. Why is liquid ammonia bottle first cooled in ice before opening it ?**

**Ans.** At room temperature, the vapour pressure of liquid ammonia is very high. On cooling vapour pressure decreases, therefore the liquid ammonia will not splash out.

**Q.19. Which colligative property is preferred for the molar mass determination of macromolecules ?**

**Ans.** Osmotic pressure measurement is preferred for molar mass determination because :

(a) even in dilute solution the osmotic pressure values are appreciably high and can be measured accurately.

(b) osmotic pressure can be measured at room temperature.

# SHORT ANSWER-II TYPE QUESTIONS (3 Marks)

**Q. 1. Determine the amount of $CaCl_2$ dissolved in 2.5L at 27°C such that its osmotic pressure is 0.75 atm at 27°C. ($i$ for $CaCl_2 = 2.47$)**

**Ans.** For $CaCl_2$, $\quad\quad\quad i\ = 2.47$

$$\pi\ = iCRT$$

$$= i\frac{n_B}{V} \times RT$$

$$0.75 = \frac{2.47 \times n_B \times 0.082 \times 300}{2.5}$$

$$n_B\ = \frac{0.75 \times 2.5}{2.47 \times 0.082 \times 300}$$

$$n_B = \ 0.0308 \text{ mol}$$

$$\text{Amount} = 0.0308 \text{ mol} \times 111\text{g mol}^{-1}$$

$$= 3.418\text{g}$$

**Q. 2. Determine the osmotic pressure of a solution prepared by dissolving 25 mg of $K_2SO_4$ in 2 litre of water at 25°C assuming that it is completely dissociated.**

**Ans.** If $K_2SO_4$ is completely dissociated,

$$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$$

$$i\ = 3$$

Mol mass of $K_2SO_4 = 2 \times 39 + 32 + 4 \times 16 = 174$ g mol$^{-1}$

$$\pi = iCRT$$

$$= i\frac{W_B \times RT}{M_B \times V}$$

$$= \frac{3 \times 25 \times 10^{-3} \times 0.082 \times 298}{174 \times 2.0}$$

$$= 5.27 \times 10^{-3} \text{ atm}$$

**Q. 3.** **If the solubility product of CuS is $6 \times 10^{-16}$, calculate the maximum molarity of CuS in aqueous solution.**

**Ans.** $K_{sp}$ of CuS $= 6 \times 10^{-16}$

If S is the solubility, then

$$CuS \rightarrow Cu^{2+} + S^{2-}$$

$$[Cu^{2+}] = S, [S^{2-}] = S$$

$$K_{sp} = [Cu^{2+}][S^{2-}]$$

$$= S \times S = S^2$$

Solubility $S = \sqrt{K_{sp}} = \sqrt{6 \times 10^{-6}}$

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

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

**Q. 4.** **Suggest the most important type of intermolecular attractive interaction in the following pairs :**

(a) **n-hexane and n-octane**     (b) **$I_2$ and $CCl_4$**

(c) **$NaClO_4$ and water**

**Ans.** (a)   Vander Waals interaction

(b)   Vander Waals interaction

(c)   Ion-dipole interaction

**Q. 5.** **The vapour pressure of water is 12.3 Kpa at 300K. Calculate vapour pressure of 1 molal solution of a non-volatile solute in it.**

**Ans.** Mole fraction of solute $= \dfrac{1}{1 + \dfrac{1000}{18}} = 0.0177$

$$\dfrac{P^0 - P_A}{P^0} = 0.0177$$

$$\dfrac{12.3 - P_A}{12.3} = 0.0177$$

$$P_A = 12.08 \text{ Kpa}$$

**Q. 6.** **6.90M solution of KOH in water contains 30% by mass of KOH. Calculate the density of the KOH solution. (Molar mass of KOH = 56 g mol⁻¹)**

**Ans.** Mass of KOH $= 30$ g

$$M = \dfrac{n_B}{V(\text{ml})} \times 1000$$

$$= \frac{W_B}{M_B \times V\,(\text{ml})} \times 1000 = \frac{30}{56 \times V} \times 1000$$

$$6.90 = \frac{30 \times 1000}{56 \times V}$$

$$V = \frac{30 \times 1000}{56 \times 6.90} = 81.43 \text{ mL}$$

$$D = \frac{M}{V}$$

$$= \frac{100}{81.43} = 1.28 \text{ g mL}^{-1}$$

**Q. 7.** **An anti-freeze solution is prepared from 222.6 g of ethylene glycol $C_2H_4(OH)_2$ and 200 g of water. Calculate the molality of the solution. If the density of this solution be 1.072 g mL$^{-1}$, what will be the molarity of the solution ?**

**Ans.** $M_B$ of $C_2H_4(OH)_2 = 62$ g mol$^{-1}$

$$\text{Molality} = \frac{n_B}{W_A} \times 1000 = \frac{W_B}{M_B \times W_B} \times 1000 = \frac{222.6 \times 1000}{62 \times 200}$$

$$= 17.95 m$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

So, $$\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{422.6}{1.072} = 394.22 \text{ ml}$$

$$M = \frac{n_B}{V} \times 1000$$

$$= \frac{222.6}{394.22 \times 62} \times 1000 = 9.11 M$$

**Q. 8.** **What would be the molar mass of compound if 6.21 g of it is dissolved in 24.0 g of $CHCl_3$ from a solution that has a boiling point of 68.04°C. The boiling point of pure chloroform is 61.7°C and the boiling point elevation constant $K_b$ for chloroform is 3.63°C/m.**

**Ans.** Elevation in boiling point $\Delta T_b = 68.04 - 61.7 = 6.31$°C

Mass of substance $W_B = 6.21$ g

Mass of CHCl3 $W_A = 24.0$ g

$$K_B = 3.63 \text{ °C/m}$$

$$M_B = \frac{K_b \times W_B \times 1000}{\Delta T_b \times W_A} = \frac{3.63 \times 6.21 \times 1000}{6.34 \times 24}$$

$$= 148.15 \text{ g mol}^{-1}$$

**Q. 9.** A solution of glycerol $(C_3H_8O_3)$ in water was prepared by dissolving some glycerol in 500 g of water. This solution has a boiling point of 100.42ºC while pure water boils at 100ºC. What mass of glycerol was dissolved to make the solution ? ($K_b = 0.512$ K kg mol$^{-1}$)

**Ans.** 37.73 g

**Q.10.** 18 g of glucose $(C_6H_{12}O_6)$ (molar mass = 180 g mol$^{-1}$) is dissolved in 1 kg of water in a sauce pan. At what temperature will this solution boil ? (Kb for water = 0.52 K kg mol$^{-1}$, boiling point of pure water = 373.1 K)

**Ans.** 373.202 K

## LONG ANSWER TYPE QUESTIONS (5 Marks)

**Q. 1. (a)** **Define Raoult's law of binary solution containing non-volatile solute in it.**

**(b)** **On dissolving 3.24 g of sulphur in 40 g of benzene, boiling point of solution was higher than that of benzene by 0.81K ($K_b$ = 2.53 K kg mol$^{-1}$). What is molecular formula of sulphur ? (Atomic mass s = 32 g mol$^{-1}$)**

**Ans. (a)** At a given temperature, the vapour pressure of a solution containing non-volatile solute is directly proportional to the mole fraction of the solvent.

(b)
$$M_B = \frac{K_b \times W_b \times 1000}{\Delta T_b \times W_A} = \frac{2.53 \times 3.24 \times 10^3}{0.81 \times 40}$$

$$= 253 \text{ g mol}^{-1}$$

Let the molecular formula of sulphur = $S_x$

Atomic mass of sulphur = 32

Molecular mass $= 32 \times x$

$32x = 253$

$x = 7.91 \approx 8$

Molecular formula of sulphur $= S_8$

**Q. 2. (a)** **Outer shells of two eggs are removed. One of the egg is placed in pure water and the other is placed in saturated solution of NaCl. What will be observed and why ?**

**(b)** **A solution prepared by dissolving 8.95 mg of a gene fragment in 35.0 ml of water has an osmotic pressure of 0.335 ton at 25ºC. Assuming the gene fragment is a non-electrolyse, determine the molar mass.**

**Ans.** (a) In pure water the egg swells and in saturated solution of NaCl it will shrinks.

(b)  Mass of gene fragment  = 8.95 mg

$$= 8.95 \times 10^{-3} \text{ g}$$

Volume of water  = 35.0 ml = $35 \times 10^{-3}$ L

$\pi$  = 0.335 ton = 0.335/760 atm

Temp  = 25 + 273 = 298 K

$$\pi = \frac{W_B RT}{M_B \times V}$$

$$\frac{0.335}{760} = \frac{8.95 \times 10^{-3} \times 0.0821 \times 298}{M_B \times 35 \times 10^{-3}}$$

$$M_B = 141933 \text{ g mol}^{-3}$$

**Q. 3. (a) Define van't Hoff factor.**

**(b) Calculate the freezing point depression expected for 0.0711M aqueous solution of Na$_2$SO$_4$. If this solution actually freezes at $-$ 0.320ºC, what would be the value of van't Hoff factor ? (K$_f$ = 1.86ºC mol$^{-1}$)**

**Ans.** (a) **Van't Hoff factor :** It is the ratio of the normal molar mass to the observed molar mass of the solute.

(b) $$\Delta T_f = K_f \times M$$

$$\Delta T_f = 1.86 \times 0.0711 = 0.132$$

Observed freezing point = 0 – (– 0.320) = 0.320ºC

$$i = \frac{\text{Observed freezing point}}{\text{Calculate freezing point}}$$

$$= \frac{0.320}{0.132} = 2.42$$

**Q. 4. (a) What is the value of $i$ when solute is associated and dissociated ?**

**(b) Calculate the freezing point of an aqueous solution containing 10.50 g of MgBr$_2$ in 200 g of water. (Molar mass of MgBr$_2$ = 184, K$_f$ = 1.86 K kg mol$^{-1}$)**

**Ans.** (a) $i < 1$ when solute is associated and

$i > 1$ when solute is dissociated.

(b) $$m = \frac{n_g \times 1000}{W_A(g)}$$

$$= \frac{W_B \times 1000}{M_B \times W_A} = \frac{10.50 \times 1000}{184 \times 200} = 0.2853 M$$

$MgBr_2$ ionizes as $MgBr_2 \rightarrow Mg^{2+} + 2Br$

$$i = 3$$

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

$$= 3 \times 1.86 \times 0.2855$$

$$= 1.59$$

Freezing point $= 0 - 1.59^{\circ}C = -1.59^{\circ}C$

**Q. 5. (a)** **What is the value of $i$ for $Al_2(SO_4)_3$ when it is completely dissociated ?**

   **(b)** **Calculate the boiling point of a solution prepared by adding 15.00 g of NaCl to 250 g of water. ($K_b$ = 0.512 K kg mol⁻¹ and molar mass of NaCl = 58.44 g mol⁻¹)**

**Ans. (a)** $Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$

$$i = 5$$

   (b)
$$\Delta T_b = \frac{iK_b \times 1000 \times W_B}{W_A \times M_B}$$

$NaCl \rightarrow Na^+ + Cl^-$

$$i = 2$$

$$\Delta T_b = \frac{2 \times 0.512 \times 1000 \times 15}{250 \times 58.44}$$

$$= 1.05$$

Boiling point of solution $= 100 + 1.05$

$$= 101.05^{\circ}C$$