Some Important Tips :

1. The component that is having more number of moles is known as solvent. Solvent determines the physical state of the solution. Water is an universal solvent.
2. Mole fraction (X) is a unitless quantity.
3. Molality (*m*) and mole fraction are temperature independent quantities whereas molarity decreases with increase in temperature.
4. As the temperature increases Henry's law constant, K_H increases so the lower is the solubility of the gas in the liquid.
5. 11.7% w/w Helium is added to air used by scuba divers due to its low solubility in the blood.
6. Raoult's law becomes a special case of Henry's law in which K_H becomes equal to P_A^0, *i.e.*, vapour pressure of pure solvent.
7. Azeotropes having the same composition in liquid and vapour phase and boil at a constant temperature and therefore can't be distilled.
8. Azeotropes arise due to very large deviation from Raoult's law. Maximum boiling azeotropes form when solutions exhibit negative deviation from Raoult's law whereas minimum boiling azeotropes form when solutions exhibit positive deviation from Raoult's law.
9. Relative lowering in vapour pressure is a colligative property but lowering in vapour pressure is not.
10. Van't Hoff factor (*i*) is the ratio of the observed value of the colligative property in solution to the theoretically calculated value of the colligative property.
    (a) A non-volatile solute undergoes dissociation, then $i > 1$.
    (b) A non-volatile solute undergoes association, then $i < 1$.

Some Important Formulae :

1. %w/w = $\frac{mass\ of\ the\ component\ \ in\ the\ solution}{Total\ mass\ of\ the\ solution} \times 100$

2. $ppm = \frac{number\ \ of\ parts\ \ of\ the\ component}{Total\ number\ \ of\ parts\ \ of\ all\ companents\ \ \ of\ the\ solutoin} \times 10^6$

3. $x_A = \frac{n_A}{n_A + n_A}$ $\qquad\qquad$ $\boldsymbol{x_1 + x_2 ..... + x_i = 1}$

4. Molarity = $\frac{moles\ \ of\ solute}{Volume\ \ of\ solution\ \ in\ liter}$

$$= \frac{mass\ \ of\ solute}{molar\ \ mass\ \ of\ solute\ \ x\ Volume\ \ of\ solution\ \ in\ liter}$$

$$= \frac{mass\ of\ solute\ \ x\ 1000}{molar\ mass\ of\ solute\ x\ Volume\ of\ solution\ in\ \boldsymbol{mililiter}}$$

$$\frac{mass\ of\ solute\ \ x\ 1000\ x\ density\ of\ solution}{molar\ mass\ of\ solute\ x\ mass\ of\ solution\ in\ \boldsymbol{grams}}$$

Dimension in always **Mole L^{-1}**

5. Molality (m) = $\frac{Moles\ \ of\ solte}{Mass\ \ of\ solvent\ \ in\ Kg}$

$$\frac{mass\ \ of\ solute}{molar\ \ mass\ \ of\ solute\ \ x\ \ mass\ \ of\ \boldsymbol{solvent}\ in\ Kg}$$

$$\frac{mass\ of\ solute\ \ x\ 1000}{molar\ mass\ of\ solute\ \ x\ \ Volume\ of\ solvent\ in\ grams}$$

Dimension in always **Mole Kg^{-1}**

- **Molarity of dilution:**

  (Before dilution) $\mathbf{M_1\ V_1}$ = $\mathbf{M_2\ V_2}$ (After dilution)

- **Molarity of mixing:** $M_1 V_1 + M_2 V_2 + M_3 V_3 = M_R (V_1 + V_2 + V_3)$

  Where M_R = Resultant molarity, $V_1 + V_2 + V_3$ = Resultant volume after mixing

- $\mathbf{P = K_H X}$ Here K_H is the Henry's law constant.

- $P_{total} = P_1 + P_2$

- $P_{total} = x_1 p_1^0 + x_2 p_2^0$

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

- $= p_1^0 + (p_2^0 - p_1^0) x_2$

- $P_1 = y_1 P_{total}$ $P_2 = y_2 P_{total}$
- $\frac{p_1^0 - p_1}{p_1^0} = x_2$ **(Relative lowering in V.P.)**
- $\Delta T_b \alpha \ m$ $or\ \Delta T_b = K_b \text{m}$ $\Delta T_b = T_b - T_1^0$
- $\Delta T_f \ \alpha \ m$ $\Delta T_f = K_f \ m$ $\Delta T_f = T_f^0 - T_f$
- $\Pi = \text{CRT}$ $\Pi = (\text{n}_2/\text{V})\ \text{RT}$
- $i = \frac{Normal\ \ molar\ \ mass}{Abnormal\ \ molar\ mass}$
- $i = \frac{observed\ \ collig\ hative\ \ propety}{Calculated\ \ Colligative\ \ propety}$
- $i = \frac{total\ number\ \ of\ moles\ \ of\ paricles\ \ after\ \ assocaiation\ \ /dissociat\ ion}{number\ \ of\ moles\ \ of\ particles\ \ \ before\ \ association\ \ /dissocation}$

:Some Important Questions :

MCQs :

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) $\Delta P = 0$ (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 ΔT_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) $\frac{M}{10}$ NaCl (b) $\frac{M}{10}$ Urea

(c) $\frac{M}{10}$ $BaCl_2$ (d) $\frac{M}{10}$ 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 3×10^{-2} atm . 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.

VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

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

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

Q. 3. Why the molecular mass becomes abnormal ?

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

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

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

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

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

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

Q.9. Why water cannot be completely separated from aqueous solution of ethyl alcohol ?

Q.10. Why anhydrous salts like NaCl or $CaCl_2$ are used to clear snow from roads on hills

Q.11. What is the effect on boiling and freezing point of a solution on addition of NaCl ?

Q.12. Why osmotic pressure is considered as colligative property ?

Q.13. Liquid A and B on mixing produce a warm solution. Which type of deviation does this solution show ?

Q.14. Give an example of a compound in which hydrogen bonding results in the formation of a dimer.

Q.15. What role does the molecular interaction play in solution containing chloroform and acetone ?

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 – 8.0ºC ? (K_f = 1.86 K kg/mol)

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.

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

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 ?

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

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

Q.15. The dissolution of ammonium chloride in water is endothermic process. What is the effect of temperature on its solubility ?

Q.16. Two liquids A and B boil at 145ºC and 190ºC respectively. Which of them has higher vapour pressure at 80ºC ?

Q.17. Why is liquid ammonia bottle first cooled in ice before opening it ?

Q.18. Which colligative property is preferred for the molar mass determination of macromolecules ?

SHORT ANSWER-II TYPE QUESTIONS (3 Marks)

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

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

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

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

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.

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})

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 ?

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 68.04ºC. The boiling point of pure chloroform is 61.7ºC and the boiling point elevation constant K_b for chloroform is 3.63ºC/m.

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})

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)

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})

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.

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

(b) Calculate the freezing point depression expected for 0.0711M aqueous solution of Na_2SO_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})

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})

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})