Van't Hoff factor: **i = normal molar mass/abnormal(observed)molar mass**

Colligative property after abnormal molar masses: -

Lowering of vapour pressure: -

$X_B = i\ p^o_A - p_s / p^o_A$

Elevation in boiling point: -

$\Delta T_b = i\ K_b\ m$

Depression in freezing point: -

$\Delta T_f = i\ K_f\ m$

Osmotic pressure: - $\pi = iCRT$

PROPERTY	ASSOCIATION	DISSOCIATION
No. of molecules	Less	more
Colligative property	Lowers	Increases
Molar mass	Greater than theoretical value	lesser
i=1	i Less than 1	i More than 1
α(extent) =degree of dissociation / association	$\frac{i-1}{\frac{1}{n}-1}$ [n = no. of particles associated]	$\frac{i-1}{n-1}$ [n = no. of dissociated particles.]

MULTIPLE CHOICE QUESTIONS (1 MARK)	
1	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
2	When a non-volatile solid is added to pure water it will: a) boil above 100°C and freeze above 0°C b) boil below 100°C and freeze above 0°C c) boil above 100°C and freeze below 0°C d) boil below 100°C and freeze below 0°C
3	Water- HCl mixture I. shows positive deviations II. forms minimum boiling azeotrope III. shows negative deviations IV. forms maximum boiling azeotrope a) I and II b) II and III c) I and IV d) III and IV
4	An azeotropic solution of two liquids has boiling point lower than either of them when solute solvent interactions are: a) Equal to solute solute and solvent solvent interactions b) Stronger than solute solute and solvent solvent interactions c)Weaker than solute solute and solvent solvent interactions d)None of the above
5	Molarity of a solution at 60°C is-------- than molarity at 30°C a) More b) less c) same d) no effect of temperature
6	For isotonic solutions which of the following is not equal a) concentration b) temperature c) osmotic pressure d) vapour pressure
7	For non-electrolyte solute value of Van't Hoff factor is a)0 b) 1 c) >1 d) <1
8	In reverse osmosis: a) a pressure greater than osmotic pressure is applied on pure water side b) a pressure lesser than osmotic pressure is applied on pure water side c)a pressure greater than osmotic pressure is applied on salt water side d)a pressure lesser than osmotic pressure is applied on salt water side

9	Which of the following salt will have same value of Van't Hoff's factor (i) as that of $K_4[Fe(CN)_6]$ (a) $Al_2(SO_4)_3$ (b) NaCl (c) $Al(NO_3)_3$ (d) Na_2SO_4
10	Pure benzene has vapour pressure three times that of pure toluene. They form nearly ideal solution. What would be the ratio of their mole fractions in the vapour phase of a solution having equal mole fractions of benzene and toluene. a) 1 b) 2/3 c) 3 d) 1/3

ANSWERS

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

ASSERTION REASON TYPE QUESTIONS (1 MARK)

	Note: In the following questions (1-5) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices. (a) Assertion and reason both are correct statements and reason is the correct explanation for assertion. (b) Assertion and reason both are correct statements but the reason is not a correct explanation for assertion. (c) Assertion is a correct statement but the reason is the wrong statement. (d) Assertion is a wrong statement but the reason is a correct statement.
1	**Assertion:** When methyl alcohol is added to water, the boiling point of water decreases. **Reason:** When a volatile solute is added to a volatile solvent elevation in boiling point is observed.
2	**Assertion**: Cooking time in pressure cooker is reduced **Reason**: Boiling point inside the pressure cooker is raised
3	**Assertion**: Vapour pressure of a liquid is constant at a constant temperature **Reason:** At equilibrium rate of evaporation becomes equal to the rate of condensation.
4	**Assertion**: The components of azeotropic mixture can be separated by distillation **Reason**: At a particular composition azeotropic mixture boil at the same temperature.
5	**Assertion**: The shrinking of cells is called hemolysis. **Reason**: Hemolysis occurs when cell comes in contact with solution of lower osmotic pressure than that of cell

ANSWERS

1 (c), 2 (a) , 3 (a) , 4 (d) , 5 (d)

VERY SHORT ANSWER QUESTIONS 1 mark Type:

Q1 Give an example of a solid solution in which solute is a liquid

Ans Amalgam of mercury with sodium

Q 2 Suggest the most important type of intermolecular attractive interaction between methanol and acetone

Ans Both methanol and acetone are polar. So, the intermolecular interactions between them are dipole – dipole interactions

Q 3 X and Y liquids on mixing produces cold solution. What type of deviation is shown by them?

Ans Positive deviation

Q 4 Aquatic species are more comfortable in cold waters rather than in warm waters. Give reason.

Ans Solubility of gases increases with decrease in temperature as it is an exothermic process.

Q 5 If is **α** the degree of dissociation of Na_2SO_4, calculate Van't Hoff factor to determine the molecular mass.
Ans 1+2α
Q 6 Give an example of a substance that can be used as a SPM.
Ans Pig's bladder or parchment or cellophane.
Q 7. What happens when blood cells are placed in a solution containing more than 0.9% (mass/volume) sodium chloride?
Ans Water will flow out of the cells and they would shrink
Q 8 People taking lot of salt experience puffiness or swelling of the body. Why ?
Ans People taking lot of salt experience puffiness or swelling of the body due to water retention in tissue cells and intercellular spaces because of osmosis.
Q 9 What are hypotonic solutions?
Ans A solution which has lower osmotic pressure than the other solution separated by a semipermeable membrane is called hypotonic solution
Q 10 How can the direction of osmosis be reversed?
Ans The direction of osmosis can be reversed if a pressure larger than the osmotic pressure is applied to the solution side.

VERY SHORT ANSWER QUESTIONS (2 MARKS)

1	a) Common salt and Calcium chloride are used to clear snow on the roads, both are of almost same cost but sodium chloride is preferred. Why? b) How the freezing point changes when mercuric iodide is added to the aqueous solution of potassium iodide?
Ans	a) NaCl is needed in lesser quantity. b) Freezing point is raised as no. of particles decreases which results in decrease in colligative property.
2	a) Write the expression for degree of dissociation of a weak electrolyte AxBy in terms of Van't Hoff factor. b) Name a substance that can be used in radiators of vehicles in places where the temperature is less than zero.
Ans	a) α = i-1/(x+y-1) b) Ethylene glycol
3	a) How the osmotic pressure of 5 % aqueous solution of glucose (π_1) is related to that of 5 %aqueous solution of urea (π_2)? b) Why do salt water fish die when they are suddenly transferred to a fresh water aquarium?
Ans	a) $\pi_1 < \pi_2$ b) Water from aquarium enters in cell causing them to expand and get ruptured.
4	a) Two 500 ml beakers were taken. One filled with 400ml water marked 'X' and another with 400ml of 2M NaCl solution marked 'Y'. At the same temperature both were placed in closed containers of same material and same capacity, in which container the vapour pressure is less. b) Out of 1M sucrose and 1M urea solution which has more osmotic pressure?
Ans	a) Y b) Both have osmotic pressure.
5	a) Sia's father is suffering from high blood pressure but he is advised to consume less quantity of common salt. Why? b) Two solutions A and B are separated by semi-permeable membrane. If the liquid flows fromA to B then which solution is more concentrated?
Ans	a) More salt use will increase ions in the body fluid which increases blood pressure b) B
6	a) Why the colligative property of an electrolyte solution is always greater than that of a non-electrolyte solution?

	b) Mohit wants to put an egg with outer shell removed in a bottle but he is unable to do so as mouth of bottle is slightly smaller. Suggest one method to help him putting the peeled egg in the bottle
Ans	a) Due to dissociation of electrolyte the number of ions increases b) Peeled egg shrinks in saturated brine solution.
7	a) Out of 1M and 2M sugar solutions which one has a lower boiling point? b) While performing practical it is directed that the bottle of liquid ammonia is to be cooled before opening the seal but Suman forgot to cool it before opening. What consequence she faced?
Ans	a)1M (higher the concentration of solute added higher is the colligative property) b) It is cooled to lower down the pressure of ammonia else the gas will bump out of the bottle.
8	a) What is the effect of temperature on the process when shrunk and dried vegetables are placed in water? b) 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 is undergoing dissociation in water?
Ans	a) Process will be accelerated with increase in temperature as osmosis becomes faster with increase in temperature. b) X
9	a) What is the unit of Ebullioscopic constant? b) Which type of deviation is shown by Carbon tetrachloride and chloroform mixture?
Ans	a) K kg mol^{-1} or K $(molality)^{-1}$ b) positive deviation
10	a) What is the significance of Henry's Law constant K_H? b) How the colligative properties change if the solute undergo dissociation in solution?
Ans	a) Henry's Law constant (K_H) helps in comparing the relative solubilities of different gases in the same solvent (e.g. water). In general, the lesser the value of K_H, the more the solubility of a gas. b) increases due to increase in number of particles on dissociation.
SHORT ANSWER TYPE QUESTIONS (3 MARKS)	
1	a) If the elevation in boiling point of a solution for which i = 1 in a solvent (K_f =x K kg mol^{-1} and K_b=y K kg mol^{-1}) is z K,then calculate the depression in freezing point of the same concentration. b) Give two examples of materials used for making semi permeable membrane for carrying out reverse osmosis.
Ans	a) z x/y b) Cellulose acetate, potassium ferrocyanide
2	a) What is the degree of dissociation for 0.1M Ba $(NO_3)_2$ if i(Van't Hoff factor) is 2.74 b) Arrange the following solutions in increasing order of Van't Hoff factor. 0.1M $CaCl_2$, 0.1M KCl, 0.1M $C_{12}H_{22}O_{11}$, 0.1 M $Al_2(SO_4)_3$
Ans	a) $\alpha = \frac{i-1}{n-1}$ α = 87% b) 0.1M $C_{12}H_{22}O_{11}$ < 0.1M KCl < 0.1M $CaCl_2$ < 0.1 M $Al_2(SO_4)_3$
3	a) Molal elevation constant for benzene is 2.52 K/m. A solution of some organic substance in benzene boils at 0.126°C higher than benzene. What is the molality of the solution? b) What are the values of Van't Hoff factor for NaCl and K_2SO_4, respectively?
Ans	a) $\Delta T_b = K_b$ m, molality=0.05m b) 2 and 3

4	a) State Henry's law. b) Which cold drink you prefer one chilled or other one at room temperature and why? c)At the same temperature hydrogen is more soluble in water than Helium. Which of them will have higher value of K_H and why?
Ans	a) Mole fraction of gas in the solution is directly proportional to partial pressure of gas in the vapour phase b) Chilled as solubility of CO_2 is more at low temp. c) Helium as greater the K_H value lower the solubility
5	a) Account for the reason, marine life like fish prefers to stay at lower level and stay away from the upper layer of water. b) Why freezing/melting point of a substance used as a criterion for testing the purity of a substance? c) Account for the reason for preservation of fruits against bacterial action by adding sugar.
Ans	a) Temperature is higher in upper layer so solubility of oxygen is less b) M.P./F.P. changes due to impurities. c) Bacterium in canned fruit loses water through the process of osmosis, shrivels and dies.
LONG ANSWER TYPE QUESTIONS (5 MARKS)	
1	a) If boiling point of an aqueous solution containing a non-volatile solute is 100.15°C. What is its freezing point? Given latent heat of fusion and vapourisation of water are 80cal/g and 540 cal/g respectively. b) Electrolyte A gives 4 ions and B is a non-electrolyte. If 0.1 molar solution of solute B produces an osmotic pressure 'p', then 0.02 molar solution of A will produce how much osmotic pressure?
Ans	a) $\Delta T_b = K_b\, m$, $\Delta T_f = K_f\, m$ $\quad K_f = \frac{R \times M_1 \times T_f^2}{1000 \times \Delta_{fus}H}$ $\quad K_b = \frac{R \times M_1 \times T_b^2}{1000 \times \Delta_{vap}H}$ $K_f/K_b = \frac{T_f^2\ X\ latent\ heat\ of\ fusion}{T_b^2 X\ latent\ heat\ of\ vapourisation} = \Delta T_f/\ \Delta T_b$ $\Delta T_f = 0.542$ $\quad T_f = 0 - 0.542 = -0.542°C$ b) 0.8p
2	a) 0.6 mL of acetic acid CH_3COOH, having density 1.06 g/mL, 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. K_f= 1.86 K kg /mol. b) How does Raoult's law become a special case of Henry's law?
Ans	a) First find out number of moles of acetic acid, mass of acetic acid =volume x density mass of acetic acid=0.6 X 1.06= 0.636 g and molar mass of acetic acid = 60 g/mol $no.\ of\ moles\ of\ acetic\ acid = \frac{mass\ of\ acetic\ acid}{molar\ mass\ of\ acetic\ acid} \frac{0.636}{60} = 0.0106$ $molality = \frac{No.\ of\ moles}{mass\ of\ solvent} = \frac{0.0106}{1} = 0.0106\, m$ (As density of water = 1 g/cm^3) $\therefore 1\, L = 1kg$) $\Delta T_f = i\, K_f\, m$ $\quad i = \frac{0.0205}{1.86 \times 0.0106} = 1.04$ $\alpha = \frac{i-1}{n-1} = \frac{1.04-1}{2-1} = 0.04$ $\quad$ As n=2, $CH_3COOH \leftrightharpoons CH_3COO^- + H^+$ Dissociation constant $K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]} = \frac{c\alpha \times c\alpha}{c(1-\alpha)} = \frac{c\alpha^2}{1-\alpha} = \frac{0.0106 \times 0.04 \times 0.04}{1-0.04} = 1.76 \times 10^{-5}$ b) In two laws only the proportionality constant K_H differs from P_A^0. Thus, Raoult's law becomes a special case of Henry's law in which $K_H = P_A^0$

CASE BASED QUESTIONS (4 MARKS)

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

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. (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	$C_6H_{12}O_6$ **OR**
c	a) as there are 2 moles of ions per mol of NaCl 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. Assuming the melting point of pure water as 0^oC, answer the following questions: (a) One temperature in the second set of results does not fit in the pattern. Which temperature is that? Justify your answer. 1 (b) Why did Henna collect two sets of results? 1 (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 **OR** (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. b) Two sets of reading help to avoid error in data collection and give more objective data. c.) ΔT_f (glucose) = $1 \times K_f \times 0.6 \times 1000 / 180 \times 10$ .... (1) ΔT_f (NaCl) = $2 \times K_f \times 0.6 \times 1000 / 58.5 \times 10$ $3.8 = 2 \times K_f \times 0.6 \times 1000 / 58.5 \times 10$ .... (2) Divide equation 1 by 2 ΔT_f (glucose)/ 3.8 = 58.5/ 2 x 180 ΔT_f (glucose) = 0.62 Freezing point or Melting point = - 0.62 ^oC OR depression in freezing point is directly proportional to molality (mass of solute when the amount of solvent remains same) 0.3 g depression is 1.9 ^oC 0.6 g depression is 3.8 ^oC 1.2 g depression will be 3.8 x2 = 7.6 ^oC
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: (a) How he can add fizz to the special drink made by his grandmother? 1 (b) What is the law stated in the chapter that can help Aarav to make his drink fizzy? 1 (c) What precautions he should take while bottling so that his product does not lose fizz during storage and handling across long distances? 2 OR

(c)The mole fraction of helium in a saturated solution at 20°C is 1.2×10^{-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 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 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.

(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)

a. Four samples $BaCl_2$, NaCl, $ZnCl_2$ and $AlCl_3$ of 0.5 M are being boiled Which of the among will show highest elevation in boiling point?

b. How does sprinkling of salt help in clearing the snow-covered roads in hilly areas?

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]

OR

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. $AlCl_3$

b. By depression of freezing point (it lowers freezing point of water less than 0 C)

c. $\Delta T_f = i\ k_f\ m$

$2=1x\ 8\ x\ (2.8/M_b\ )x1000/100 =8x2.8x10/M_b$

$M_b=8x28/2=8x14=112g/mol$

OR

$\Delta T_b = i\ k_b\ m$

$0.21= 1x\ 2.52x2x1000/100xM_b$

$M_b=\ 2.52x2x10/0.21=240\ g/mol$