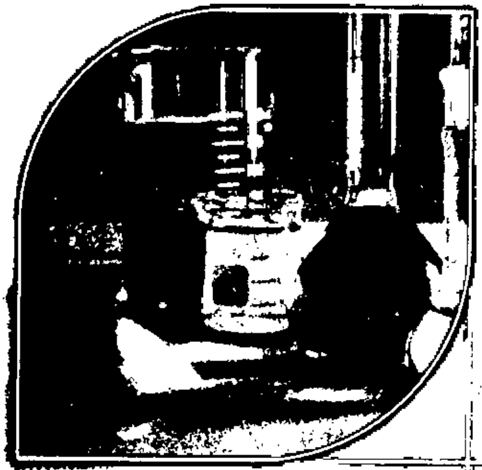


9

DILUTE SOLUTION

Vapour Pressure : The pressure exerted by the vapour of liquid which are in equilibrium with it at a given temperature.

- Vapour pressure is not a surface phenomena.
- Vapour pressure increases with increase in temperature.

$$X(l) \rightleftharpoons X(g)$$

$$K_p = P_{x(g)}$$

$$\ln\frac{K_{P_2}}{K_{P_1}} = \ln\frac{P_2}{P_1} = \frac{\Delta H_{\text{vap.}}}{R}\left(\frac{1}{T_1}-\frac{1}{T_2}\right);$$

where $\Delta H_{\text{vap.}}$ is molar enthalpy of vaporisation (j/mol or cal/mol)

Raoult's Law

(i) Liquid solution containing non volatile solute :

Vapour pressure of liquid solution $\propto$ Mole fraction of solvent in liquid solution.

$$P_{\text{Solution}} \propto X_{\text{Solvent}}$$

$$P_{\text{Solution}} = P^{\circ}_{\text{Solvent}} \cdot X_{\text{Solvent}}$$

Where $P^{\circ}_{\text{Solvent}}$ = Vapour pressure of pure liquid solvent, X_{Solvent} = Mole fraction of solvent.

For binary liquid solution ; $X_{\text{Solute}} + X_{\text{Solvent}} = 1$

Relative lowering of vapour pressure $= \frac{P^{\circ}-P}{P^{\circ}} = X_{\text{Solute}}$

(ii) Vapour Pressure of Solution containing volatile solute (B) and volatile solvent (A) :

The equilibrium vapour pressure of a volatile component is linearly proportional to the mole fraction of that component in liquid phase.

A solution contains volatile solute (B) and volatile solvent (A) :

$$P_A = P_A^{\circ} X_A \text{ and } P_B = P_B^{\circ} X_B$$

$$P = P_A^{\circ} X_A + P_B^{\circ} X_B$$

Where :

P_A and P_B are partial vapour pressure of A and B at given temperature.

P_A° = vapour pressure of pure A. ; P_B° = vapour pressure of pure B.

X_A = mole fraction of A in liquid phase. ; X_B = mole fraction of B in liquid phase.

y_A = mole fraction of A in vapour phase ; y_B = mole fraction of B in vapour phase.

Partial vapour pressure of 'A' = mole fraction of 'A' in vapour phase × total vapour pressure.

$$P_A = y_A P \quad \text{and} \quad P_B = y_B P$$

$$P_A^{\circ} X_A = y_A P \quad \text{and} \quad P_B^{\circ} X_B = y_B P$$

$$X_A + X_B = 1$$

$$\frac{y_A P}{P_A^{\circ}} + \frac{y_B P}{P_B^{\circ}} = 1 ; \qquad \frac{y_A}{P_A^{\circ}} + \frac{y_B}{P_B^{\circ}} = \frac{1}{P}$$

$$y_A = \frac{P_A^{\circ} X_A}{P_A^{\circ} X_A + P_B^{\circ} X_B} ; \qquad y_B = \frac{P_B^{\circ} X_B}{P_A^{\circ} X_A + P_B^{\circ} X_B}$$

Ideal Solutions

The solutions which obey Raoult's Law are called ideal solutions. For ideality :

$$F_{\text{Solute ...... Solvent}} \approx F_{\text{Solute...... Solute}} \quad (F = \text{Intermolecular attractive interactions})$$
$$\approx F_{\text{Solvent ...... Solvent}}$$

$\Delta H_{\text{mix}} = 0$; $\Delta V_{\text{mix}} = 0$

$\Delta S_{\text{mix}} > 0$; $\Delta G_{\text{mix}} < 0$

Examples : Benzene & Toluene, Hexane & Heptane, C_2H_5Br & C_2H_5I

Non-ideal solutions : The mixture which do not follow Raoult's Law will be known as non-ideal solutions.

Types of Real or Non-ideal Solutions

- Non-ideal solution with positive deviation.
- Non-ideal solution with negative deviation.

Solution shows positive deviation	Solution shows negative deviation
$P_{T,\text{exp}} > (P_A^{\circ} X_A + P_B^{\circ} X_B)$	$P_{T,\text{exp}} < (P_A^{\circ} X_A + P_B^{\circ} X_B)$
$A\text{----}B < \begin{matrix} A\text{----}A \\ B\text{----}B \end{matrix}$	$A\text{----}B > \begin{matrix} A\text{----}A \\ B\text{----}B \end{matrix}$
$\Delta H_{\text{mix}} = +\text{ve}$	$\Delta H_{\text{mix}} = -\text{ve}$
$\Delta V_{\text{mix}} = +\text{ve}$	$\Delta V_{\text{mix}} = -\text{ve}$
$\Delta S_{\text{mix}} = +\text{ve}$	$\Delta S_{\text{mix}} = +\text{ve}$
$\Delta G_{\text{mix}} = -\text{ve}$	$\Delta G_{\text{mix}} = -\text{ve}$
Ex. $H_2O + CH_3OH$ $H_2O + C_2H_5OH$ $CHCl_3 + CCl_4$	**Ex.** $H_2O + CH_3COOH$ $CHCl_3 + CH_3COCH_3$ $H_2O + HNO_3$

Azeotropic Solutions. During distillation, the mole fraction of more volatile component in vapour state is higher than that in liquid state. This makes distillation possible. However, there exist some solutions for particular compositions of which the mole fraction of components in liquid and vapour state is same. Thus, no distillation is possible, a mixture and it is termed as **azeotropic mixture.**

Azeotropes are binary mixtures having the same composition in liquid and vapour phase and boil at a constant temperature.

The solutions which show a large positive deviation from Raoult's law form minimum boiling azeotrope at a specific composition.

The solutions which show a large negative deviation from Raoult's law form maximum boiling azeotrope at a specific composition.

Completely Immiscible Liquids : When they are distilled, they distil in the ratio of their vapour pressure at that temperature.

$$P = P_A^\circ + P_B^\circ$$

For vapour of pure liquid we can apply : $P_A^\circ V = n_A RT$ and $P_B^\circ V = n_B RT$

So, $$\frac{P_A^\circ}{P_B^\circ} = \frac{n_A}{n_B}$$

When A and B are distilled wt. ratio is given as $\dfrac{w_B}{w_A} = \dfrac{P_B^\circ \cdot M_B}{P_A^\circ \cdot M_A}$

Colligative Properties : Colligative Properties depend on the number of solute particles irrespective to their nature.

- Relative lowering of vapour pressure
- Elevation of boiling point
- Depression of freezing point
- Osmotic pressure

Normal Colligative Properties : When neither association nor dissociation of solute particles take place.

(i) Relative Lowering of Vapour Pressure : $\dfrac{P^\circ - P}{P^\circ} = X_{\text{Solute}}$

(ii) Elevation of boiling point : $\Delta T_b = K_b m$

(iii) Depression of freezing point : $\Delta T_f = K_f m$

(iv) Osmotic pressure : $\pi = CRT$

(i) Relative lowering of Vapour Pressure :

$$\frac{P^\circ - P}{P^\circ} = X_{\text{Solute}} = \frac{n}{n+N}$$

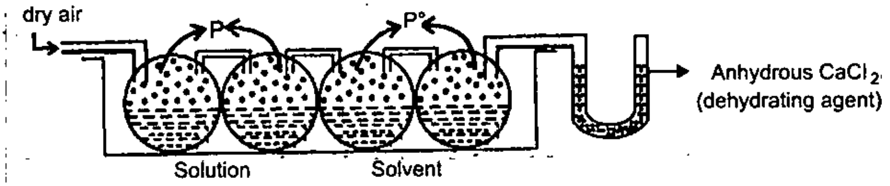
Where, n = mole of solute, N = mole of solvent

$$\frac{P^\circ - P}{P} = \frac{n}{N}$$

$$\text{Molality } (m) = \left(\frac{P^\circ - P}{P}\right) \times \frac{1000}{M(\text{in g/mol})}$$

Where, M = molar mass of solvent.

Ostwald-Walker Method



Loss in wt of solution containers αP
Loss in wt of solvent containers $\alpha (P^\circ - P)$
gain in wt of dehydrating agent αP°

$$\frac{P^\circ - P}{P^\circ} = \frac{\text{Loss in weight of solvent}}{\text{Gain in weight of dehydrating agent}}$$

(ii) Elevation in Boiling Point :

$\Delta T_b = K_b m$

where $\Delta T_b = T_b - T_b^\circ$

K_b = Boiling point elevation constant or ebullioscopic constant

$$K_b = \frac{RT_b^{\circ 2}}{1000 L_v}$$

L_v = Latent heat of vapourisation per gram

$$K_b = \frac{MRT_b^{\circ 2}}{1000 \Delta H_{Vap}}$$

ΔH_{vap} = enthalpy of vapourisation per mole
M = molar mass of solvent (in g/mol)
T_b° = Boiling point of solvent

(iii) Depression in Freezing point :

$\Delta T_f = K_f m$

where $\Delta T_f = T_f - T_f^\circ$

K_f = Freezing point depression constant or cryoscopic constant

$$K_f = \frac{RT_f^{\circ 2}}{1000 L_f}$$

L_f = Latent heat of fusion per gram

$$K_f = \frac{MRT_f^{\circ 2}}{1000 \Delta H_{Fus}}$$

ΔH_{Fus} = enthalpy of fusion per mole
M = molar mass of solvent (in g/mol)
T_f° = freezing point of solvent

(iv) Osmotic Pressure (π) : The hydrostatic pressure built up on the solution which just stops osmosis. Alternatively, it may be defined as the pressure which must be applied to the concentrated solution in order to stop osmosis.

For dilute solutions $\pi = CRT = h\rho g$

where C is the total molar concentration of all the free species present in the solution, h is the height developed by the column of the concentrated solution and ρ is the density of the solution in the column.

On the basis of osmotic pressure, the solutions can be classified in three classes.

- **Isotonic solutions:** Two solutions having same osmotic pressures are cold isotonic solutions.

(This implies $C_1 = C_2$ at same temperature).

- **Hypertonic and hypotonic solution :** When two solutions are being compared, then the solution with higher osmotic pressure is termed as hypertonic. The solution with lower osmotic pressure is termed as **hypotonic.**
- **Abnormal Colligative Properties :** When solute particle associated or dissociated in solvent.

$$i = \text{Vant Hoff factor} = \frac{\text{Actual moles of solute}}{\text{Moles of solute without dissociation or association}}$$

$$= \frac{\text{Observed or experimental colligative properties}}{\text{Theoretical or calculated colligative properties}}$$

(i) Relative lowering of vapour pressure : $\frac{P^\circ - P}{P^\circ} = \frac{i.n_{\text{solute}}}{i.n_{\text{solute}} + n_{\text{solvent}}}$

(ii) Elevation of boiling point : $\Delta T_b = i.K_b m$

(iii) Depression of freezing point : $\Delta T_f = i.K_f m$

(iv) Osmotic pressure : $\pi = i.CRT$

For dissociation : $i = 1 + (n-1)\alpha$

For association : $i = 1 + \left(\frac{1}{n} - 1\right)\alpha$

Degree of dissociation $\alpha = \frac{i-1}{n-1}$

Degree of association $\alpha = \frac{1-i}{1-1/n}$

Where n = Total number of particles of solute after dissociation or association.

Henry Law

This law deals with dissolution of gas in liquid *i.e.*, mass of any gas dissolved in any solvent per unit volume is proportional to pressure of gas in equilibrium with liquid.

(i) $m = k \times P$

Where, m = mass of gas dissolved per unit volume.
k = proportionality constant.
P = pressure of gas.

(ii) $P = K_H . X_{\text{gas}}$

Where, P = Pressure of gas.
K_H = Henry's constant
X_{gas} = Mole fraction of gas

Level 1

1. The vapour pressure of a given liquid will decrease if :
(a) surface area of liquid is decreased
(b) the volume of liquid in the container is decreased
(c) the volume of the vapour phase is increased
(d) the temperature is decreased

2. The normal boiling point of water is 373 K. Vapour pressure of water at temperature T is 19 mm Hg. If enthalpy of vaporisation is 40.67 kJ/mol, then temperature T would be (Use : $\log 2 = 0.3, R : 8.3\ \text{JK}^{-1}\ \text{mol}^{-1}$):
(a) 250 K (b) 291.4 K (c) 230 K (d) 290 K

3. A sample of liquid H_2O of mass 18.0 g is injected into an evacuated 7.6 L flask maintained at 27.0°C. If vapour pressure of H_2O at 27°C is 24.63 mm Hg. What weight percentage of the water will be vapourised when the system comes to equilibrium? Assume water vapours behaves as an ideal gas. The volume occupied by the liquid water is negligible compared to the volume of the container:
(a) 1% (b) 10% (c) 18% (d) 20%

4. Raoult's law is obeyed by each constituent of a binary liquid solution when:
(a) the forces of attractions between like molecules are greater than those between unlike molecules
(b) the forces of attractions between like molecules are smaller than those between unlike molecules
(c) the forces of attractions between like molecules are identical with those between unlike molecules
(d) the volume occupied by unlike molecules are different

5. For a binary ideal liquid solution, the total pressure of the solution is given as:
(a) $P_{\text{total}} = P_A^* + (P_A^* - P_B^*)X_B$ (b) $P_{\text{total}} = P_B^* + (P_A^* - P_B^*)X_A$
(c) $P_{\text{total}} = P_B^* + (P_B^* - P_A^*)X_A$ (d) $P_{\text{total}} = P_B^* + (P_B^* - P_A^*)X_B$

6. For an ideal binary liquid solution with $P_A^\circ > P_B^\circ$, which relation between X_A (mole fraction of A in liquid phase) and Y_A (mole fraction of A in vapour phase) is correct ?
(a) $Y_A < Y_B$ (b) $X_A > X_B$ (c) $\frac{Y_A}{Y_B} > \frac{X_A}{X_B}$ (d) $\frac{Y_A}{Y_B} < \frac{X_A}{X_B}$

7. An ideal solution is formed by mixing two volatile liquids A and B. X_A and X_B are the mole fractions of A and B respectively in the solution and Y_A and Y_B are the mole fractions of A and B respectively in the vapour phase. A plot of $\frac{1}{Y_A}$ along y-axis against $\frac{1}{X_A}$ along x-axis gives a straight line. What is the slope of the straight line ?
(a) $\frac{P_B^\circ}{P_A^\circ}$ (b) $\frac{P_A^\circ}{P_B^\circ}$ (c) $P_B^\circ - P_A^\circ$ (d) $P_A^\circ - P_B^\circ$

8. For a dilute solution, Raoult's law states that :

(a) the lowering of vapour pressure is equal to the mole fraction of solute
(b) the relative lowering of vapour pressure is equal to the mole fraction of solute
(c) the relative lowering of vapour pressure is proportional to the amount of solute in solution
(d) the vapour pressure of the solution is equal to the mole fraction of solvent

9. The solubility of a specific non-volatile salt is 4 g in 100 g of water at 25°C. If 2.0 g, 4.0 g and 6.0 g of the salt added of 100 g of water at 25°C, in system X, Y and Z. The vapour pressure would be in the order:

(a) $X < Y < Z$ (b) $X > Y > Z$ (c) $Z > X = Y$ (d) $X > Y = Z$

10. The boiling point of C_6H_6, CH_3OH, $C_6H_5NH_2$ and $C_6H_5NO_2$ are 80°C, 65°C, 184°C and 212°C respectively. Which will show highest vapour pressure at room temperature :

(a) C_6H_6 (b) CH_3OH (c) $C_6H_5NH_2$ (d) $C_6H_5NO_2$

11. 6.0 g of urea (molecular weight = 60) was dissolved in 9.9 moles of water. If the vapour pressure of pure water is $P°$, the vapour pressure of solution is:

(a) $0.10\,P°$ (b) $1.10\,P°$ (c) $0.90\,P°$ (d) $0.99\,P°$

12. An ideal solution was found to have a vapour pressure of 80 torr when the mole fraction of a non-volatile solute was 0.2. What would be the vapour pressure of the pure solvent at the same temperature?

(a) 64 torr (b) 80 torr (c) 100 torr (d) 400 torr

13. The vapour pressure of an aqueous solution of sucrose at 373 K is found to be 750 mm Hg. The molality of the solution at the same temperature will be :

(a) 0.26 (b) 0.73 (c) 0.74 (d) 0.039

14. Estimate the lowering of vapour pressure due to the solute (glucose) in a 1.0 M aqueous solution at 100°C :

(a) 10 torr (b) 18 torr (c) 13.45 torr (d) 24 torr

15. Calculate the weight of non-volatile solute having molecular weight 40, which should be dissolved in 57 gm octane to reduce its vapour pressure to 80%:

(a) 47.2 g (b) 5 g (c) 106.2 g (d) None of these

16. Equal weight of a solute are dissolved in equal weight of two solvents A and B and formed very dilute solution. The relative lowering of vapour pressure for the solution B has twice the relative lowering of vapour pressure for the solution A. If M_A and M_B are the molecular weights of solvents A and B respectively, then:

(a) $M_A = M_B$ (b) $M_B = 2 \times M_A$ (c) $M_A = 4M_B$ (d) $M_A = 2M_B$

17. An ideal solution has two components A and B. A is more volatile than B, *i.e.*, $P_A^\circ > P_B^\circ$ and also $P_A^\circ > P_{\text{total}}$. If X_A and Y_A are mole fractions of components A in liquid and vapour phases, then:

(a) $X_A = Y_A$ (b) $X_A > Y_A$ (c) $X_A < Y_A$ (d) Data insufficient

18. At 25°C, the vapour pressure of pure liquid A (mol. wt. = 40) is 100 torr, while that of pure liquid B is 40 torr, (mol. wt. = 80). The vapour pressure at 25°C of a solution containing 20 g of each A and B is:

(a) 80 torr (b) 59.8 torr (c) 68 torr (d) 48 torr

19. Two liquids A and B from ideal solutions. At 300 K, the vapour pressure of solution containing 1 mole of A and 3 mole of B is 550 mm Hg. At the same temperature, if one more mole of B is added to this solution, the vapour pressure of the solution increases by 10 mm Hg. Determine the vapour pressure of A and B in their pure states (in mm Hg):

(a) 400, 600 (b) 500, 500 (c) 600, 400 (d) None of these

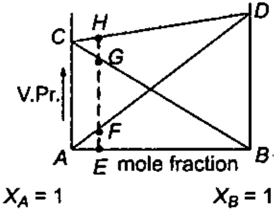
20. Two liquids A and B have vapour pressure in the ratio $P_A^\circ : P_B^\circ = 1 : 3$ at a certain temperature. Assume A and B form an ideal solution and the ratio of mole fractions of A to B in the vapour phase is 4 : 3. Then the mole fraction of B in the solution at the same temperature is :

(a) $\frac{1}{5}$ (b) $\frac{2}{3}$ (c) $\frac{4}{5}$ (d) $\frac{1}{4}$

21. Two liquids A and B have P_A° and P_B° in the ratio of 1 : 3 and the ratio of number of moles of A and B in liquid phase are 1 : 3 then mole fraction of 'A' in vapour phase in equilibrium with the solution is equal to:

(a) 0.1 (b) 0.2 (c) 0.5 (d) 1.0

22. Based on the given diagram, which of the following statements regarding the homogenous solutions of two volatile liquids are correct?



(1) Plots AD and BC show that Raoult's law is obeyed for the solution in which B is a solvent and A is the solute and as well as for that in which A is solvent and B is solute.

(2) Plot CD shows that Dalton's law of partial pressures is obeyed by the binary solution of components A and B.

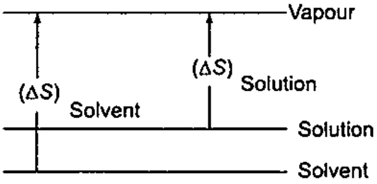
(3) $EF + EG = EH$; and AC and BD correspond to the vapour pressures of the pure solvents A and B respectively.

Select the correct answer using the options given below:

(a) Only 1 (b) 2 and 3 (c) 1 and 3 (d) All

23. Which represents correct difference when non-volatile solute is present in an ideal solution?

(I)



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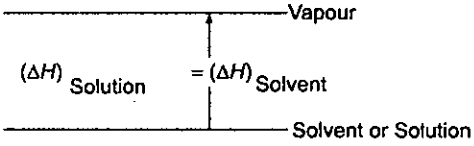
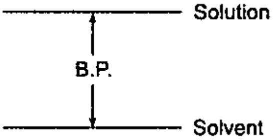
(II)



(III)



(a) I, II, III (b) I, III (c) II, III (d) I, II

24. Select correct statement :

(a) Solution has more molecular randomness than a pure solvent has, the entropy change between solution and solid is larger than the entropy change between pure solvent and solid

(b) Heat of fusion of solution and solvent are similar since similar forces of intermolecular forces are involved

(c) Sugar containing solution freezes at a lower temperature than pure water

(d) All are correct statements

25. Select correct statement?

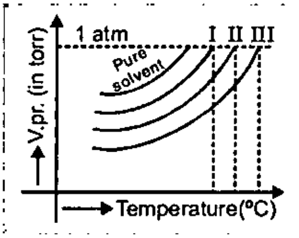
(a) Heats of vaporisation for a pure solvent and for a solution are similar because similar intermolecular forces between solvent molecules must be overcome in both cases

(b) Entropy change between solution and vapour is smaller than the entropy change between pure solvent and vapour

(c) Boiling point of the solution is larger than that of the pure solvent

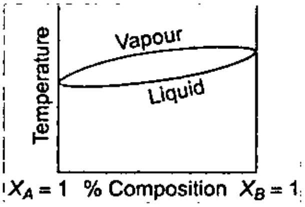
(d) All are correct statements

26. The vapour pressure curves of the same solute in the same solvent are shown. The curves are parallel to each other and do not intersect. The concentrations of solutions are in order of:



(a) I < II < III (b) I = II = III (c) I > II > III (d) I > III > II

27. Boiling point composition diagram of the liquid-vapour equilibrium for *A* and *B* is shown figure. If a binary liquid mixture of *A* and *B* is distilled fractionally, which of the following would be correct observation?



(a) Composition of the still (residue) will approach pure liquid *B*

(b) Composition of the distillate will approach pure *A*

(c) Composition of distillate and residue will approach pure *B* and *A* respectively

(d) Neither of the component can be obtained in pure state

28. The boiling point of an azeotropic mixture of water–ethanol is less than that of both water and ethanol. Then:

(a) the mixture will show negative deviation from Raoult's law

(b) the mixture will show positive deviation from Raoult's law

(c) the mixture will show no deviation from Raoult's law

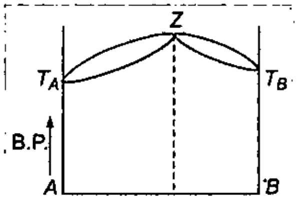
(d) this mixture cannot be considered as true solution

29. Formation of a solution from two components can be considered as :
(i) Pure solvent → separated solvent molecules, ΔH_1
(ii) Pure solute → separated solute molecules, ΔH_2
(iii) separated solvent and solute molecules → solution, ΔH_3
Solution so formed will be ideal if :
(a) $\Delta H_{\text{Soln}} = \Delta H_1 + \Delta H_2 + \Delta H_3$ (b) $\Delta H_{\text{Soln}} = \Delta H_1 + \Delta H_2 - \Delta H_3$
(c) $\Delta H_{\text{Soln}} = \Delta H_1 - \Delta H_2 - \Delta H_3$ (d) $\Delta H_{\text{Soln}} = \Delta H_3 - \Delta H_1 - \Delta H_2$

30. Total vapour pressure of mixture of 1 mol X ($P_x^\circ = 150$ torr) and 2 mol Y ($P_Y^\circ = 300$ torr) is 240 torr. In this case:
(a) There is a negative deviation from Raoult's law
(b) There is a positive deviation from Raoult's law
(c) There is no deviation from Raoult's law
(d) Can not be decided

31. In a mixture of A and B, components show positive deviation when:
(a) $A-B$ interaction is stronger than $A-A$ and $B-B$ interaction
(b) $A-B$ interaction is weaker than $A-A$ and $B-B$ interaction
(c) ΔV mix < 0, ΔS mix > 0
(d) ΔV mix $= 0$, ΔS mix > 0

32. A liquid mixture having composition corresponding to point Z in the figure shown is subjected to distillation at constant pressure. Which of the following statement is correct about the process?



(a) The composition of distillate differs from the mixture
(b) The boiling point goes on changing
(c) The mixture has highest vapour pressure than for any other composition
(d) Composition of an azeotrope alters on changing the external pressure

33. Which will form maximum boiling azeotrope ?
(a) $C_6H_6 + C_6H_5CH_3$ solution (b) $HNO_3 + H_2O$ solution
(c) $C_2H_5OH + H_2O$ solution (d) n-hexane and n-heptane

34. Total vapour pressure of mixture of 1 mole of volatile component A ($P_A^\circ = 100$ mm Hg) and 3 mole of volatile component B ($P_B^\circ = 80$ mm Hg) is 90 mm Hg. For such case:
(a) there is positive deviation from Raoult's law
(b) boiling point has been lowered
(c) force of attraction between A and B is smaller than that between A and A or between B and B
(d) all the above statements are correct

35. The azeotropic mixture of water (B. P. = 100°C) and HCl (B.P. = 86°C) boils at about 120°C. During fractional distillation of this mixture it is possible to obtain :

(a) pure HCl
(b) pure H_2O
(c) pure H_2O as well as pure HCl
(d) neither H_2O nor HCl

36. Azeotropic mixture of water and HCl boils at 381.5 K. By distilling the mixture it is possible to obtain :

(a) Pure HCl only
(b) Pure water only
(c) Neither HCl nor water
(d) Both water and HCl in pure state

37. An azeotropic mixture of two liquids has a boiling point higher than either of them when it:

(a) shows positive deviation from Raoult's law
(b) shows negative deviation from Raoult's law
(c) shows ideal behaviour
(d) is saturated

38. If two liquids A ($P_A^\circ = 100$ torr) and B ($P_B^\circ = 200$ torr) are completely immiscible with each other (each one will behave independently of the other) are present in a closed vessel. The total vapour pressure of the system will be:

(a) less than 100 torr
(b) greater than 200 torr
(c) between 100 to 200 torr
(d) 300 torr

39. When a liquid that is immiscible with water was steam distilled at 95.2°C at a total pressure of 748 torr, the distillate contained 1.25 g of the liquid per gram of water. The vapour pressure of water is 648 torr at 95.2°C, what is the molar mass of liquid?

(a) 7.975 g/mol
(b) 166 g/mol
(c) 145.8 g/mol
(d) None of these

40. Water and chlorobenzene are immiscible liquids. Their mixture boils at 89°C under a reduced pressure of 7.7×10^4 Pa. The vapour pressure of pure water at 89°C is 7×10^4 Pa. Weight per cent of chlorobenzene in the distillate is :

(a) 50
(b) 60
(c) 78.3
(d) 38.46

41. Which of the following is not a colligative property?

(a) Vapour pressure
(b) Depression in f.pt.
(c) Elevation in b.pt.
(d) Osmotic pressure

42. The degree of dissociation of an electrolyte is α and its van't Hoff factor is i. The number of ions obtained by complete dissociation of 1 molecule of the electrolyte is :

(a) $\frac{i + \alpha - 1}{\alpha}$
(b) $i - \alpha - 1$
(c) $\frac{i - 1}{\alpha}$
(d) $\frac{i + 1 + \alpha}{1 - \alpha}$

43. One mole of a solute A is dissolved in a given volume of a solvent. The association of the solute take place as follows:

$$nA \rightleftharpoons A_n$$

If α is the degree of association of A, the van't Hoff factor i is expressed as:

(a) $i = 1 - \alpha$
(b) $i = 1 + \frac{\alpha}{n}$
(c) $i = \frac{1 - \alpha + \frac{\alpha}{n}}{1}$
(d) $i = 1$

44. The van't Hoff factor i for an electrolyte which undergoes dissociation and association in solvent are respectively:

(a) greater than one and less than one
(b) less than one and greater than one
(c) less than one and less than one
(d) greater than one and greater than one

45. Which solution has the highest vapour pressure?
(a) 0.02 *M* NaCl at 50°C (b) 0.03 *M* sucrose at 15°C
(c) 0.005 *M* $CaCl_2$ at 50°C (d) 0.005 *M* $CaCl_2$ at 25°C

46. An aqueous solution is 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase ?
(a) addition of water (b) addition of NaCl
(c) addition of Na_2SO_4 (d) Addition of 1.0 molal KI

47. Four solutions of K_2SO_4 with the concentrations 0.1 *m*, 0.01 *m*, 0.001 *m* and 0.0001 *m* are available. The maximum value of colligative property corresponds to :
(a) 0.0001 *m* solution (b) 0.001 *m* solution (c) 0.01 *m* solution (d) 0.1 *m* solution

48. Moles of Na_2SO_4 to be dissolved in 12 mole water to lower its vapour pressure by 10 mm Hg at a temperature at which vapour pressure of pure water is 50 mm is:
(a) 1.5 mole (b) 2 mole (c) 1 mole (d) 3 mole

49. A very diluted saturated solution of a sparingly soluble salt X_3Y_4 has a vapour pressure of 20 mm Hg at temperature *T*, while pure water exerts a pressure of 20.0126 mm Hg at the same temperature. Calculate molality (*m*) at temperature *T*:
(a) 6.3×10^{-4} (b) 3.5×10^{-2} (c) 5×10^{-3} (d) None of these

50. When 1 mole of a solute is dissolved in 1 kg of H_2O, boiling point of solution was found to be 100.5°C. K_b for H_2O is:
(a) 0.5 (b) 100 (c) 100.5 (d) 95.5

51. Chloroform, $CHCl_3$, boils at 61.7°C. If the K_b for chloroform is 3.63°C/molal, what is the boiling point of a solution of 15.0 kg of $CHCl_3$ and 0.616 kg of acenaphthalene, $C_{12}H_{10}$?
(a) 61.9 (b) 62.0 (c) 52.2 (d) 62.67

52. A compound has the empirical formula $C_{10}H_8Fe$. A solution of 0.26 g of the compound in 11.2 g of benzene (C_6H_6) boils at 80.26°C. The boiling point of benzene is 80.10°C; the K_b is 2.53°C/molal. What is the molecular formula of the compound?
(a) $C_{30}H_{24}Fe_3$ (b) $C_{10}H_8Fe$ (c) C_5H_4Fe (d) $C_{20}H_{16}Fe_2$

53. A solution of 0.640 g of azulene in 100.0 g of benzene boils at 80.23°C. The boiling point of benzene is 80.10°C; the K_b is 2.53°C/molal. What is the molecular weight of azulene?
(a) 108 (b) 99 (c) 125 (d) 134

54. One molal solution of a carboxylic acid in benzene shows the elevation of boiling point of 1.518 K. The degree of association for dimerization of the acid in benzene is (K_b for benzene $= 2.53$ K kg mol^{-1}):
(a) 60% (b) 70% (c) 75% (d) 80%

55. The boiling point elevation constant for toluene is 3.32 K kg mol^{-1}. The normal boiling point of toluene is 110.7°C. The enthalpy of vaporisation of toluene would be nearly:
(a) 17.0 kJ mol^{-1} (b) 34.0 kJ mol^{-1} (c) 51.0 kJ mol^{-1} (d) 68.0 kJ mol^{-1}

56. Which one of the following aqueous solutions will exhibit highest boiling point:
(a) 0.015 *M* urea (b) 0.01 *M* KNO_3 (c) 0.10 *M* Na_2SO_4 (d) 0.015 *M* glucose

57. Calculate the percentage degree of dissociation of an electrolyte XY_2 (Normal molar mass = 164) in water if the observed molar mass by measuring elevation in boiling point is 65.6:
(a) 75% (b) 25% (c) 65% (d) None of these

58. If the elevation in boiling point of a solution of non-volatile, non-electrolytic and non-associating solute in solvent ($K_b = x \text{ K. kg. mol}^{-1}$) is y K, then the depression in freezing point of solution of same concentration would be
(K_f of the solvent $= z \text{ K. kg. mol}^{-1}$)
(a) $\dfrac{2xz}{y}$ (b) $\dfrac{yz}{x}$ (c) $\dfrac{xz}{y}$ (d) $\dfrac{yz}{2x}$

59. When a solution containing non-volatile solute freezes, which equilibrium would exist?
(a) solid solvent $\rightleftharpoons$ liquid solvent (b) solid solute $\rightleftharpoons$ liquid solution
(c) solid solute $\rightleftharpoons$ liquid solvent (d) solid solvent $\rightleftharpoons$ liquid solution

60. Bromoform has a normal freezing point of 7.734°C/m and it's $K_f = 14.4$°C/m. A solution of 2.60 g of an unknown in 100 g of bromoform freezes at 5.43°C. What is the molecular weight of the unknown?
(a) 16.25 (b) 162.5 (c) 100 (d) none of these

61. C_6H_6 freezes at 5.5°C. At what temperature will a solution of 10.44 g of C_4H_{10} in 200 g of C_6H_6 freeze? K_f $(C_6H_6) = 5.12$°C/m
(a) 4.608°C (b) 0.892°C (c) 5.5°C (d) none of these

62. How much ethyl alcohol must be added to 1.0 L of water so that solution will not freeze at –4°F? ($K_f = 1.86$°C/m)
(a) < 20 g (b) < 10.75 g (c) < 494.5 g (d) > 494.5 g

63. The freezing point of a solution of 2.40 g of biphenyl ($C_{12}H_{10}$) in 75.0 g of benzene (C_6H_6) is 4.40°C. The normal freezing point of benzene is 5.50°C. What is the molal freezing point constant (°C/m) for benzene?
(a) – 5.3 (b) – 5.1 (c) – 4.6 (d) – 4.8

64. A solution containing 1.8 g of a compound (empirical formula CH_2O) in 40 g of water is observed to freeze at –0.465°C. The molecular formula of the compound is (K_f of water $= 1.86 \text{ kg K mol}^{-1}$) :
(a) $C_2H_4O_2$ (b) C_3H_6 (c) $C_4H_8O_4$ (d) $C_6H_{12}O_6$

65. Freezing point of the following equilibrium, liquid solvent $\rightleftharpoons$ solid solvent is :
(a) $\dfrac{\Delta H - \Delta G}{T\Delta S}$ (b) $\dfrac{\Delta H}{\Delta S}$ (c) $\dfrac{\Delta G}{\Delta S}$ (d) $\dfrac{\Delta S}{\Delta H}$

66. Freezing point of a solution is smaller than that point of a solvent. It is due to :
(a) ΔH of solution and solvent is almost identical since intermolecular forces between solvent molecules are involved
(b) ΔS of solution (between solution and solid) is larger than that of the ΔS of solvent (between solvent and solid)
(c) ΔS of the solution is smaller than that of the solvent
(d) ΔH of the solution is much higher than of solvent but ΔS of solution is smaller than that of the solvent

67. When 36.0 g of a solute having the empirical formula CH_2O is dissolved in 1.20 kg of water, the solution freezes at –0.93°C. What is the molecular formula of the solute? ($K_f = 1.86$°C kg mol^{-1})
(a) C_2H_4O (b) $C_2H_2O_2$ (c) $C_2H_4O_3$ (d) $C_2H_4O_2$

68. Calculate the molecular weight of a substance whose 7.0% by mass solution in water freezes at –0.93°C. The cryoscopic constant of water is 1.86°C kg mol^{-1}:
(a) 140 g mol^{-1} (b) 150.5 mol^{-1}
(c) 160 g mol^{-1} (d) 155 g mol^{-1}

69. Camphor is often used in molecular mass determination because
(a) it is readily available (b) it has a very high cryoscopic constant
(c) it is volatile (d) it is solvent for organic substances

70. For 1 molal solution of each compound minimum freezing point will be assuming complete ionisation in each case:
(a) $[Fe(H_2O)_6]Cl_3$ (b) $[Fe(H_2O)_5Cl]Cl_2 \cdot H_2O$
(c) $[Fe(H_2O)_4Cl_2]Cl \cdot 2H_2O$ (d) $[Fe(H_2O)_3Cl_3] \cdot 3H_2O$

71. For 1 molal solution of each compound maximum freezing point will be assuming complete ionisation in each case:
(a) $[Fe(H_2O)_6]Cl_3$ (b) $[Fe(H_2O)_5Cl]Cl_2 \cdot H_2O$
(c) $[Fe(H_2O)_4Cl_2]Cl \cdot 2H_2O$ (d) $[Fe(H_2O)_3Cl_3] \cdot 3H_2O$

72. $PtCl_4 \cdot 6H_2O$ can exist as a hydrated complex. Its 1 molal aq. solution has depression in freezing point of 3.72. Assume 100% ionisation and $K_f(H_2O) = 1.86°C\ mol^{-1}$ kg, then complex is :
(a) $[Pt(H_2O)_6]Cl_4$ (b) $[Pt(H_2O)_4Cl_2]Cl_2 \cdot 2H_2O$
(c) $[Pt(H_2O)_3Cl_3]Cl \cdot 3H_2O$ (d) $[Pt(H_2O)_2Cl_4] \cdot 4H_2O$

73. A complex is represented as $CoCl_3xNH_3$. Its 0.1 molal solution in water shows $\Delta T_f = 0.558$ K. K_f for H_2O is 1.86 K $molality^{-1}$. Assuming 100% ionisation of complex and co-ordination number of Co is six, calculate formula of complex:
(a) $[Co(NH_3)_6]Cl_3$ (b) $[Co(NH_3)_5Cl]Cl_2$
(c) $[Co(NH_3)_4Cl_2]Cl$ (d) none of these

74. The freezing point of equimolal aqueous solutions will be highest for:
(a) $C_6H_5NH_3Cl$ (b) $Ca(NO_3)_2$ (c) $La(NO_3)_2$ (d) $C_6H_{12}O_6$

75. The freezing point of a 4% aqueous solution of '*A*' is equal to the freezing point of 10% aqueous solution of '*B*'. If the molecular weight of '*A*' is 60, then the molecular weight of '*B*' will be:
(a) 160 (b) 90 (c) 45 (d) 180

76. Depression in freezing point of 0.01 molal aqueous HCOOH solution is 0.02046. 1 molal aqueous urea solution freezes at –1.86°C, assuming molality equal to molarity, pH of HCOOH solution is:
(a) 2 (b) 3 (c) 4 (d) 5

77. When mercuric iodide is added to the aqueous solution of KI, then the:
(a) freezing point is raised (b) freezing point is lowered
(c) freezing point does not change (d) boiling point does not change

78. Dimer of acetic acid in liquid benzene is in equilibrium with acetic acid monomer at certain temperature and pressure. If 25% of the dimer molecules are separated out then
(a) Freezing point of the solution reduces (b) Average molar mass of solute increases
(c) Boiling point of solution increases (d) Molar mass of solute decreases

79. The temperature of a city was found to be –9.3°C. A car was used, whose radiator was filled with 5 L of water. What quantity of antifreezing agent ethylene glycol were added to water of radiator in order to use the car for travelling? (K_f of water 1.86 K kg mol^{-1})

(a) 3200 g (b) 1670 g (c) 1550 g (d) 2100 g

80. The cryoscopic constant of water is 1.86 K kg mol^{-1}. A 0.01 molal acetic acid solution produces a depression of 0.0194°C in the freezing point. The degree of dissociation of acetic acid is:

(a) zero (b) 0.043 (c) 0.43 (d) 1

81. If 1m solution of benzoic acid in benzene has a freezing point depression of 2.4°C. ($K_f = 5.12$°C mol^{-1} kg) and boiling point elevation of 2.53°C ($K_b = 2.53$°C mol^{-1} kg), then select the correct statement/s :

Statement I : there is dimer formation when undergoing freezing

Statement II : there is no change when undergoing boiling

Statement III : reverse of I and II

Statement IV : dimer formation in freezing and boiling state

(a) I, II (b) II, III (c) III, I (d) only I

82. In a 0.5 molal solution KCl, KCl is 50% dissociated. The freezing point of solution will be ($K_f = 1.86$ K kg mol^{-1}):

(a) 274.674 K (b) 271.60 K (c) 273 K (d) none of these

83. A 1.0 g sample of $Co(NH_2CH_2CH_2NH_2)_3Cl_3$ is dissolved in 25.0 g of water and the freezing point of the solution is –0.87°C. How many ions are produced per mole of compound? The K_f of water is 1.86°C/molal

(a) 2 (b) 3 (c) 4 (d) 5

84. An aqueous solution contains 3% and 1.8% by wt. urea and glucose respectively. What is the freezing point of solution? ($K_f = 1.86$°C/m)

(a) –1.172°C (b) –2.27°C (c) –1.5°C (d) none of these

85. Phenol associates in benzene to a certain extent in dimerisation reaction. A solution containing 0.02 kg of phenol in 1.0 kg of benzene has its freezing point depressed 0.69 K. Hence, degree of association of phenol dimerized will be :

[$K_f(C_6H_6) = 5.12$ K kg mol^{-1}]

(a) 0.63 (b) 0.73 (c) 0.83 (d) 0.93

86. Assuming complete ionisation, the solution having maximum freezing point will be:

(a) 1 *M* CaF_2 (b) 1.5 *M* $Al_2(SO_4)_3$ (c) 2 *M* NaCl (d) 1 *M* $AgNO_3$

87. In a 0.2 molal aqueous solution of a weak acid *HX* the degree of ionisation is 0.25. The freezing point of the solution will be nearest to: ($K_f = 1.86$ K kg mol^{-1})

(a) –0.26°C (b) 0.465°C (c) –0.48°C (d) –0.465°C

88. An aqueous solution of 0.01 *M* KCl causes the same elevation in boiling point as an aqueous solution of urea causes the depression in freezing point. The concentration of urea solution is:

(a) 0.01 *M* (b) 0.005 *M* (c) 0.02 *M* (d) 0.04*M*

89. When some NaCl was dissolved in water, the freezing point depression was numerically equal to twice the molal depression constant. The relative lowering of vapour pressure of the solution is :

(a) 0.117 (b) 0.034 (c) 0.0585 (d) none of these

90. Which one of the following statements is false ?

(a) The correct order of osmotic pressure for 0.01 *M* aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH >$ sucrose

(b) Isotonic solutions are those solutions which have the same osmotic pressure

(c) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction in liquid state

(d) Two sucrose solutions of same molality prepared in different solvents will have the same freezing point depression

91. 0.1 molal aqueous solution of an electrolyte AB_3 is 90% ionised. The boiling point of the solution at 1 atm is : $(K_{b(H_2O)} = 0.52 \text{ K kg mol}^{-1})$

(a) 273.19 K (b) 374.92 K (c) 376.4 K (d) 373.19 K

92. Which of the following aqueous solutions has osmotic pressure nearest to pure solvent?

(a) Na_2SO_4 (b) $BaCl_2$ (c) $Al_2(SO_4)_3$ (d) $C_{12}H_{22}O_{11}$

93. 0.1*M* NaCl and 0.05*M* $BaCl_2$ solutions are separated by a semi-permeable membrane in a container. For this system, choose the correct answer :

(a) There is no movement of any solution across the membrane

(b) Water flows from $BaCl_2$ solution towards NaCl solution

(c) Water flows from NaCl solution towards $BaCl_2$ solution

(d) Osmotic pressure of 0.1*M* NaCl is lower than the osmotic pressure of $BaCl_2$ (assume complete dissociation)

94. Two aqueous solutions, *A* and *B*, are separated by a semi-permeable membrane. The osmotic pressure of solution *A* immediately begins to decrease. Which of the following statement is true ?

(a) The solvent molecules are moving from the solution of higher osmotic pressure to that of lower osmotic pressure.

(b) The initial osmotic pressure of solution *B* is greater than that of solution *A*.

(c) Solvent molecules are moving from solution *B* into solution *A*.

(d) Both (a) and (b) are true statements.

95. Which one of the following pairs of solution can we expect to be isotonic at the same temperature?

(a) 0.1 *M* urea and 0.1 *M* NaCl (b) 0.1 *M* urea and 0.2 *M* $MgCl_2$

(c) 0.1 *M* NaCl and 0.1 *M* Na_2SO_4 (d) 0.1 *M* $Ca(NO_3)_2$ and 0.1 *M* Na_2SO_4

96. The empirical formula of a non-electrolyte is CH_2O. A solution containing 3 g L^{-1} of the compound exerts the same osmotic pressure as that of 0.05*M* glucose solution. The molecular formula of the compound is :

(a) CH_2O (b) $C_2H_4O_2$ (c) $C_4H_8O_4$ (d) $C_3H_6O_3$

97. A semipermeable membrane used in the measurement of osmotic pressure of a solution allows the passage of:

(a) solute molecules through it (b) solvent molecules through it

(c) both solvent and solute molecules (d) either solvent or solute

98. In the case of osmosis, solvent molecules move from :

(a) Higher vapour pressure to lower vapour pressure

(b) Higher concentration to lower concentration

(c) Lower vapour pressure to higher vapour pressure
(d) Higher osmotic pressure to lower osmotic pressure

99. The osmotic pressures of equimolar solutions of urea, $BaCl_2$ and $AlCl_3$ will be in the order :

(a) $AlCl_3 > BaCl_2 >$ urea
(b) $BaCl_2 > AlCl_3 >$ urea
(c) urea $> BaCl_2 > AlCl_3$
(d) $BaCl_2 >$ urea $> AlCl_3$

100. Which of the following solutions will have maximum osmotic pressure? Assume 90% dissociation of each salt:

(a) decinormal aluminium sulphate
(b) decinormal barium chloride solution
(c) decinormal sodium sulphate solution
(d) solution of equal volumes of decinormal barium chloride and decinormal sodium sulphate solutions

101. Consider 0.1 *M* solutions of two solutes *X* and *Y*. The solute *X* behaves as a univalent electrolyte while the solute *Y* dimerises in solution. Which of the following statements are correct regarding these solutions?

(1) The boiling point of the solution of *X* will be higher than that of *Y*
(2) The osmotic pressure of the solution of *Y* will be lower than that of *X*
(3) The freezing point of the solution of *X* will be lower than that of *Y*
(4) The relative lowering of vapour pressure of both the solutions will be the same

Select the correct answer from the option given below :

(a) 1, 2 and 3
(b) 2, 3 and 4
(c) 1, 2 and 4
(d) 1, 3 and 4

102. If M_{normal} is the normal molecular mass and α is the degree of ionization of $K_3[Fe(CN)_6]$, then the abnormal molecular mass of the complex in the solution will be:

(a) $M_{\text{normal}}\ (1+2\alpha)^{-1}$
(b) $M_{\text{normal}}\ (1+3\alpha)^{-1}$
(c) $M_{\text{normal}}\ (1+\alpha)^{-1}$
(d) equal to M_{normal}

103. Equal volumes of 0.1 *M* urea and 0.1 *M* glucose are mixed. The mixture will have:

(a) lower osmotic pressure
(b) same osmotic pressure
(c) higher osmotic pressure
(d) none of these

104. A 5% (w/V) solution of cane sugar (molecular weight = 342) is isotonic with 1% (w/V) solution of a substance *X*. The molecular weight of *X* is:

(a) 34.2
(b) 171.2
(c) 68.4
(d) 136.8

105. Insulin is dissolved in a suitable solvent and the osmotic pressure (π) of solutions of various concentrations (g/cm^3) C is measured at 20°C. The slope of a plot of π against C is found to be 4.65×10^{-3}. The molecular weight of the insulin (g/mol) is:

(a) 3×10^5
(b) 9×10^5
(c) 4.5×10^5
(d) 5.16×10^6

106. An aqueous solution of sucrose ($C_{12}H_{22}O_{11}$) having a concentration of 34.2 gram/litre has an osmotic pressure of 2.38 atmospheres at 17°C. For an aqueous solution of glucose ($C_6H_{12}O_6$) to be isotonic with this solution, its concentration should be :

(a) 34.2 gram per litre
(b) 17.1 gram per litre
(c) 18.0 gram per litre
(d) 36.0 gram per litre

107. Which of the following experimental methods is adopted to determine osmotic pressure?
(a) Berkley-Hartely's method (b) Beckmann's method
(c) Landsberger's method (d) Differential method

108. Based upon the technique of reverse osmosis the approximate pressure required to desalinate sea water containing 2.5% (mass/volume) KNO_3 at 27°C will be
(a) 10.5 atm (b) 21 atm (c) 12.2 atm (d) 6.09 atm

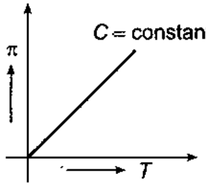
109. A 1% (wt/vol) KCl solution is ionised to the extent of 80%. The osmotic pressure at 27°C of the solution will be:
(a) 6.95 atm (b) 5.94 atm
(c) 2.71 atm (d) 3.30 atm

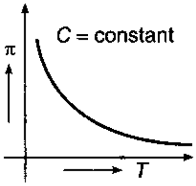
110. Osmotic pressure of blood is 7.40 atm, at 27°C. Number of moles of glucose to be used per litre for an intravenous injection that is to have same osmotic pressure of blood is:
(a) 0.3 (b) 0.2 (c) 0.1 (d) 0.4

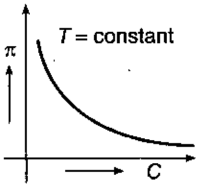
111. The relationship between osmotic pressures (π_1, π_2 and π_3) at a definite temperature when 1 g glucose, 1 g urea and 1 g sucrose are dissolved in 1 litre of water is (assume $i = 1$ for all):
(a) $\pi_1 > \pi_2 > \pi_3$ (b) $\pi_3 > \pi_1 > \pi_2$
(c) $\pi_2 > \pi_1 > \pi_3$ (d) $\pi_2 > \pi_3 > \pi_1$

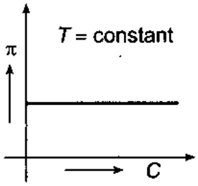
112. van't Hoff proved that osmotic pressure (π) is a colligative property. For an ideal solution, osmotic pressure (π) is helpful to determine that molecular mass of solute using $M_B = \dfrac{W_B RT}{\pi \cdot V}$

Law can be show by the curve (C = concentration):

(a)


(b)


(c)


(d)


113. A solution containing 4.0 g of PVC in 2 litre of dioxane (industrial solvent) was found to have an osmotic pressure 3.0×10^{-4} atm at 27°C. The molar mass of the polymer (g/mol) will be :
(a) 1.6×10^4 (b) 1.6×10^5 (c) 1.6×10^3 (d) 1.6×10^2

114. The osmotic pressures of 0.010 M solutions of KI and of sucrose ($C_{12}H_{22}O_{11}$) are 0.432 atm and 0.24 atm respectively. The van't Hoff factor for KI is :
(a) 1.80 (b) 0.80 (c) 1.2 (d) 1.0

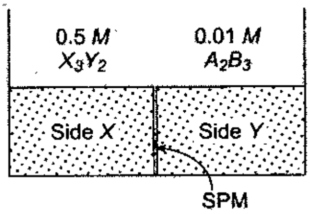
115. What is the correct sequence of osmotic pressure of 0.01 M *aq.* solution of :
(1) $Al_2(SO_4)_3$ (2) Na_3PO_4
(3) $BaCl_2$ (4) Glucose
(a) $\pi_4 > \pi_2 > \pi_3 > \pi_1$ (b) $\pi_3 > \pi_4 > \pi_2 > \pi_1$
(c) $\pi_3 > \pi_4 > \pi_1 > \pi_2$ (d) $\pi_1 > \pi_2 > \pi_3 > \pi_4$

116. 1.0 molar solution of the complex salt, $CrCl_3 \cdot 6H_2O$, displays an osmotic pressure of $3RT$. 0.5 L of the same solution on treatment with excess of $AgNO_3$ solution will yield (assume $\alpha = 1$) :
(a) 0.5 mole of AgCl (b) 1.0 mole of AgCl (c) 1.5 mole of AgCl (d) 3.0 mole of AgCl

117. A 0.010 g sample of $Cr(NH_3)_4(SO_4)Cl$ is dissolved in 25.0 mL of water and the osmotic pressure of the solution is 59.1 torr at 25°C. How many moles of ions are produced per mole of compound?
(a) 1 (b) 4 (c) 2 (d) 3

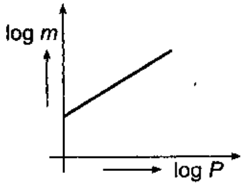
118. Which of the following aqueous solutions should have the highest osmotic pressure?
(a) 0.011 M $AlCl_3$ at 50°C (b) 0.03 M NaCl at 25°C
(c) 0.012 M $(NH_4)_2SO_4$ at 25°C (d) 0.03 M NaCl at 50°C

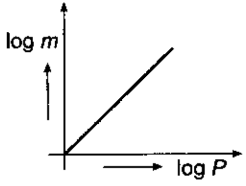
119. $X_3Y_2 (i = 5)$ when reacted with $A_2B_3 (i = 5)$ in aqueous solution gives brown colour. These are separated by a semipermeable membrane AB as shown. Due to osmosis there is:

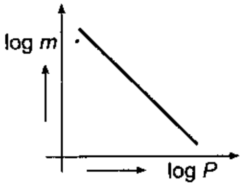


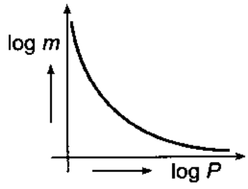
(a) brown colour formation in side X (b) brown colour formation in side Y
(c) formation in both of the sides X and Y (d) no brown colour formation

120. Which of the following curves represents the Henry's law?

(a)


(b)


(c)


(d)


121. According to Henry's law, the solubility of a gas in a given volume of liquid increases with increase in:
(a) Temperature (b) Pressure
(c) Both (a) and (b) (d) None of these

122. At 300 K, 40 mL of $O_3(g)$ dissolves in 100 g of water at 1.0 atm. What mass of ozone dissolved in 400 g of water at a pressure of 4.0 atm at 300 K?
(a) 0.1 g (b) 1.2 g
(c) 0.48 g (d) 4.8 g

123. 1 kg of water under a nitrogen pressure of 1 atmosphere dissolves 0.02 gm of nitrogen at 293 K. Calculate Henry's law constant :

(a) 7.7×10^4 atm (b) 7.7×10^3 atm

(c) 2×10^{-5} atm (d) 2×10^{-2} atm

124. According to Henry's law, the partial pressure of gas (P_g) is directly proportional to mole fraction of gas in liquid solution, $P_{gas} = K_H . X_{gas}$, where K_H is Henry's constant. Which is incorrect ?

(a) K_H is characteristic constant for a given gas-solvent system

(b) Higher is the value of K_H, lower is solubility of gas for a given partial pressure of gas

(c) K_H has temperature dependence

(d) K_H decreases with increase of temperature

125. At 760 torr pressure and 20°C temperature, 1 L of water dissolves 0.04 gm of pure oxygen or 0.02 gm of pure nitrogen. Assuming that dry air is composed of 20% oxygen and 80% nitrogen (by volume). The masses (in g/L) of oxygen and nitrogen dissolved by 1 L of water at 20°C exposed to air at a total pressure of 760 torr are respectively :

(a) 0.008, 0.016 (b) 0.016, 0.008

(c) 0.16, 0.08 (d) 0.04, 0.02

Level 2

1. Two beaker A and B present in a closed vessel. Beaker A contains 152.4 g aqueous solution of urea, containing 12 g of urea. Beaker B contains 196.2 g glucose solution, containing 18 g of glucose. Both solutions allowed to attain the equilibrium. Determine wt. % of glucose in it's solution at equilibrium :

(a) 6.71 (b) 14.49 (c) 16.94 (d) 20

2. Two components A and B form an ideal solution. The mole fractions of A and B in ideal solution are X_A and X_B, while that of in vapour phase, these components have their mole fractions as Y_A and Y_B. Then, the slope and intercept of plot of $\frac{1}{Y_A}$ vs. $\frac{1}{X_A}$ will be :

(a) $\frac{P_A^\circ}{P_B^\circ}, \frac{P_B^\circ - P_A^\circ}{P_B^\circ}$ (b) $\frac{P_B^\circ}{P_A^\circ}, \frac{P_A^\circ - P_B^\circ}{P_A^\circ}$ (c) $\frac{P_B^\circ}{P_A^\circ}, \frac{P_B^\circ}{P_B^\circ - P_A^\circ}$ (d) $P_A^\circ - P_B^\circ, \frac{P_A^\circ}{P_B^\circ}$

3. At 48°C, the vapour pressure of pure CS_2 is 850 torr. A solution of 2.0 g of sulphur in 100 g of CS_2 has a vapour pressure 844.9 torr. Determine the atomicity of sulphur molecule:

(a) 1 (b) 2 (c) 4 (d) 8

4. An ideal solution contains two volatile liquids A ($P^\circ = 100$ torr) and B ($P^\circ = 200$ torr). If mixture contain 1 mole of A and 4 mole of B then total vapour pressure of the distillate is:

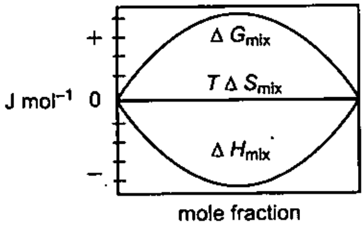
(a) 150 (b) 180 (c) 188.88 (d) 198.88

5. The vapour pressure of two pure liquids A and B, that form an ideal solution are 100 and 900 torr respectively at temperature T. This liquid solution of A and B is composed of 1 mole of A and 1 mole of B. What will be the pressure, when 1 mole of mixture has been vaporized?

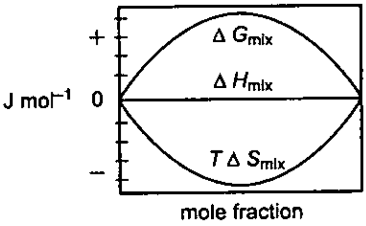
(a) 800 torr (b) 500 torr (c) 300 torr (d) None of these

6. Which of the following represents correctly the changes in thermodynamic properties during the formation of 1 mole of an ideal binary solution :

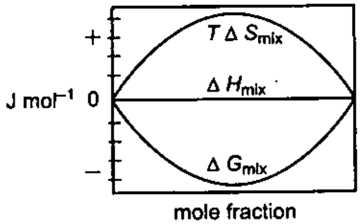
(a)



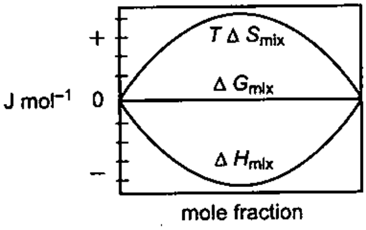
(b)



(c)



(d)



7. A saturated solution of XCl_3 has a vapour pressure 17.20 mm Hg at 20°C, while pure water vapour pressure is 17.25 mm Hg. Solubility product (K_{sp}) of XCl_3 at 20°C is:
(a) 9.8×10^{-2} (b) 10^{-5} (c) 2.56×10^{-6} (d) 7×10^{-5}

8. A certain non-volatile electrolyte contains 40% carbon, 6.7% hydrogen and 53.3% oxygen. An aqueous solution containing 5% by mass of the solute boils at 100.15°C. Determine the molecular formula of the compound ($K_b = 0.51°C/m$):
(a) HCHO (b) CH_3OH (c) C_2H_5OH (d) $C_6H_{12}O_6$

9. A 0.10 *M* solution of a monoprotic acid ($d = 1.01 \text{ g/cm}^3$) is 5% ionized. What is the freezing point of the solution? The mol. wt. of the acid is 300 and $K_f(H_2O) = 1.86°C/m$:
(a) –0.189°C (b) –0.194°C (c) –0.199°C (d) None of these

10. An aqueous solution boils at 101°C. What is the freezing point of the same solution? (Given : $K_f = 1.86°C/m$ and $K_b = 0.51°C/m$)
(a) 3.647°C (b) –3.647°C (c) –0.364°C (d) None of these

11. An industrial waste water is found to contain 8.2% Na_3PO_4 and 12% $MgSO_4$ by weight in solution. If % ionisation of Na_3PO_4 and $MgSO_4$ are 50 and 60 respectively then it's normal boiling point is [$K_b(H_2O) = 0.50 \text{ K kg mol}^{-1}$] :
(a) 102.3°C (b) 103.35°C (c) 101.785°C (d) None of these

12. Ratio of $\frac{\Delta T_b}{K_b}$ of 10 g AB_2 and 14 g A_2B per 100 g of solvent in their respective, solution (AB_2 and A_2B both are non-electrolytes) is 1 mol/kg in both cases. Hence, atomic wt. of *A* and *B* are respectively :
(a) 100, 40 (b) 60, 20 (c) 20, 60 (d) None of these

13. The freezing point of a solution containing 0.2 g of acetic acid in 20.0 g benzene is lowered by 0.45°C. Calculate the degree of dimerization of acetic acid in benzene. K_f for benzene is 5.12 K mol^{-1} kg :
(a) 0.527 (b) 0.80 (c) 0.945 (d) None of these

14. If boiling point of an aqueous solution is 100.1°C, what is its freezing point? Given, enthalpy of fusion and vaporisation of water are 80 cal g^{-1} and 540 cal g^{-1} respectively:
(a) 0.361°C (b) –0.361°C (c) –3.61°C (d) None of these

15. 100 g of $C_6H_{12}O_6$ (*aq.*) solution has vapour pressure is equal to 40 torr at certain temperature. Vapour pressure of $H_2O(l)$ is 40.8 torr at same temperature. If this solution is cooled to –0.93°C, what mass of ice will be separated out? ($K_f = 1.86 \text{ kg mol}^{-1}$)
(a) 95.5 g (b) 4.5 g (c) 45.5 g (d) 47.8 g

16. 1.0 g of a monobasic acid *HA* in 100 g water lowers the freezing point by 0.155 K. If 0.75 g, of same acid requires 15 mL of *N*/5 NaOH solution for complete neutralisation then %, degree of ionization of acid is (K_f of $H_2O = 1.86 \text{ K kg mol}^{-1}$) :
(a) 20% (b) 25% (c) 40% (d) 50%

17. 0.1 *M* KI and 0.2 *M* $AgNO_3$ are mixed in 3 : 1 volume ratio. The depression of freezing point of the resulting solution will be [$K_f(H_2O) = 1.86 \text{ K kg mol}^{-1}$] :
(a) 3.72 K (b) 1.86 K (c) 0.93 K (d) 0.279 K

18. If 0.1 M $H_2SO_4(aq.)$ solution shows freezing point $-0.3906°C$ then what is the K_{a_2} for H_2SO_4? (Assume $m = M$ and $K_{f(H_2O)} = 1.86$ K kg mol^{-1})

(a) 0.122 (b) 0.0122 (c) 1.11×10^{-3} (d) None of these

19. A living cell contains a solution which is isotonic with 0.2 M glucose solution. What osmotic pressure develops when the cell is placed in 0.05 M $BaCl_2$ solution at 300 K?

(a) 1.23 atm (b) 3.69 atm (c) 6.15 atm (d) None of these

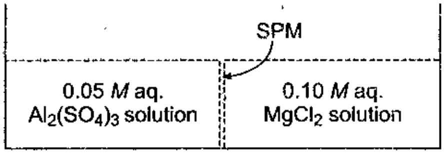
20. What is the osmotic pressure of 0.2 M HX $(aq.)$ solution at 300 K?
(Given : $K_{a(HX)} = 8 \times 10^{-5}$)

(a) 4.926 atm (b) 0.5024 atm (c) 5.024 atm (d) None of these

21. A solution contain 8 g of a carbohydrate in 100 g of water has a density 1.025 g/mL and an osmotic pressure of 5 atm at 27°C. What is the molar mass of the carbohydrate?

(a) 387 (b) 374 (c) 3740 (d) None of these

22. Study the following figure and choose the correct options. Assuming complete dissociation of electrolyte:



(a) There will be no net moment of any substance across the membrane
(b) $MgCl_2$ will flow towards the $Al_2(SO_4)_3$ solution
(c) $Al_2(SO_4)_3$ will flow towards the $MgCl_2$ solution
(d) The π (osmotic pressure) of 0.1 M $MgCl_2$ is higher than the π of 0.05 M $Al_2(SO_4)_3$

23. The total vapour pressure of a 4 mole % solution of NH_3 in water at 293 K is 50.0 torr, the vapour pressure of pure water is 17.0 torr at this temperature. Applying Henry's and Raoult's laws, calculate the total vapour pressure for a 5 mole % solution:

(a) 58.25 torr (b) 33 torr (c) 42.1 torr (d) 52.25 torr

24.-25. The vapour pressure of two pure liquids A and B which form an ideal solution are 500 and 800 torr respectively at 300 K. A liquid solution of A and B for which the mole fraction of A is 0.60 is contained in a cylinder closed by a piston on which the pressure can be varied. The solution is slowly vaporized at 300 K by decreasing the applied pressure.

24. The composition of vapour when first bubble formed is:

(a) $y_A = 0.6; y_B = 0.4$ (b) $y_A = 0.48; y_B = 0.52$
(c) $y_A = 0.52; y_B = 0.48$ (d) $y_A = 0.5; y_B = 0.5$

25. What is the composition of last droplet of liquid remaining in equilibrium with vapour?

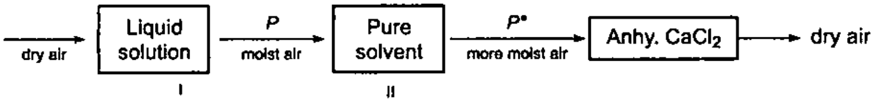
(a) $x_A = 0.6; x_B = 0.4$ (b) $x_A = 0.5; x_B = 0.5$
(c) $x_A = 0.7; x_B = 0.3$ (d) $x_A = 0.3; x_B = 0.7$

Level 3

PASSAGE 1

Lowering of vapour pressure is determined by Ostwald and Walker dynamic method. It is based on the principle, when air is allowed to pass through a solvent or solution, it takes up solvent vapour with it to get itself saturated at that temperature

I and II are weighted separately before and after passing dry air. Loss in mass of each set, gives the lowering of vapour pressure. The temperature of air, the solution and the solvent is kept constant.



1. Loss in mass of solvent (w_{II}) will be proportional to:

(a) $P^\circ - P$ (b) $P - P^\circ$ (c) $\frac{P}{P^\circ}$ (d) $P \times P^\circ$

2. Gain in mass of anhydrous $CaCl_2$ is proportional to:

(a) P (b) P° (c) $P - P^\circ$ (d) $P^\circ - P$

3. $\frac{P^\circ - P}{P^\circ}$ is equal to:

(a) $\frac{w_I}{w_I + w_{II}}$ (b) $\frac{w_{II}}{w_I + w_{II}}$ (c) $\frac{w_I}{w_I - w_{II}}$ (d) $\frac{w_{II}}{w_I}$

4. Dry air was passed through 9.24 g of solute in 108 g of water and then through pure water. The loss in weight of solution was 3.2 g and that of pure water was 0.08 g. The molecular weight (g/mol) of solute is nearly :

(a) 50 (b) 62 (c) 70 (d) 80

PASSAGE 2

A dilute solution contains 'x' moles of solute A in 1 kg of solvent with molal elevation constant K_b. The solute dimerises in the solution according to the following equation. The degree of association is (α) is:

$$2A \rightleftharpoons A_2$$

1. The van't Hoff factor will be:

(a) $i = 1 - 2\alpha$ (b) $i = 1 - \frac{\alpha}{2}$ (c) $i = 1 + \frac{\alpha}{2}$ (d) $i = 1 + \alpha$

2. The molecular weight observed will be:

(a) greater than actual molecular weight (b) lesser than actual molecular weight
(c) equal to the actual molecular weight (d) cannot be predicted by the data given

3. The degree of association is equal to:

(a) $\alpha = \frac{(K_b x - \Delta T_b)}{\Delta T_b . 2}$ (b) $\alpha = \frac{2(K_b x - \Delta T_b)}{K_b x}$ (c) $\alpha = 2 + \frac{2\,\Delta T_b}{K_b x}$ (d) $\alpha = \frac{\Delta T_b}{2K_b x}$

ONE OR MORE ANSWERS IS/ARE CORRECT

1. Which of the following statement(s) is/are correct, if intermolecular forces in liquids *A*, *B* and *C* are in the order of $A < B < C$?

(a) *B* evaporates more readily than *A*
(b) *B* evaporates more readily than *C*
(c) *A* evaporates more readily than *C*
(d) all evaporate at same rate at constant temperature.

2. When non-volatile solute is added to a pure solvent, the:

(a) vapour pressure of the solution becomes lower than the vapour pressure of the pure solvent
(b) rate of evaporation of solvent is reduced
(c) solute does not affect the rate of condensation
(d) none of these

3. The total vapour pressure of a binary solution is given by

$$P = (100\,X_A + 260\,X_B)\text{ mm Hg}$$

where, X_A and X_B are the mole fractions of components *A* and *B*. This indicates that the:

(a) vapour pressure of solution is less than the pure *B* component
(b) vapour pressure of solution is more than that of pure *A* component
(c) vapour pressure of pure *A* is 100 mm Hg and that of pure *B* is 260 mm Hg
(d) the vapour pressure of pure *A* and *B* are 260 mm Hg and 100 mm Hg respectively

4. Which of the following is correct for an ideal solution?

(a) $\Delta H_{\text{mix}} = 0$ and $\Delta V_{\text{mix}} = 0$ (b) $\Delta V_{\text{mix}} = 0$ and $\Delta S_{\text{mix}} > 0$
(c) $\Delta H_{\text{mix}} > 0$ and $\Delta S_{\text{mix}} > 0$ (d) $\Delta G_{\text{mix}} = 0$ and $\Delta S_{\text{mix}} > 0$

5. For a non-ideal solution with a negative deviation:

(a) $\Delta H_{\text{mix}} = -\text{ve}$ (b) $\Delta V_{\text{mix}} = -\text{ve}$ (c) $\Delta S_{\text{mix}} = -\text{ve}$ (d) $\Delta G_{\text{mix}} = -\text{ve}$

6. A binary solution of liquids *A* and *B* will show positive deviation from Raoult's law if it fulfils the following condition:

(a) $P_A > X_A P_A^\circ$ and $P_B > X_B P_B^\circ$
(b) The intermolecular forces of $A - B < A - A, B - B$
(c) ΔH mixing is positive
(d) ΔV mixing is negative

7. Which of the following statements is/are correct about acetone and trichloromethane mixture?

(a) mixtures of acetone and trichloromethane shows positive deviation from Raoult's law
(b) the forces of attraction acting between molecules of acetone and trichloro-methane in a mixture are greater than those acting between the molecules in pure acetone
(c) pure acetone can be obtained by the careful fractional distillation of any mixture of acetone and trichloro-methane
(d) when acetone and trichloro-methane are mixed, the enthalpy change is negative

8. The azeotropic solutions of two miscible liquids:
(a) can be separated by simple distillation
(b) may show positive or negative deviation from Raoult's law
(c) are supersaturated solution
(d) behave like a single component and boil at a constant temperature

9. For exact determination of molecular mass through colligative properties measurement:
(a) solute must be volatile
(b) solution must be very dilute
(c) solution must be formed by similar nature of substances
(d) solute must not be dissociated or associated

10. For the depression of freezing point experiment. The correct statement(s) is/are:
(a) Vapour pressure of pure solvent is more than that of solution
(b) Vapour pressure of pure solvent is less than that of solution
(c) Only solute molecules solidify at the freezing point
(d) Only solvent molecules solidify at the freezing point

11. The cryoscopic constant value depends upon:
(a) The molar mass of the solute in the solution
(b) The molar mass of the solvent in the solution
(c) The enthalpy of vaporisation of the solvent
(d) The freezing point of the solvent

12. Consider 0.1 *M* solutions of two solutes *X* and *Y*. The solute *X* behaves as univalent electrolyte, while the solute *Y* dimerises in solution. Select correct statement(s) regarding these solutions:
(a) The boiling point of solution of '*X*' will be higher than that of '*Y*'
(b) The osmotic pressure of solution of '*Y*' will be lower than that of '*X*'
(c) The freezing point of solution of '*X*' will be lower than that of '*Y*'
(d) The relative lowering of vapour pressure of both the solution will be the same

13. Consider following solutions:
(I) I *M* glucose (aq) (II) 1 *M* sodium chloride (aq)
(III) 1 *M* acetic acid in benzene (IV) 1 *M* ammonium phosphate (aq)
(a) all are isotonic solutions (b) III is hypotonic of I, II, IV
(c) I, II, IV are hypertonic of III (d) IV is hypertonic of I, II, III

14. Which of the following statements is (are) incorrect?
(a) 0.1 *M* KCl solution will have the same osmotic pressure as 0.1 *M* glucose solution
(b) 0.1 *M* KCl solution will have the same boiling point as 0.1 *M* urea solution
(c) 0.1 *m* glucose and 0.1 *m* urea are isotonic
(d) 0.1 *m* $MgCl_2$ solution will have less relative lowering of vapour pressure than 0.1 *m* NaCl

15. Consider following solutions:
0.1 *m* $C_6H_5NH_3^+Cl^-$; 0.1 *m* KCl; 0.1 m Glucose; 0.1 *m* $Na_2C_2O_4 \cdot 10H_2O$
(a) the solution with highest boiling point is 0.1 *m* $Na_2C_2O_4 \cdot 10H_2O$
(b) the solution with highest freezing point is 0.1 *m* glucose
(c) 0.1 *m* $C_6H_5NH_3Cl$ and 0.1 *m* NaCl will have the same osmotic pressure
(d) 0.1 *m* glucose solution will have the lowest osmotic pressure

MATCH THE COLUMN

Column-I and **Column-II** contains four entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II.

1.

Column-I	**Column-II**
(A) *n*-hexane + *n*-heptane	(P) Can be separated by fractional distillation
(B) Acetone + chloroform	(Q) Maximum boiling azeotrope
(C) Chloro-benzene and bromo-benzene	(R) Cannot be separated by fractional distillation completely
(D) Ethanol + water	(S) Minimum boiling azeotrope

2.

Column-I	**Column-II**
(A) π_1 : 0.1 M glucose; π_2 : 0.1 M urea	(P) π_1 and π_2 are isotonic
(B) π_1 : 0.1 M NaCl; π_2 : 0.1 M Na_2SO_4	(Q) No net migration of solvent across the membrane
(C) π_1 : 0.1 M NaCl; π_2 : 0.1 M KCl	(R) π_1 is hypertonic to π_2
(D) π_1 : 0.1 M $CuSO_4$; π_2 : 0.1 M sucrose	(S) π_1 is hypotonic to π_2

3.

Column-I	**Column-II**
(A) 0.1 M $Al_2(SO_4)_3$	(P) Solution with highest boiling point
(B) 0.1 M $AlPO_4$	(Q) Van't Hoff factor is greater than 1
(C) 0.1 M urea	(R) Solution with lowest osmotic pressure
(D) 0.1 M $MgCl_2$	(S) Solution with lowest freezing point

4.

Column-I	**Column-II**
(Solute)	(Van't Hoff factor, i)
(A) $AlCl_3$ if $\alpha = 0.8$	(P) $i = 3.4$
(B) $BaCl_2$ if $\alpha = 0.9$	(Q) $i = 2.8$
(C) Na_3PO_4 if $\alpha = 0.9$	(R) $i = 3.8$
(D) $K_4[Fe(CN)_6]$ if $\alpha = 0.7$	(S) $i = 3.7$

5.

Column-I	**Column-II**
(A) Elevation of B.P.	(P) Colligative property
(B) Osmotic pressure	(Q) Ebullioscopic constant
(C) Relative lowering in V.P.	(R) Berkeley-Heartley
(D) Depression of F.P.	(S) Ostwald and Walker method

ASSERTION-REASON TYPE QUESTIONS

Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason).

Examine the statement carefully and mark the correct answer according to the instructions given below:

(A) If both the statements are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1

(B) If both the statements are TRUE but STATEMENT-2 is NOT the correct explanation of STATEMENT-1

(C) If STATEMENT-1 is TRUE and STATEMENT-2 is FALSE

(D) If STATEMENT-1 is FALSE and STATEMENT-2 is TRUE

1. **STATEMENT-1 :** An increase in surface area increases the rate of evaporation.
   STATEMENT-2 : Stronger the inter-molecular attraction forces, faster is the rate of evaporation at a given temperature.
2. **STATEMENT-1 :** An ideal solution obeys Raoult's law.
   STATEMENT-2 : In an ideal solution, solute-solute as well as solvent-solvent, interactions are similar to solute-solvent interactions.
3. **STATEMENT-1 :** If a liquid solute more volatile than the solvent is added to the solvent, the vapour pressure of the solution is greater than vapour pressure of pure solvent.
   STATEMENT-2 : Vapour pressure of solution is equal to vapour pressure of solvent.
4. **STATEMENT-1 :** ΔV_{mix} and ΔS_{mix} for an ideal solution is zero.
   STATEMENT-2 : $A...B$ interaction in an ideal solution are same as between $A...A$ and $B...B$.
5. **STATEMENT-1 :** Elevation in boiling point will be high if the molal elevation constant of the liquid is high.
   STATEMENT-2 : Elevation in boiling point is a colligative property.
6. **STATEMENT-1 :** The boiling point of 0.1 M urea solution is less than that of 0.1 M KCl solution.
   STATEMENT-2 : Elevation of boiling point is directly proportional to the number of moles of non-volatile solute particles present in the solution.
7. **STATEMENT-1 :** The observed molar mass of acetic acid in benzene is more than the normal molar mass of acetic acid.
   STATEMENT-2 : Molecules of acetic acid dimerise in benzene due to hydrogen bonding.
8. **STATEMENT-1 :** Addition of ethylene glycol to water lowers the freezing point of water, therefore, used as antifreeze substance.
   STATEMENT-2 : Ethylene glycol is soluble in water.
9. **STATEMENT-1 :** Osmotic pressure is a colligative property.
   STATEMENT-2 : Osmotic pressure developed in a column due to osmosis.
10. **STATEMENT-1 :** Osmosis involves movement of solvent molecules from its lower concentration to its higher concentration.
    STATEMENT-2 : Solutions having the same osmotic pressure are called isotonic solutions.

11. **STATEMENT-1 :** Isotonic solutions must have the same molar concentration.
    STATEMENT-2 : Solutions which have the same osmotic pressure are known as isotonic solution.
12. **STATEMENT-1 :** Isotonic solutions do not show phenomenon of osmosis.
    STATEMENT-2 : Isotonic solutions have same molar concentration at same temperature.
13. **STATEMENT-1 :** When dried fruits and vegetables are placed in water, they slowly get swelled.
    STATEMENT-2 : It happens due to the phenomenon of osmosis.
14. **STATEMENT-1 :** Reverse osmosis is used to purify sea water.
    STATEMENT-2 : Solvent molecules pass from concentrate solution to pure solvent through semipermeable membrane if high pressure is applied on solution side.
15. **STATEMENT-1 :** All solutes becomes more soluble in water at higher temperature.
    STATEMENT-2 : Solubility of solute depends upon temperature.
16. **STATEMENT-1 :** Henry's law is always applicable for gases.
    STATEMENT-2 : Raoult's law is a special case of Henry's law.
17. **STATEMENT-1 :** Increasing pressure on pure water decrease its freezing point.
    STATEMENT-2 : Density of water is maximum at 273 K.
18. **STATEMENT-1 :** The molecular weight of acetic acid determined by depression in freezing point method in benzene and water was found to be different.
    STATEMENT-2 : Water is polar and benzene is non-polar.
19. **STATEMENT-1 :** If red blood cells were removed from the body and placed in pure water, pressure inside the cell increases.
    STATEMENT-2 : The concentration of the salt content in the cells increases.
20. **STATEMENT-1 :** Azeotrope is a binary mixture formed by ideal solutions.
    STATEMENT-2 : Azeotrope boils with unchanged composition.

SUBJECTIVE PROBLEMS

1. The vapour pressure of two pure liquids A and B are 5 and 10 torr respectively. Calculate the total pressure of the solution (in torr) obtained by mixing 2 mole of A and 3 mole of B.
2. The vapour pressure of two pure liquids A and B are 50 and 40 torr respectively. If 8 moles of A is mixed with x moles of B, then vapour pressure of solution obtained is 48 torr. What is the value of x.
3. The vapour pressure of a liquid solution containing A and B is 99 torr. Calculate mole % of B in vapour phase.
   (Given : $P_A^\circ = 100$ torr ; $P_B^\circ = 80$ torr)
4. If 30 g of a solute of molecular weight 154 is dissolved in 250 g of benzene. What will be the boiling point of the resulting solution ?
   (Given : $K_{b(C_6H_6)} = 2.6\,\text{K kg mol}^{-1}$)

5. Calculate elevation in boiling point for 2 molal aqueous solution of glucose.
(Given : $K_{b(H_2O)} = 0.5\text{K kg mol}^{-1}$)

6. Calculate depression of freezing point for 0.56 molal aq. solution of KCl.
(Given : $K_{f(H_2O)} = 1.8\text{K kg mol}^{-1}$).

7. What is the maximum value of van't Hoff factor for $AlCl_3$?

8. A solution containing 500 g of a protein per litre is isotonic with a solution containing 3.42g sucrose per litre. The molecular mass of protein in 5×10^x, hence x is.

9. An aqueous solution of urea has a freezing point of −0.515°C. Predict the osmotic pressure (in atm) of the same solution at 37°C.
(Given : $K_{f(H_2O)} = 1.86\text{K kg mol}^{-1}$)

10. $0.2M$ aq. solution of KCl is isotonic with $0.2M$ K_2SO_4 at same temperature.
What is the van't Hoff factor of K_2SO_4 ?

ANSWERS

Level 1

1. (d)	2. (b)	3. (a)	4. (c)	5. (b)	6. (c)	7. (a)	8. (b)	9. (d)	10. (b)
11. (d)	12. (c)	13. (c)	14. (c)	15. (b)	16. (b)	17. (c)	18. (a)	19. (a)	20. (a)
21. (a)	22. (d)	23. (a)	24. (d)	25. (d)	26. (a)	27. (c)	28. (b)	29. (a)	30. (a)
31. (b)	32. (d)	33. (b)	34. (d)	35. (d)	36. (c)	37. (b)	38. (d)	39. (c)	40. (d)
41. (a)	42. (a)	43. (c)	44. (a)	45. (c)	46. (a)	47. (d)	48. (c)	49. (c)	50. (a)
51. (d)	52. (d)	53. (c)	54. (d)	55. (b)	56. (c)	57. (a)	58. (b)	59. (d)	60. (b)
61. (b)	62. (d)	63. (a)	64. (d)	65. (b)	66. (b)	67. (d)	68. (b)	69. (b)	70. (a)
71. (d)	72. (c)	73. (b)	74. (d)	75. (a)	76. (b)	77. (a)	78. (b)	79. (c)	80. (b)
81. (a)	82. (b)	83. (c)	84. (a)	85. (b)	86. (d)	87. (d)	88. (c)	89. (a)	90. (d)
91. (d)	92. (d)	93. (b)	94. (c)	95. (d)	96. (b)	97. (b)	98. (a)	99. (a)	100. (a)
101. (a)	102. (b)	103. (b)	104. (c)	105. (d)	106. (c)	107. (a)	108. (c)	109. (b)	110. (a)
111. (c)	112. (a)	113. (b)	114. (a)	115. (d)	116. (b)	117. (c)	118. (d)	119. (d)	120. (a)
121. (b)	122. (d)	123. (a)	124. (d)	125. (a)					

Level 2

1. (b)	2. (b)	3. (d)	4. (c)	5. (c)	6. (c)	7. (d)	8. (d)	9. (c)	10. (b)
11. (c)	12. (b)	13. (c)	14. (b)	15. (d)	16. (b)	17. (d)	18. (b)	19. (a)	20. (c)
21. (b)	22. (d)	23. (a)	24. (b)	25. (c)					

Level 3

Passage–1:	1. (a)	2. (b)	3. (b)	4. (b)
Passage–2:	1. (b)	2. (a)	3. (b)	

One or More Answers is/are Correct

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

9. (b,d) **10.** (a,d) **11.** (b,c,d) **12.** (a,b,c) **13.** (b,c,d) **14.** (a,b,d) **15.** (a,b,c,d)

Match the Column

1. A→ P; B→ Q, R; C→ P; D→ R, S
2. A→ P, Q; B→ S; C→ P, Q; D→ R
3. A→ P, Q, S; B→ Q; C→ R; D→ Q
4. A→ P; B→ Q; C→ S; D→ R
5. A→ P, Q; B→ P, R; C→ P, R; D→ P

Assertion-Reason Type Questions

1. (C) **2.** (A) **3.** (C) **4.** (D) **5.** (B) **6.** (A) **7.** (A) **8.** (B) **9.** (B) **10.** (B)

11. (D) **12.** (A) **13.** (A) **14.** (B) **15.** (D) **16.** (D) **17.** (C) **18.** (A) **19.** (C) **20.** (D)

Subjective Problems

1. (8 **2.** 2 **3.** 4 **4.** 2 **5.** 1 **6.** 2 **7.** 4 **8.** 4 **9.** 7 **10.** 2

Hints and Solutions

Level 1

2. (b) Given $P_1 = 19$ mm Hg, $P_2 = 760$ mm Hg;

$\Delta H_{\text{vap.}} = 40670$ J/mol

Applying Clausius-Clapeyron's equation

$$\log \frac{P_2}{P_1} = \frac{\Delta H_{\text{vap}}}{2.303 \times R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$$

$$\text{or} \ \log \frac{760}{19} = \frac{40670}{2.303 \times 8.3}\left(\frac{373 - T_1}{T_1 \times 373}\right)$$

on solving, we get $T_1 = 291.4$ K

3. (a) Initial wt. of $H_2O(l) = 18$ g;

$$n_{H_2O}(g) = \frac{\left(\frac{24.63}{760}\right) \times 7.6}{0.0821 \times 300} \Rightarrow 0.01$$

$$\% \text{ wt. of } H_2O \text{ vaporised} = \frac{0.01 \times 18}{18} \times 100$$

$$\Rightarrow \quad 1\%$$

9. (d) Solution X is unsaturated so v. pr. will be more, solution Y and Z are saturated so v. pr. of Y = v. pr. of Z and 2 gm of solute would be present in form of solid in system Z.

11. (d) $\frac{P^\circ - P}{P^\circ} = x_{\text{solute}}$ or $\frac{P^\circ - P}{P^\circ} = \frac{n}{n+N}$

$$\Rightarrow \quad \frac{0.1}{0.1 + 9.9} \Rightarrow 0.01; \ P = 0.99\,P^\circ$$

13. (c) Given $P_A = 750$ mm Hg

$\because$ 373 K is boiling point of water.

Thus, $P_A^\circ = 760$ mm Hg

$$m = \left(\frac{P^\circ - P}{P}\right) \times \frac{1000}{M_{\text{solvent}}}$$

$$\Rightarrow \quad \frac{10}{750} \times \frac{1000}{18} \Rightarrow 0.74$$

14. (c) Normal boiling point of water is 100°C, hence

$P^\circ(H_2O) = 760$ torr; $M(H_2O) = 18$ g/mol

$$m = \left(\frac{P^\circ - P}{P}\right) \times \frac{1000}{M_{H_2O}}$$

$$\Rightarrow \ P = 746.5; \quad \Delta P = 13.45 \text{ torr}$$

15. (b) $P_s = \left(\frac{80}{100}\right) P^\circ$, $w = ?$,

$M_{\text{solute}} = 40$, $w = 114$ g, $M_{\text{solvent}} = 114$

$$\because \quad \frac{P^\circ - P_s}{P_s} = \frac{w \times M_{\text{solvent}}}{M_{\text{solute}} \times W}$$

$$\text{or} \quad \frac{P^\circ - (80/100)\,P^\circ}{(80/100)\,P^\circ} = \frac{w \times 114}{40 \times 57};$$

$$\therefore \quad w = 5 \text{ g}$$

16. (b) $\frac{P^\circ - P}{P^\circ} = \frac{n}{n+N} \approx \frac{n}{N}$

(for very dilute solution)

$$2 \times \frac{n}{N_A} = \frac{n}{N_B}$$

$$\Rightarrow \quad M_B = 2M_A$$

17. (c) We know that

$$Y_A = \frac{P_A^\circ X_A}{P_{\text{total}}} \quad \text{or} \quad \frac{Y_A}{X_A} = \frac{P_A^\circ}{P_{\text{total}}}$$

$$\because \ P_A^\circ > P_{\text{total}} \ \text{ so } \ \frac{Y_A}{X_A} > 1 \ \text{ or } \ Y_A > X_A$$

18. (a) Moles of $A = \frac{20}{40} \Rightarrow 0.5$;

moles of $B = \frac{20}{80} \Rightarrow 0.25$

$$x_A = \frac{0.5}{0.5 + 0.25} = 0.67; \quad x_B = 0.33$$

$$P_{\text{total}} = P_A^\circ X_A + P_B^\circ X_B$$

$$\Rightarrow 100 \times 0.67 + 40 \times 0.33 \Rightarrow 80 \text{ torr}$$

19. (a) Since, $P = X_A P_A^\circ + X_B P_B^\circ$, we have

$$\left(\frac{1}{1+3}\right) P_A^\circ + \left(\frac{3}{1+3}\right) P_B^\circ = 550 \text{ mm Hg};$$

$$\left(\frac{1}{1+4}\right) P_A^\circ + \left(\frac{4}{1+4}\right) P_B^\circ = 560 \text{ mm Hg}$$

That is, $0.25\,P_A^\circ + 0.75\,P_B^\circ = 550$ mm Hg;

$0.20\,P_A^\circ + 0.8\,P_B^\circ = 560$ mm Hg

Solving for P_A° and P_B°, we get;

$P_A^\circ = 400$ mm Hg and $P_B^\circ = 600$ mm Hg

20. (a) $y_A = \frac{P_A}{P} \Rightarrow \frac{P_A^\circ x_A}{P}$ and $y_B = \frac{P_B^\circ x_B}{P}$;

$$\frac{y_A}{y_B} = \frac{P_A^\circ}{P_B^\circ} \times \frac{x_A}{x_B} \Rightarrow \frac{4}{3} = \frac{1}{3} \times \frac{x_A}{(1 - x_A)}$$

$$x_A = \frac{4}{5} \text{ or } x_B = \frac{1}{5}$$

21. (a) $x_A = \frac{1}{1+3} \Rightarrow \frac{1}{4}$; $x_B = \frac{3}{4}$;

$$\frac{y_A}{y_B} = \frac{P_A^\circ}{P_B^\circ} \times \frac{x_A}{x_B}$$

$$\frac{y_A}{(1 - y_A)} = \frac{1}{3} \times \frac{1}{3}$$

$$\Rightarrow \frac{1}{9} \text{ or } y_A = \frac{1}{10}$$

26. (a) Elevation in boiling point $\propto$ concentration of a solution. Thus, the order of concentration of solution is I < II < III.

34. (d) $P_{\text{ideal}} = P_A^\circ x_A + P_B^\circ x_B$;

$$= 100 \times \frac{1}{4} + 80 \times \frac{3}{4} \Rightarrow 85 \text{ mm Hg}$$

$P_{\text{actual}} = 90$ mm Hg;

$\because$ Actual v. pr. is greater than ideal solution v. pr. so +ve deviation from Raoult's law.

35. (d) From an azeotropic mixture the components cannot be separated at boiling point because it is a constant temperature boiling mixture.

39. (c) For two immiscible liquid;

$$P_A^\circ = P_{\text{total}} - P_{H_2O}^\circ = 748 - 648 \Rightarrow 100$$

$$\frac{W_A}{W_B} = \frac{P_A^\circ M_A}{P_B^\circ M_B}; \quad M_A = \frac{1.25}{1} \times \frac{648 \times 18}{100}$$

$$\Rightarrow 145.8$$

40. (d) $\frac{W_A}{W_B} = \frac{P_A^\circ}{P_B^\circ} \times \frac{M_A}{M_B} \Rightarrow \frac{0.7}{7} \times \frac{112.5}{18}$

$$\Rightarrow 0.625$$

$$\% \frac{W_A}{W_A + W_B} \times 100 = \frac{0.625}{1.625} \times 100$$

$$\Rightarrow 38.46$$

42. (a) $i = 1 + (n - 1)\alpha$ so $n = \frac{i + \alpha - 1}{\alpha}$

43. (c) $i = \frac{C(1 - \alpha) + \frac{C\alpha}{n}}{C} \Rightarrow i = 1 - \alpha + \frac{\alpha}{n}$

45. (c) For high v. pr. concentration of solute should be low and temperature should be high.

49. (c) $mi = \frac{P^\circ - P}{P} \times \frac{1000}{M_{\text{solvent}}}$;

$$7\, m = \frac{(20.0126 - 20) \times 1000}{20 \times 18};$$

$$m = 5 \times 10^{-3}$$

51. (d) $\Delta T_b = K_b . m \Rightarrow 3.63 \times \frac{0.616/154}{15} \times 1000$;

$$T_b = 61.7 + 0.968$$

$$\Rightarrow 62.67°\text{C}$$

52. (d) $T_b = 80.26$, $\Delta T_b = 0.16$;

$$0.16 = 2.53 \times \frac{0.26/M}{11.20} \times 1000; \; M \approx 367$$

that is almost molar mass of $C_{20}H_{16}Fe_2$.

54. (d) ΔT_b (normal) $= K_b m = 2.53 \times 1 = 2.53$ K;

$$i = \frac{\Delta T_{b(\text{obs})}}{\Delta T_{b(\text{nor})}} = \frac{1.518}{2.53} = 0.6$$

$$i = 1 - \left(1 - \frac{1}{n}\right)\alpha; \quad \alpha = 0.8$$

55. (b) $\Delta H_{\text{vap.}} = \frac{M_{\text{solvent}} \times R \times T_{b(\text{solvent})}^{o}}{1000 \times K_b}$;

$$\therefore \Delta H_{\text{vap.}} = \frac{92 \times 8.314 \times (383.7)^2}{1000 \times 3.32}$$

$$= 33.91 \text{ kJ/mol} \approx 34 \text{ kJ/mol}$$

57. (a)

$$\begin{array}{lcccccc} & XY_2 & \rightleftharpoons & X^{2+} & + & 2Y^- \\ \text{Initially} & 1 & & 0 & & 0 \\ \text{at equilibrium} & 1 - \alpha & & \alpha & & 2\alpha \end{array}$$

Total no. of moles $= 1 - \alpha + \alpha + 2\alpha = 1 + 2\alpha$

$$i = \frac{\text{Normal molar mass}}{\text{Observed molar mass}}; \quad \frac{1 + 2\alpha}{1} = \frac{164}{65.6}$$

$$\therefore \quad \alpha = 0.75; \; \% \alpha = 75\%$$

60. (b) $\Delta T_f = 2.304$; $m = \frac{2.304}{14.4} \Rightarrow 0.16$;

$$m = \frac{n_{\text{solute}}}{W_{\text{solvent}}} \times 1000$$

$$0.16 = \frac{2.6}{M} \times \frac{1000}{100}; \quad M \Rightarrow 162.5$$

61. (b) $n_{C_4H_{10}} = \frac{10.44}{58} \Rightarrow 0.18$;

$$m = \frac{0.18}{200} \times 1000 \Rightarrow 0.9$$

$$\Delta T_f = 5.12 \times 0.9 \Rightarrow 4.608;$$

$$T_f = 5.5 - 4.608 \Rightarrow 0.892°\text{C}$$

62. (d) $-4°F = -20°C; \quad \therefore \Delta T_f = 20°C$

$\Delta T_f = K_f.m \Rightarrow m = \frac{20}{1.86} = 10.75$

mass of C_2H_5OH required

$\Rightarrow 10.75 \times 46 \Rightarrow 494.5$ g

67. (d) $\Delta T_f = K_f.m \Rightarrow 0.93 = 1.86 \times \frac{36}{M} \times \frac{1}{1.2}$,

$M = 60$ and $30 \times n = 60; \quad \therefore n = 2$

so compound is $C_2H_4O_2$.

73. (b) $\Delta T_f = K_f \times \text{molality} \times i$;

$0.558 = 1.86 \times 0.1 \times i$ or $i = 3$

Thus complex is $[CoCl.\,xNH_3].Cl_2$. Since co-ordination number of CO is six, thus complex is $[CO(NH_3)_5Cl]Cl_2$.

74. (d) Depression in freezing point, $\Delta T_f = iK_f m$. The value of van't Hoff factor (i) is minimum for the glucose, which is a non-electrolyte. Hence, aqueous solution of glucose has highest freezing point.

75. (a) Molality of solution should be same $M_1 = M_2$;

$\frac{4}{60} \times \frac{1000}{96} = \frac{10}{M_B} \times \frac{1000}{90}$ or $M_B = 160$

76. (b) $\Delta T_f = K_f.m \Rightarrow 1.86 = K_f \times 1$

$\Rightarrow K_f(H_2O) = 1.86$

for HCOOH; $0.02046 = 1.86 \times 0.01\,(1 + \alpha)$;

$\alpha = 0.1$; so $[H^+] = \alpha \Rightarrow 10^{-3}$; pH = 3

77. (a) The reaction when KI is added in HgI_2

$HgI_2 + 2KI \longrightarrow K_2HgI_4 \rightleftharpoons 2K^+ + HgI_4^{2-}$

Since, number of ions decreased, so freezing point increases.

78. (b) $\Delta T_f = mK_f i$

$\Delta T_b = mK_b i$

$M_{obs} = \frac{M}{i}$

$i\downarrow$, So M_{obs} increases

79. (c) To use car; $\Delta T_f = T_f^\circ - T_f = 9.3$ K

$\therefore \Delta T_f = K_f\, m \Rightarrow 9.3 = 1.86\, m \Rightarrow m = 5$

$\therefore$ number of moles of ethylene glycol added to 5 L of water of radiator $= 5 \times 5 = 25$

or $25 \times 62 \Rightarrow 1550$ g

80. (b) Given $K_1 = 1.86 \text{ K kg mol}^{-1}$, $m = 0.01$,

$\Delta T_f = 0.0194°C$

$\therefore \Delta T_f = i.K_f m; \quad \frac{0.0194}{1.86 \times 0.01} = i$

or $i = 1.043$ or $\alpha = 0.043$

83. (c) $\Delta T_f = K_f.m.i$;

$0.87 = 1.86 \times i \times \left(\frac{1}{345.5} \times \frac{1000}{25}\right); \quad i = 4$

84. (a) $\Delta T_f = K_f \left(\frac{n_1 + n_2}{W_{solvent}} \times 1000\right)$;

$$\Delta T_f = 1.86\left(\frac{\frac{3}{60} + \frac{1.8}{180}}{95.2} \times 1000\right) \Rightarrow 1.172$$

$T_f^\circ - T_f = 1.172°C; \quad T_f = -1.172°C$

85. (b) $\Delta T_f = K_f.m.i \Rightarrow i = 0.633$;

$i = 1 - \alpha + \frac{\alpha}{2} \Rightarrow \alpha = 0.73$

87. (d) $i = 1 + \alpha \Rightarrow 1.25$

$\Delta T_f = K_f.m.i \Rightarrow 1.86 \times 0.2 \times 1.25$

or $\Delta T_f = 0.465$ or $T_f = -0.465°C$

89. (a) $\Delta T_f = K_f.m.i \Rightarrow m.i \Rightarrow \frac{\Delta T_f}{K_f} = 2$;

$\because i = 2$ so $m = 1$

$$\frac{P^0 - P}{P^0} = \frac{i.n}{i.n + N} \approx i \cdot \frac{n}{N} = \frac{i \times m.M}{1000};$$

$$= \frac{2 \times 1 \times 58.5}{1000} \Rightarrow 0.117$$

91. (d) $i = 1 + 3\alpha \Rightarrow 1 \times 3 \times 0.9 \Rightarrow 3.7$;

$\Delta T_b = i\,K_b.m \Rightarrow 0.52 \times 0.1 \times 3.7 \Rightarrow 0.19$

$\therefore T_b = T_b^\circ + 0.19 \Rightarrow 373 + 0.19 \Rightarrow 373.19$

102. (b) $K_3[Fe(CN)_6] \rightleftharpoons 3K^+ + [Fe(CN)_6]^{3-}$

At $t = 0$ 1 0 0

After ionization $(1 - \alpha)$ 3α α; $i = 1 + 3\alpha$

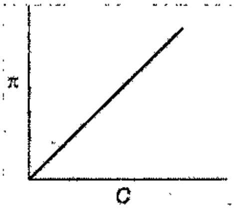
Since, $i = \frac{M_{normal}}{M_{abnormal}}$;

$\therefore \frac{1 + 3\alpha}{1} = \frac{M_{normal}}{M_{abnormal}}$

104. (c) $\pi_1 = \pi_2; \quad \frac{5}{342} \times \frac{1000}{100} = \frac{1}{X} \times \frac{1000}{100}$

$\Rightarrow X = 68.4$

105. (d)



$$\pi = \frac{W}{M} \times \frac{RT}{V} \quad \text{or} \quad \frac{\pi}{C} = \frac{RT}{M}$$

$$\therefore \quad \text{slope} = \frac{RT}{M}$$

$$\text{or} \quad M = \frac{0.082 \times 293}{4.65 \times 10^{-3} \times 10^{-3}}$$

$$\Rightarrow \quad 5.16 \times 10^{6} \text{ g}$$

109. (b) $\pi = i.C.RT$

$$\Rightarrow \quad 1.8 \times \left(\frac{1}{74.5} \times \frac{1}{0.1}\right) \times 24.63$$

$$\Rightarrow \quad 5.94$$

111. (c) $\pi = iCRT$; Where, $i = 1$ for each of the solution

$$\because \quad \pi \propto \frac{1}{\text{molecular mass of solute}};$$

$$\therefore \quad \underset{\substack{\text{urea}\\(60)}}{\pi_2} > \underset{\substack{\text{glucose}\\(180)}}{\pi_1} > \underset{\substack{\text{sucrose}\\(342)}}{\pi_3}$$

113. (b) $M_B = \dfrac{W_B \times R \times T}{\pi \times V} = \dfrac{4 \times 0.0821 \times 300}{3 \times 10^{-4} \times 2}$

$$\approx 1.6 \times 10^{5}$$

114. (a) $i = \dfrac{\text{Number of particles in KI solution}}{\text{Number of particles in sucrose solution}}$

$$\Rightarrow \quad \frac{\pi\,(\text{KI solution})}{\pi\,(\text{sucrose solution})} = \frac{0.432 \text{ atm}}{0.24 \text{ atm}} = 1.80$$

115. (d) $\pi = iCRT$; $i = 5$ for $Al_2(SO_4)_3$,

$i = 4$ for Na_3PO_4,

$i = 3$ for $BaCl_2$, $i = 1$ for glucose

So osmotic pressure of :

Glucose $< BaCl_2 < Na_3PO_4 < Al_2(SO_4)_3$

116. (b) $\pi = iCRT, i = 3 = 1 + (n - 1)\alpha$;

For the salt $\alpha = 1$, hence $n = 3$

$$[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O + 2AgNO_3 \longrightarrow [Cr(H_2O)_5Cl]^{2+} + 2AgCl(s)$$

0.5 L of 1m salt $= 0.5 \times 2 = 1.0$ mole of AgCl

119. (d) Only solvent molecules can passed through SPM so only dilution is possible.

120. (a) Henry's law is $m = K \cdot P$; where, m = mass of gas absorbed by given volume of the solvent.

P = pressure of gas;

$\therefore \quad \log m = \log K + \log P$

122. (d) 40 mL O_3 dissolve in 100 g water at 300 K and 1 atm

40×4 mL O_3 dissolve in 400 g water at 300 K and 1 atm

$\because \quad m \propto P$ so $(40 \times 4) \times 4$ mL O_3 dissolve in 400 g water at 300 K and 4 atm

$$n_{O_3} \text{ dissolved} = \frac{4 \times 640 \times 10^{-3}}{0.0821 \times 300} = 0.1$$

or mass of $O_3 = 4.8$ g

Level 2

1. (b) Mole fraction of urea in it's solution

$$= \frac{\frac{12}{60}}{\frac{12}{60} + \frac{140.4}{18}} \quad \Rightarrow 0.025$$

Mole fraction of glucose

$$= \frac{\frac{18}{180}}{\frac{18}{180} + \frac{178.2}{18}} \quad \Rightarrow 0.01$$

$\because$ Mole fraction of glucose is less so vapour pressure above the glucose solution will be higher than the pressure above urea solution, so some H_2O molecules will transfer from glucose to urea side in order to make the solutions of equal mole fraction to attain equilibrium, let x moles H_2O transfered

$$\therefore \quad \frac{0.2}{0.2 + 7.8 + x} = \frac{0.1}{0.1 + 9.9 - x} \quad \Rightarrow \quad x = 4$$

now mass of glucose solution

$$\Rightarrow \quad 196.2 - 4 \times 18 \quad \Rightarrow \quad 124.2$$

$$\text{wt. \% of glucose} = \frac{18}{124.2} \times 100 \quad \Rightarrow \quad 14.49$$

2. (b) $\because \quad P_A = P_A^{\circ} X_A$,

$P_B = P_B^{\circ} X_B$

(P_A° and P_B° = v. pr. of pure A and B)

$$\text{and} \quad Y_A = \frac{P_A}{P_A + P_B}$$

$$\Rightarrow \quad \frac{P_A^{\circ} X_A}{P_A^{\circ} X_A + P_B^{\circ}(1 - X_A)}$$

$$\Rightarrow \quad Y_A = \frac{P_A^{\circ} X_A}{X_A(P_A^{\circ} - P_B^{\circ}) + P_B^{\circ}}$$

$$\Rightarrow \quad \frac{1}{Y_A} = \left(\frac{P_A^{\circ} - P_B^{\circ}}{P_A^{\circ}}\right) + \frac{P_B^{\circ}}{P_A^{\circ}} \cdot \frac{1}{X_A}$$

So, slope of $\frac{P_B^\circ}{P_A^\circ}$ and intercept $= \frac{P_A^\circ - P_B^\circ}{P_A^\circ}$

3. (d) $\frac{P^\circ - P}{P} = \frac{n}{N} \Rightarrow \frac{W}{W \times N}$

$$\Rightarrow \frac{850 - 844.9}{844.9} = \frac{2 \times 76}{M \times 100}$$

$$M \approx 252; \quad n = \frac{252}{32} \approx 8$$

$\therefore$ atomicity of sulphur is 8

4. (c) $P = P_A^\circ x_A + P_B^\circ x_B \Rightarrow 100 \times \frac{1}{5} + 200 \times \frac{4}{5}$

$\Rightarrow$ 180 torr

y_A(composition of A vapour phase) $= \frac{P_A^\circ x_A}{p}$

$$\Rightarrow \frac{20}{180} \Rightarrow \frac{1}{9}, \quad \therefore Y_B = \frac{8}{9}$$

For condensation $y_A = x_A^1; \quad y_B = x_B^1$

$$P_{\text{total}} = P_A^\circ x_A^1 + P_B x_B^1;$$

$$P_{\text{total}} = 100 \times \frac{1}{9} + \frac{8}{9} \times 200 \Rightarrow 188.88 \text{ torr}$$

5. (c) Let n_B mole of B present in 1 mole of mixture that has been vaporized. Thus, $y_B = \frac{n_B}{1}$

Mole fraction of B in the remaining liquid phase will be $x_B = \frac{1 - n_B}{1}$

$$x_B = \frac{P - P_T^\circ}{P_B^\circ - P_T^\circ} \qquad \ldots(1)$$

$$[\because P = P_T^\circ + (P_B^\circ - P_T^\circ)\, x_B]$$

and $$y_B = \frac{P_B}{P} \Rightarrow \frac{P_B^\circ x_B}{P} \qquad \ldots(2)$$

After substitution of values of x_B and y_B in (1) and (2)

we get $$1 - n_B = \frac{P - P_T^\circ}{P_B^\circ - P_T^\circ} \qquad \ldots(3)$$

and $$n_B = \frac{(1 - n_B)\, P_B^\circ}{P} \qquad \ldots(4)$$

or $n_B = \frac{P_B^\circ}{P + P_B}$

so $$1 - \frac{P_B^\circ}{P + P_B} = \frac{P - P_T^\circ}{P_B^\circ - P_T^\circ}$$

$$\Rightarrow P = \sqrt{P_B^\circ \cdot P_T^\circ} = \sqrt{100 \times 900}$$

$\Rightarrow$ 300 torr

6. (c) For an ideal solution $\Delta H_{\text{mix}} = 0$ and ΔS_{mix} is always positive so ΔG_{mix} is negative.

7. (d) $mi = \frac{P^\circ - P}{P} \times \frac{1000}{M_{\text{solvent}}}$;

$$4.\, m = \frac{(17.25 - 17.20) \times 1000}{17.2 \times 18}; \quad m = 0.04$$

for dilute solution molality $\approx$ molarity or S;

$K_{sp} \Rightarrow 27\, S^4 \simeq 7 \times 10^{-5}$

8. (d) Mole ratio of C : H : O is 1 : 2 : 1 so empirical formula is CH_2O

$$m = \frac{\Delta T_b}{K_b} \Rightarrow \frac{0.15}{0.51} \Rightarrow 0.294;$$

$$0.294 = \frac{50}{M} \times \frac{1000}{950}; \quad M \approx 180$$

$(CH_2O)_n = 180$ or $30 \times n = 180$ or $n = 6$;

$\therefore$ molecular formula is $C_6H_{12}O_6$.

9. (c) Mass of 1 litre of solution = 1010 g;

mass of solvent $= 1010 - 300 \times 0.1 \Rightarrow 980$ g

$$m = \frac{0.1}{0.98} \Rightarrow 0.102;$$

$$\Delta T_f = K_f . m . i \;= (1 + \alpha) K_f \cdot m$$

$$\Delta T_f = 1.05 \times 1.86 \times 0.102 = 0.199°\text{C};$$

$$T_f = 0 - 0.199 = -0.199°\text{C}$$

10. (b) $m = \frac{\Delta T_b}{K_b} \Rightarrow \frac{1}{0.51} = \frac{\Delta T_f}{K_f}$

$$\Rightarrow \frac{1}{0.51} = \frac{\Delta T_f}{1.86}$$

$\Delta T_f = 3.647$ or $T_f = -3.647°\text{C}$

11. (c) For Na_3PO_4, $i = 1 + 3\alpha = 1 + 3 \times 0.5 = 2.5$; for $MgSO_4$, $i = 1.6$

100 g solution contains 8.2 g Na_3PO_4 and 12 g $MgSO_4$

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

$$K_b \cdot \left[\frac{\text{effective no. of moles of } (Na_3PO_4 + MgSO_4)}{\text{wt. of solvent (in g)}} \times 1000\right]$$

$$\Delta T_b = 0.50 \left[\frac{\frac{8.2}{164} \times 2.5 + \frac{12}{120} \times 1.6}{79.8}\right] \times 1000$$

$= 1.785°\text{C}$

$T_b = 100 + 1.785 \Rightarrow 101.785°\text{C}$

12. (b) $\Delta T_b = K_b \left(\frac{w_{\text{solute}}}{W_{\text{solvent}}} \times \frac{1}{M_{\text{solute}}}\right) \times 1000$

$$1 = \frac{1000 \times 10}{100 \times M_{AB_2}} \Rightarrow M_{AB_2} = 100$$

similarly $M_{A_2B} = 140$

$100 = M_A + 2 \cdot M_B$

and $140 = 2.M_A + M_B$;

$M_A = 60$ and $M_B = 20$

13. (c) Given $w = 0.2\text{g}$, $W = 20\text{ g}$, $\Delta T = 0.45$;

$$\Delta T_f = \frac{1000 \times K_f \times w}{M \times W}$$

or $$0.45 = \frac{1000 \times 5.12 \times 0.2}{20 \times M}$$

∴ M (observed) $= 113.78$

Now for $2CH_3COOH \rightleftharpoons (CH_3COOH)_2$

Before association 1 0

After association $1 - \alpha$ $\alpha/2$;

where α is the degree of association.

$$\therefore \frac{M_{\text{normal}}}{M_{\text{observed}}} = 1 - \alpha + \frac{\alpha}{2};$$

or $$\frac{60}{113.78} = 1 - \alpha + \frac{\alpha}{2}; \quad \alpha = 0.945$$

14. (b) Given $\Delta H_{\text{fus.}} = 80 \text{ cal g}^{-1}$,

$\Delta H_{\text{vap.}} = 540 \text{ cal g}^{-1}$

We know, $\Delta T_b = K_b \times m$

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

Also $$K = \frac{RT^2}{1000 \times \Delta H}$$

$$\therefore \frac{\Delta T_b}{\Delta T_f} = \frac{K_b}{K_f}$$

$$\Rightarrow \frac{RT_b^2}{1000 \times \Delta H_{\text{vap.}}} \times \frac{1000 \times \Delta H_{\text{fus.}}}{RT_f^2}$$

$$\Rightarrow \frac{\Delta T_b}{\Delta T_f} = \frac{T_b^2 \times \Delta H_{\text{fus.}}}{T_f^2 \times \Delta H_{\text{vap.}}}$$

$$\frac{0.1}{\Delta T_f} = \frac{373 \times 373 \times 80}{273 \times 273 \times 540}$$

∵ $\Delta T_f = 0.361$ so,

$T_f = -0.361°\text{C}$

15. (d) Molality of solution $= \frac{P° - P}{P} \times \frac{1000}{M}$

$$\Rightarrow \frac{40.8 - 40}{40} \times \frac{1000}{18} \Rightarrow 0.25$$

1000 g water present with 45 g glucose or 100 g solution has 4.31 g glucose and 95.69 g H_2O. Final molality is 0.5, 1000 g solvent contain 90 g glucose or 4.31 g glucose present with $\frac{1000}{90} \times 4.31 = 47.88$ g H_2O wt. of ice formed $= 95.69 - 47.88 = 47.8$g

16. (b) $\Delta T_f = K_f \times \frac{w_{\text{acid}}}{M_{\text{acid}} \times W_{H_2O}} \times 1000$;

∴ M_{acid} (observed) $= 120$

Normal molecular mass of acid can calculate as

milli-equivalents of acid = milli-equivalents of base

(for HA and NaOH, $N = M$)

$$\frac{0.75}{M_{\text{acid}}} \times 1000 = 15 \times \frac{1}{5}$$

$\Rightarrow$ $M_{\text{acid (Normal)}} = 150$

∴ $i = \frac{150}{120} \Rightarrow 1.25$

$i = 1 + \alpha \Rightarrow 0.25$

∴ % α = 25

17. (d) $KI(aq) + AgNO_3(aq) \longrightarrow AgI(s)\downarrow + KNO_3(aq)$

	KI +	$AgNO_3$ ⟶	KNO_3 +	AgI↓
Initial :	0.3 mole	0.2 mole	—	—
Final :	0.1 mole	—	0.2	0.2

Total moles of solute ions $= (0.1 + 0.2) \times 2$ (∵ $i = 2$)

$$[\text{Solute}] = \frac{0.6}{4} M$$

$$\Delta T_f = K_f \cdot \frac{0.6}{4}$$

$$= 1.86 \times \frac{0.6}{4} = 0.279 \text{ K}$$

18. (b) $\Delta T_f = K_f . m . i \Rightarrow 0.3906 = i \times 1.86 \times 0.1$, $i = 2.1$

first step of H_2SO_4 is strong so

$H_2SO_4 \longrightarrow H^+ + HSO_4^-$;

0 C $C(1-\alpha)$

$HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$

$C(1-\alpha)$ $C\alpha$ $C\alpha$

$$i = \frac{C(1-\alpha) + C\alpha + C\alpha + C}{C} \Rightarrow 2.1;$$

$\alpha = 0.1$

Now, $HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$

$C(1-\alpha)$ $(C\alpha + C)$ $C\alpha$

$$K_{a_2} = \frac{C(1+\alpha) \times C\alpha}{C(1-\alpha)}$$

$$\Rightarrow \frac{1.1 \times 0.1 \times 0.1}{0.9} = 0.0122$$

19. (a) $\pi = (iC_1 - i_2C_2)RT$

$\Rightarrow (1 \times 0.2 - 3 \times 0.05)\, 0.0821 \times 300$

$\Rightarrow$ 1.23 atm

20. (c) $\alpha = \sqrt{\dfrac{8 \times 10^{-5}}{0.2}} \Rightarrow 0.02;$

$i = (1 + \alpha) \Rightarrow 1.02$

$\pi = i.C.R.T$

$\Rightarrow 1.02 \times 0.2 \times 0.0821 \times 300$

$\Rightarrow$ 5.024 atm

21. (b) 8 g of carbohydrate is present with 100 g of water in solution

or 108 g solution contains 8 g of carbohydrate;

$$V_{\text{solution}} = \frac{108}{1.025} \times 10^{-3} \text{ litre}$$

$$\pi = \frac{n}{V} \times R \times T$$

$$\Rightarrow \frac{8}{M} \times \frac{1.025}{108} \times 1000 \times 0.0821 \times 300 = 5;$$

$$M = 374 \text{ g/mol}$$

23. (a) The given data are

$P_{\text{water}} = 17.0$ torr;

P_{total} (4 mole % solution)

$= P_{NH_3} + P_{\text{water}} = 50.0$ torr

$x_{NH_3} = 0.04$ and $x_{\text{water}} = 0.96$

Now according to Raoult's law;

$P_{\text{water}} = x_{\text{water}}\, P^{\circ}_{\text{water}}$

$= 0.96 \times 17.0 \text{ torr} = 16.32$ torr

Now Henry's law constant for ammonia is

$$K_H(NH_3) = \frac{P_{NH_3}}{x_{NH_3}} = \frac{33.68 \text{ torr}}{0.04} = 842 \text{ torr}$$

Hence, for 5 mole % solution, we have

$P_{NH_3} = K_H(NH_3)\, x_{NH_3}$

$= (842 \text{ torr})(0.05) = 42.1$ torr

$P_{\text{water}} = P^{\circ}_{\text{water}}\, x_{\text{water}}$

$= (17 \text{ torr})(0.95) = 16.15$ torr

Thus, P_{total} (5 mole % solution)

$= P_{NH_3} + P_{\text{water}} = 42.1 + 16.15 = 58.25$ torr

24. (b) $P = P^{\circ}_A x_A + P^{\circ}_B x_B$

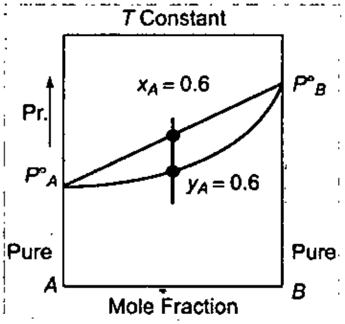
$\Rightarrow 500 \times 0.6 + 800 \times 0.4$

$\Rightarrow$ 620 torr

$$y_A = \frac{P_A}{P} \Rightarrow \frac{300}{620}$$

$\Rightarrow 0.48; \quad y_B = 0.52$

25. (c) $P^{\circ}_A = 500; \ P^{\circ}_B = 800$ torr



When most of the liquid has vaporized $x_A = 0.6$ (given) would be $y_A = 0.6$

$$y_A = \frac{P^{\circ}_A x_A}{P^{\circ}_A x_A + P^{\circ}_B(1 - x_A)}$$

$$\Rightarrow 0.6 = \frac{500.\, x_A}{500x_A + 800\,(1 - x_A)}$$

$x_A = 0.70; \quad x_B = 0.30$