Exercise-1

✍ **Marked questions are recommended for Revision.**

PART - I : SUBJECTIVE QUESTIONS

Section (A) : General Introduction & types of solution

A-1.✍ What are the characteristics of the supersaturated solution.

A-2.✍ What do you mean by Hygroscopic compound ?

A-3. Why are some solution processes exothermic whereas others are endothermic ?

Section (B) : Concentration terms (Revision of mole)

Commit to memory :

$$\text{Molarity} = \frac{\text{no. of moles of solute}}{\text{volume of solution (in L)}}\ ; \quad \text{Molality} = \frac{\text{no. of moles of solute}}{\text{W(g) of solvent}} \times 1000$$

$$\text{Molality} = \frac{\text{molarity} \times 1000}{1000\text{d} - \text{molarity} \times \text{m.wt. of solute}}$$ (where d is density of solution in g/ml)

$$\%\frac{w}{w} = \frac{m_{\text{solute}}(g)}{m_{\text{solution}}(g)} \times 100\ ; \qquad x_{\text{solute}} = \frac{n}{n+N}$$ (where, n is moles of solute, N is moles of solvent)

$$x_{\text{solute}} + x_{\text{solvent}} = 1$$

B-1. Calculate the concentration of NaOH solution in g/ml which has the same molarity as that of a solution of HCl of concentration 0.0365 g/ml.

B-2.✍ The density of 3M solution of sodium thiosulphate ($Na_2S_2O_3$) is 1.58 g/ml. Calculate
(i) amount of $Na_2S_2O_3$ in % w/w
(ii) mole fraction of $Na_2S_2O_3$
(iii) molality of Na^+ and $S_2O_3^{2-}$ ions.

B-3.✍ Calculate the molality and molarity of a solution made by mixing equal volumes of 30% by weight of H_2SO_4 (density = 1.20 g/mL) and 70% by weight of H_2SO_4 (density = 1.60 g/mL).

Section (C) : Vapour Pressure

Commit to memory :

* The partial pressure of vapours of X in equilibrium with X at a given temperature is called as its vapour pressure. (X is given pure solid or pure liquid)

* A gas is said to be saturated with vapours of a liquid if the partial pressure of liquid vapours is equal to its (saturated) vapour pressure.

* Partial pressure of vapours of X (pure solid or liquid) will remain equal to its vapour pressure till the vapours of X are in equilibrium with X.

C-1.✍ The vapour pressure of water at 80ºC is 355 torr. A 100 ml vessel contained water−saturated oxygen at 80º C, the total gas pressure being 760 torr. The contents of the vessel were pumped into a 50.0 ml, vessel at the same temperature. What were the partial pressures of oxygen and of water vapour and the total pressure in the final equilibrium state? Neglect the volume of any water which might condense.

C-2. A vessel has nitrogen gas and water vapours in equilibrium with liquid water at a total pressure of 1 atm. The partial pressure of water vapours is 0.3 atm. The volume of this vessel is reduced to one third of the original volume, at the same temperature, then find total pressure of the system. (Neglect volume occupied by liquid water)

Section (D) : Solutions of Solid and Gases in Liquids

Commit to memory :

* The solubility of gas in a liquid at a given temperature is directly proportional to its partial pressure above liquid in which it is dissolved.

$P = K_H x$ (where x is mole fraction of unreacted, dissolved gas and P is its partial pressure above liquid.)

D-1. The partial pressure of ethane over a solution containing 6.56×10^{-3} g of ethane is 1 bar. If the solution contains 5.00×10^{-2} g of ethane, then what shall be the partial pressure of the gas ?

D-2.✍ If N_2 gas is bubbled through water at 293 K, how many millimoles of N_2 gas would dissolve in 300 mole of water, if N_2 exerts a partial pressure of 1 bar. Given that Henry's law constant for N_2 at 293 K is 75.00 kbar.

Section (E) : Immiscible Liquids

Commit to memory :

If A and B are volatile immiscible liquids, then above their mixture.

* $P_T = P^o_A + P^o_B$ (P_T = Total pressure above mixture of A and B, P^o_A = vapour pressure of A, P^o_B = vapour pressure of B)

$\frac{P_A^o}{P_B^o} = \frac{n_A}{n_B}$ (n_A and n_B are moles of A and B in distillate)

$\frac{w_A}{w_B} = \frac{P_A^\circ M_A}{P_B^\circ M_B}$ (w_A and w_B are masses of A and B in distillate, M_A and M_B are molar masses of A and B)

E-1.✍ A mixture of an organic liquid A and water distilled under one atmospheric pressure at 99.2ºC. How many grams of steam will be condensed to obtain 1.0 g of liquid A in the distillate ? (Vapour pressure of water at 99.2ºC is 739 mm Hg. Molecular weight of A = 123)

E-2. Boiling point of a mixture of water and nitrobenzene is 99°C, the vapour pressure of water is 733 mm of Hg and the atmospheric pressure is 760 mm of Hg. The molecular weight of nitrobenzene is 123. Find the ratio of weights of the components of the distillate.

Commit to memory :

Statement of Raoult's law (for volatile liq. mixture) : In solution of volatile liquids, the partial vapour pressure of each component is directly proportional to its mole fraction in solution.

$p_A \propto x_A$

$\mathbf{p_A = x_A P_A^o}$ .... (1)

where p_A = Partial vapour pressure of component A, x_A = Mole fraction of component ‘A’ in solution, P_A^o = Vapour pressure of pure component ‘A’ at given temperature

Hence $\mathbf{P_T = x_A P_A^o + x_B P_B^o}$ .... (2)

(P_T = Total pressure of vapour above solution, P_B^o = vapour pressure of pure component 'B' at given temperature.)

Thus, $\frac{1}{P_T} = \frac{y_A}{P_A^o} + \frac{y_B}{P_B^o}$ (for complete derivation, refer page no. 12 of sheet)

(y_A = mole fraction of A in vapour phase above the solution and y_B = mole fraction of B in vapour phase above the solution)

F-1.✍ Two liquids A and B form an ideal solution. At 300 K, the vapour pressure of a solution containing 1 mole of A and 3 moles of B is 550 mm of Hg. At the same temperature, if one mole of B is added to this solution, the vapour pressure of the solution increases by 10 mm of Hg. Determine the vapour pressure of A and B in their pure states.

F-2.✍ Two liquids, A and B, form an ideal solution. At the specified temperature, the vapour pressure of pure A is 200 mm Hg while that of pure B is 75 mm Hg. If the vapour over the mixture consists of 50 mol percent A, what is the mole percent A in the liquid ?

F-3. Two solutions of A and B are available. The first is known to contain 1 mole of A and 3 moles of B and its total vapour pressure is 1.0 atm. The second is known to contain 2 moles of A and 2 moles of B; its vapour pressure is greater than 1 atm, but it is found that this total vapour pressure may be reduced to 1 atm by the addition of 6 moles of C. The vapour pressure of pure C is 0.80 atm. Assuming ideal solutions and that all these data refer to 25°C, calculate the vapour pressure of pure A and of pure B.

F-4. At 80ºC, the vapour pressure of pure benzene is 753 mm Hg and of pure toluene 290 mm Hg. Calculate the composition of a liquid in mole per cent which at 80ºC is in equilibrium with the vapour containing 30 mole per cent of benzene.

F-5.✍ Vapour pressure of C_6H_6 and C_7H_8 mixture at 50ºC is given P (mm Hg) = $180X_B + 90$, where X_B is the mole fraction of C_6H_6. A solution is prepared by mixing 12 mol benzene and 8 mol toluene and if vapours over this solution are removed and condensed into liquid and again brought to the temperature 50ºC, what would be mole fraction of C_6H_6 in the vapour state. (At. wt. of C = 12, H = 1)

Section (G) : Non-ideal Solutions

Commit to memory :

*

+ve deviation	**ve deviation**
$P_{T.exp} > (x_AP^o_A + x_BP^o_B)$	$P_{T.exp} < (x_AP^o_A + x_BP^o_B)$
ΔH_{mix} = +ve	ΔH_{mix} = –ve
ΔV_{mix} = +ve	ΔV_{mix} = –ve
ΔS_{mix} = +ve	ΔS_{mix} = +ve
ΔG_{mix} = –ve	ΔG_{mix} = –ve

(where $P_{T.exp}$ is experimental total pressure above mixture of volatile liquids A and B).

G-1. A non ideal solution was prepared by mixing 30 ml chloroform and 50 ml acetone. Comment on volume of mixture.

G-2.✍ Total vapour pressure of mixture of 1 mole of volatile component A (P^o_A = 100 mm Hg) and 3 mole of volatile component B (P^o_B = 80 mm Hg) is 90 mm Hg. Find out nature of solution and sign of entropy of solution.

Section (H) : Degree of Ionisation/Dissociation for Weak Electrolytes

Commit to memory :

***** For dissociation/association $i = 1 + (n - 1)\alpha$

(where n is total number of particles produced per solute particle after association/dissociation, i = vant Hoff factor, α = degree of dissociation / association.

$$i = \frac{\text{Moles of solute particles after association/dissociation of X}}{\text{Moles of X without association / dissociation}} = \frac{\text{Observed value of colligative property}}{\text{Theoretical value of that colligative property}}$$

$$i = \frac{\text{Theoretical molar mass of solute}}{\text{Observed molar mass of solute}}$$

H-1.✍ Complete the following table.

Solute	**Dissociation / association reaction**	**Degree of dissociation / association**	**n**	**i**
KCl		1		
H_2SO_4		1		
CH_3COOH (in water)		0.2		
CH_3COOH (in benzene)		0.5		
Urea				
NaBr		0.8		
A	$3A \rightarrow A_3$	1		

H-2.✍ 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.

Section (I) : Relative lowering of vapour pressure

Commit to memory :

* RLVP = $\frac{P^o - P_S}{P^o}$ = x_{solute}; $\frac{P^o - P_S}{P_S} = \frac{n}{N}$

(where P^o = vapour pressure of pure solvent, P_s = partial pressure of vapour above solution, n = dissolved moles of solute, N = moles of solvent.)

$\frac{P^o - P_S}{P_S} = \frac{m_{solute(g)}}{M_{solute}} \times \frac{M_{solvent}}{m_{solvent(g)}}$ (where m = given mass in solution, M = molar mass.)

$\frac{P^o - P_S}{P_S}$ = (molality) × $\frac{M_{solvent}}{1000}$

If solution is of single solute and it gets associated or dissociated;

$\frac{P^o - P_S}{P_S} = \frac{i.n}{N}$; that is $\frac{P^o - P_S}{P_S}$ = i × (molality) × $\frac{M_{solvent}}{1000}$

I-1. Twenty grams of a solute are added to 100 g of water at 25ºC. The vapour pressure of pure water is 23.76 mmHg; the vapour pressure of the solution is 22.41 Torr.
(a) Calculate the molar mass of the solute.
(b) What mass of this solute is required in 100 g of water to reduce the vapour pressure to one-half the value for pure water ?

I-2. The degree of dissociation of $Ca(NO_3)_2$ in a dilute aqueous solution containing 7 g salt per 100 g of water at 100ºC is 70%. If the vapour pressure of water at 100ºC is 760 mm of Hg, calculate the vapour pressure of the solution.

Section (J) : Elevation of Boiling Point & Depression of Freezing Point

Commit to memory :

* ΔT_b = i × K_b × m (where ΔT_b = elevation in boiling point of solution, K_b = ebullioscopic constant, m = molality of single solute, T_b = boiling point of solvent (in K).

$K_b = \frac{RT_b^2M}{1000 \times \Delta H_{vap}} = \frac{RT_b^2}{1000 \times L_{vap}}$ (M = Molar mass of solvent)

ΔT_f = i × K_f × m (where ΔT_f = depression in freezing point of solution, K_f = cryoscopic constant, T_f = freezing point of solvent (in K).

$K_f = \frac{RT_f^2 \ M}{1000 \times \Delta H_{fusion}} = \frac{RT_f^2}{1000 \times L_{fusion}}$

J-1. (a) A solution containing 0.5 g of naphthalene in 50 g CCl_4 yield a boiling point elevation of 0.4 K, while a solution of 0.6 g of an unknown solute in the same mass of the solvent gives a boiling point elevation of 0.65 K. Find the molar mass of the unknown solute.
(b) The boiling point of a solution of 0.1 g of a substance in 16 g of ether was found to be 0.100ºC higher that of pure ether. What is the molecular mass of the substance. K_b(ether) = 2.16 K kg mol^{-1}.

J-2. The amount of benzene that will separate out (in grams) if a solution containing 7.32 g of triphenylmethane in 1000 g of benzene is cooled to a temperature which is 0.2°C below the freezing point of benzene ? (K_f = 5.12 K-Kg/mol)

J-3. The boiling point of a solution of 5 g of sulphur in 100 g of carbon disulphide is 0.474ºC above that of pure solvent. Determine the molecular formula of sulphur in this solvent. The boiling point of pure carbon disulphide is 47ºC and its heat of vaporisation is 84 calories per gram.

[Hint : $K_b = \frac{RT_b^2}{1000L_V} = \frac{2 \times (320)^2}{1000 \times 84}$ = 2.438]

J-4. A 0.01 molal solution of ammonia freezes at –0.02ºC. Calculate the van't Hoff factor, i and the percentage dissociation of ammonia in water. $(K_{f(H_2O)})$ = 1.86 deg molal^{-1}.

Section (K) : Osmotic Pressure

Commit to memory :

* $\pi = CRT = \frac{n}{V} RT$ (n = Total moles of solute particles in solution, V = Total volume of solution in L)

K-1.✍ **(a)** Predict the osmotic pressure order for the following (assume salts are 100% dissociated).

I 0.1 M urea II 0.1 M NaCl
III 0.1 M Na_2SO_4 IV 0.1 M Na_3PO_4

(b) If equal volumes of all these solutions are mixed then calculate the osmotic pressure of the net resultant solution obtained at 300K.

K-2.✍ A solution containing 3.00 g of calcium nitrate in 100 c.c. of solution had an osmotic pressure of 11.2 atmosphere at 12°C. Calculate the degree of ionisation of calcium nitrate at this dilution and temperature.

K-3.✍ 17.4% (w/v) K_2SO_4 solution at 27ºC is isotonic with 5.85% (w/v) NaCl solution at 27ºC. If NaCl is 100% ionised, what is % ionisation of K_2SO_4 in aq. solution ?

K-4.✍ At 2ºC the osmotic pressure of a urea solution is found to be 500 mm of Hg. The solution is diluted and the temperature is raised to 27ºC, when the osmotic pressure is found to be 109.09 mm of Hg. Determine the extent of dilution.

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : General Introduction & types of solution

A-1. Which statement best explains the meaning of the phrase “like dissolves like “ ?
(A) A Solute will easily dissolve a solute of similar mass
(B) A solvent and solute with similar intermolecular forces will readily form a solution
(C) The only true solutions are formed when water dissolves a non-polar solute
(D) The only true solutions are formed when water dissolves a polar solute

A-2.✍ An ionic compound that attracts atmospheric water so strongly that a hydrate is formed is said to be :
(A) Dilute (B) Hygroscopic (C) Immiscible (D) Miscible

Section (B) : Concentration terms (Revision of mole)

B-1.✍ Persons are medically considered to have lead poisoning if they have a concentration greater than 10 micrograms of lead per decilitre of blood. Concentration in parts per billion is :
(A) 1000 (B) 100 (C) 10 (D) 1

Section (C) : Vapour Pressure

C-1.✍ A liquid is kept in a closed vessel. If a glass plate (negligible mass) with a small hole is kept on top of the liquid surface, then the vapour pressure of the liquid in the vessel is :
(A) More than what would be if the glass plate were removed
(B) Same as what would be if the glass plate were removed
(C) Less than what would be if the glass plate were removed
(D) Cannot be predicted

C-2.✍ The vapour pressure of water depends upon :
(A) Surface area of container (B) Volume of container
(C) Temperature (D) All

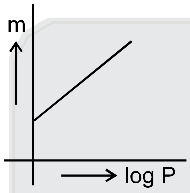
C-3. Among the following substances, the lowest vapour pressure is exerted by :
(A) Water (B) Mercury (C) Acetone (D) Ethanol

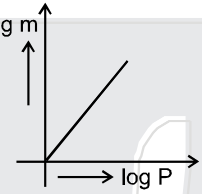
C-4.✍ At higher altitudes, water boils at temperature < 100ºC because
(A) temperature of higher altitudes is low (B) atmospheric pressure is low
(C) the proportion of heavy water increases (D) atmospheric pressure becomes more.

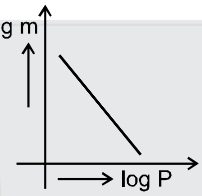
Section (D) : Solutions of Solid and Gases in Liquids

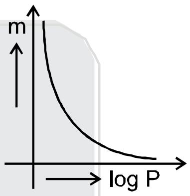
D-1. The solubility of gases in liquids :
(A) increases with increase in pressure and temperature
(B) decreases with increase in pressure and temperature
(C) Increases with increase in pressure and decrease in temperature
(D) decreases with increase in pressure and increase in temperature

D-2. Which of the following curves represents theHenry'slaw?

(A)


(B)


(C)


(D)


D-3. 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

D-4. Some of the following gases are soluble in water due to formation of their ions :
I : CO_2 ; II : NH_3 ; III : HCl ; IV : CH_4 ; V : H_2
Water insoluble gases can be :
(A) I, IV , V (B) I, V (C) I, II, III (D) IV, V

D-5. The solubility of $N_2(g)$ in water exposed to the atmosphere, when its partial pressure is 593 mm is 5.3×10^{-4} M. Its solubility at 760 mm and at the same temperature is :
(A) 4.1×10^{-4} M (B) 6.8×10^{-4} M (C) 1500 M (D) 2400 M

Section (E) : Immiscible Liquids

E-1. When a liquid that is immiscible with water was steam distilled at 95.2ºC 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 95.2ºC, 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

F-1. For a binary ideal liquid solution, the total pressure of the solution is given as :
(A) $P_{total} = P^o_A + (P^o_A - P^o_B) X_B$ (B) $P_{total} = P^o_B + (P^o_A - P^o_B) X_A$
(C) $P_{total} = P^o_B + (P^o_B - P^o_A) X_A$ (D) $P_{total} = P^o_B + (P^o_B - P^o_A) X_B$

F-2. An ideal solution contains two volatile liquids A (p^o = 100 torr) and B (p^o = 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

F-3. At 323 K, the vapour pressure in millimeters of mercury of a methanol-ethanol solution is represented by the equation $p = 120 X_A + 140$, where X_A is the mole fraction of methanol.Then the value of $\lim_{x_A \to 1} \frac{p_A}{X_A}$ is
(A) 250 mm (B) 140 mm (C) 260 mm (D) 20 mm

F-4. Given at 350 K $p_A°$ = 300 torr and $p_B°$ = 800 torr, the composition of the mixture having a normal boiling point of 350 K is :
(A) $X_A = 0.08$ (B) $X_A = 0.06$ (C) $X_A = 0.04$ (D) $X_A = 0.02$

F-5. Two liquids A and B have P^o_A and P^o_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

Section (G) : Non-ideal Solutions

G-1. The vapour pressure of the solution of two liquids A(p^o = 80 mm) and B(p^o = 120 mm) is found to be 100 mm when x_A = 0.4. The result shows that
(A) solution exhibits ideal behaviour
(B) solution shows positive deviations
(C) solution shows negative deviations
(D) solution will show positive deviations for lower concentration and negative deviations for higher concentrations.

G-2. Consider a binary mixture of volatile liquids. If at X_A = 0.4 the vapour pressure of solution is 580 torr then the mixture could be (p_A^o = 300 torr, p_B° = 800 torr) :
(A) $CHCl_3 - CH_3COCH_3$
(B) $C_6H_5Cl - C_6H_5Br$
(C) $C_6H_6 - C_6H_5CH_3$
(D) $nC_6H_{14} - nC_7H_{16}$

G-3. A solution of sulphuric acid in water exhibits :
(A) Negative deviations from Raoult's law
(B) Positive deviations from Raoult's law
(C) Ideal properties
(D) The applicability of Henry's law

G-4. When KCl dissolves in water (assume endothermic dissolution), then :
(A) $\Delta H = +$ ve, $\Delta S = +$ ve, $\Delta G = +$ ve
(B) $\Delta H = +$ ve, $\Delta S = -$ ve, $\Delta G = -$ ve
(C) $\Delta H = +$ ve, $\Delta S = +$ ve, $\Delta G = -$ ve
(D) $\Delta H = -$ ve, $\Delta S = -$ ve, $\Delta G = +$ ve

G-5. The dissolving process is exothermic when :
(A) The energy released in solvation exceeds the energy used in breaking up solute-solute and solvent-solvent interactions.
(B) The energy used in solvation exceeds the energy released in breaking up solute-solute and solvent-solvent interactions.
(C) The energy released in solvation is about the same as the energy used in breaking up solute-solute and solvent-solvent interactions.
(D) The energy used in solvation is about the same as the energy used in breaking up solute-solute and solvent-solvent interactions.

G-6. Which of the following is less than zero for ideal solutions ?
(A) ΔH_{mix}
(B) ΔV_{mix}
(C) ΔG_{mix}
(D) ΔS_{mix}

Section (H) : Degree of Ionisation/Dissociation for Weak Electrolytes

H-1. One mole of a solute A is dissolved in a given volume of 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) $i = \dfrac{1 - \alpha + \frac{\alpha}{n}}{1}$
(D) i = 1

H-2. 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) $\dfrac{i + \alpha - 1}{\alpha}$
(B) $i - \alpha - 1$
(C) $\dfrac{i - 1}{\alpha}$
(D) $\dfrac{i + 1 + \alpha}{1 - \alpha}$

H-3. 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) $M_{normal} (1 + 2\alpha)^{-1}$
(B) $M_{normal} (1 + 3\alpha)^{-1}$
(C) $M_{normal} (1 + \alpha)^{-1}$
(D) equal to M_{normal}

H-4. A complex containing K^+, Pt(IV) and Cl^- is 100% ionised giving i = 3. Thus, complex is :
(A) $K_2[PtCl_4]$
(B) $K_2[PtCl_6]$
(C) $K_3[PtCl_5]$
(D) $K[PtCl_3]$

Section (I) : Relative lowering of vapour pressure

I-1.✍ If P_0 and P are the vapour pressures of a solvent and its solution respectively and N_1 and N_2 are the mole fractions of the solvent and non-volatile solute respectively, then correct relation is :
(A) $P = P_0N_2$ (B) $P = P_0N_1$ (C) $P_0 = PN_1$ (D) $P = P_0(N_1/N_2)$

I-2. Relative decrease in vapour pressure of an aqueous NaCl is 0.167. Number of moles of NaCl present in 180g of H_2O is :
(A) 2 mol (B) 1 mol (C) 3 mol (D) 4 mol

I-3.✍ The vapour pressure of pure benzene, C_6H_6 at 50°C is 268 Torr. How many moles of non-volatile solute per mol of benzene is required to prepare a solution of benzene having a vapour pressure of 167 Torr at 50°C?
(A) 0.377 (B) 0.605 (C) 0.623 (D) 0.395

I-4. If relative decrease in vapour pressure is 0.4 for a solution containing 1 mol NaCl in 3 mol H_2O, NaCl is .... % ionised.
(A) 60% (B) 50% (C) 100% (D) 40%

I-5.✍ The vapour pressure of a solution of a non-volatile solute B in a solvent A is 95% of the vapour pressure of the solvent at the same temperature. If the molecular weight of the solvent is 0.3 times the molecular weight of the solute, what is the ratio of weight of solvent to solute.
(A) 0.15 (B) 5.7 (C) 0.2 (D) none of these

I-6.✍ Relative decrease in vapour pressure of an aqueous solution containing 2 moles $[Cu(NH_3)_3Cl]Cl$ in 3 moles H_2O is 0.50. On reaction with $AgNO_3$, this solution will form(assuming no change in degree of ionisation of substance on adding $AgNO_3$)
(A) 1 mol AgCl (B) 0.25 mol AgCl (C) 0.5 mol AgCl (D) 0.40 mol AgCl

Section (J) : Elevation of Boiling Point & Depression of Freezing Point

J-1.✍ An aqueous solution containing 1g of urea boils at 100.25°C. The aqueous solution containing 3 g of glucose in the same volume will boil at -
(A) 100.75 °C (B) 100.5 °C (C) 100°C (D) 100.25°C

J-2. Elevation in boiling point was 0.52 °C when 6 g of a compound x was dissolved in 100 g of water. Molecular weight of x is : (K = 0.52 kg mol^{-1})
(A) 120 (B) 60 (C) 100 (D) 342

J-3.✍ A solute'S' undergoes a reversible trimerization when dissolved in a certain solvent. The boiling point elevation of its 0.1 molal solution was found to be identical to the boiling point elevation in case of a 0.08 molal solution of a solute which neither undergoes association nor dissociation. To what percent had the solute 'S' undergone trimerization?
(A) 30% (B) 40% (C) 50% (D) 60%

J-4.✍ A complex of iron and cyanide ions is 100% ionised at 1m (molal). If its elevation in b.p. is 2.08. Then the complex is (K_b = 0.52° mol^{-1} kg) :
(A) $K_3[Fe(CN)_6]$ (B) $Fe(CN)_2$ (C) $K_4[Fe(CN)_6]$ (D) $Fe(CN)_4$

J-5.✍ $PtCl_4.6H_2O$ can exist as a hydrated complex 1 molal aq. solution has depression in freezing point of 3.72°. Assume 100% ionisation and $K_f(H_2O)$ = 1.86° mol^{-1} kg, then complex is -
(A) $[Pt(H_2O)_6]Cl_4$ (B) $[Pt(H_2O)_4Cl_2]Cl_2 . 2H_2O$
(C) $[Pt(H_2O)_3Cl_3]Cl . 3H_2O$ (D) $[Pt(H_2O)_2Cl_4] . 4H_2O$

J-6. How many moles of sucrose should be dissolved in 500 g of water so as to get a solution which has a difference of 104°C between boiling point and freezing point.
(K_f = 1.86 K Kg mol^{-1}, K_b = 0.52 K Kg mol^{-1})
(A) 1.68 (B) 3.36 (C) 8.40 (D) 0.840

J-7.✍ Which of the following has been arranged in order of decreasing freezing point?
(A) 0.05 M KNO_3 > 0.04 M $CaCl_2$ > 0.140 M sugar > 0.075 M $CuSO_4$
(B) 0.04 M $BaCl_2$ > 0.140 M sucrose > 0.075 M $CuSO_4$ > 0.05 M KNO_3
(C) 0.075 M $CuSO_4$ > 0.140 M sucrose > 0.04 M $BaCl_2$ > 0.05 M KNO_3
(D) 0.075 M $CuSO_4$ > 0.05 M $NaNO_3$ > 0.140 M sucrose > 0.04 M $BaCl_2$

J-8. A solution of x moles of sucrose in 100 grams of water freezes at –0.2ºC. As ice separates the freezing point goes down to – 0.25ºC. How many grams of ice would have separated?
(A) 18 grams (B) 20 grams (C) 25 grams (D) 23 grams

J-9.✍ Sea water is found to contain 5.85 % NaCl and 9.50% $MgCl_2$ by weight of solution. Calculate its normal boiling point assuming 80% ionisation for NaCl and 50% ionisation of $MgCl_2$ ($K_b(H_2O)$ = 0.51 kgmol^{-1} K).
(A) T_b = 101.9°C (B) T_b = 102.3°C (C) T_b = 108.5°C (D) T_b = 110.3°C

Section (K) : Osmotic Pressure

K-1. The relationship between osmotic pressure at 273 K when 10 g glucose (P_1), 10 g urea (P_2) and 10 g sucrose (P_3) are dissolved in 250 mL of water is :
(A) $P_1 > P_2 > P_3$ (B) $P_3 > P_1 > P_2$ (C) $P_2 > P_1 > P_3$ (D) $P_2 > P_3 > P_1$

K-2. 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 the same osmotic pressure as blood is :
(A) 0.3 (B) 0.2 (C) 0.1 (D) 0.4

K-3. The total concentration of dissolved particles inside red blood cells is approximately 0.30 M and the membrane surrounding the cells is semipermeable. What would the osmotic pressure (in atmosphere) inside the cells become if the cells were removed from the blood plasma and placed in pure water at 298 K ?
(A) 7.34 atm (B) 1.78 atm (C) 2.34 atm (D) 0.74 atm

K-4.✍ Consider following cases :
I : 2M CH_3COOH solution in benzene at 27°C where there is dimer formation to the extent of 100%
II : 0.5 M KCl aq. solution at 27°C, which ionises 100%
Which is/are true statements(s) :
(A) both are isotonic (B) I is hypertonic (C) II is hypotonic (D) none is correct

PART - III : MATCH THE COLUMN

1. If at a particular temperature, the density of 18 M H_2SO_4 is 1.8 g cm^{-3}. Then :

	Column I		**Column II**
(A)	Molality	(p)	0.1
(B)	% concentration by wt. of solute	(q)	0.9
(C)	mole fraction of H_2SO_4	(r)	500
(D)	mole fraction of H_2O	(s)	98

2.✍ Match the following column-

	Column I		**Column II**
(A)	Acetone + $CHCl_3$	(p)	$\Delta S_{mix.} > 0$
(B)	Ethanol + Water	(q)	$\Delta V_{mix.} > 0$
(C)	$C_2H_5Br + C_2H_5I$	(r)	$\Delta H_{mix.} < 0$
(D)	Acetone + Benzene	(s)	Maximum boiling azeotropes
		(t)	Minimum boiling azeotropes

Exercise-2

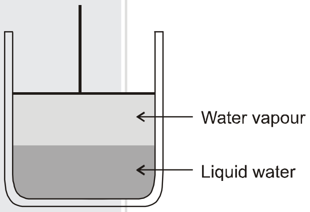
✍ **Marked questions are recommended for Revision.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. All of the water in a 0.20 M solution of NaCl was evaporated and a 0.150 mol of NaCl was obtained. What was the original volume of the sample ?
(A) 30 mL (B) 333 mL (C) 750 mL (D) 1000 mL

2.✍ A 20.0 mL sample of $CuSO_4$ solution was evaporated to dryness, leaving 0.967 g of residue. What was the molarity of the original solution ? (Cu = 63.5)
(A) 48.4 M (B) 0.0207 M (C) 0.0484 M (D) 0.303 M

3.✍ The vapour pressure of water at 20°C is 17.54 mmHg. What will be the vapour pressure of the water in the apparatus shown after the piston is lowered, decreasing the volume of the gas above the liquid to one half of its initial volume (assume temperature constant).
(A) 8.77 mmHg (B) 17.54 mmHg
(C) 35.08 mmHg (D) between 8.77 and 17.54 mmHg

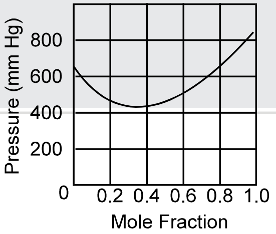


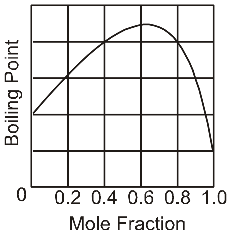
4.✍ A sample of air is saturated with benzene (vapor pressure = 100 mm Hg at 298 K) at 298K, 750mm Hg pressure. If it is isothermally compressed to one third of its initial volume, the final pressure of the system is
(A) 2250 torr (B) 2150 torr (C) 2050 torr (D) 1950 torr

5. Water and chlorobenzene are immiscible liquids. Their mixture boils at 89ºC under a reduced pressure of 7.7×10^4 Pa. The vapour pressure of pure water at 89ºC is 7×10^4 Pa. Weight percent of chlorobenzene in the distillate is:
(A) 50 (B) 60 (C) 78.3 (D) 38.46

6. If two liquids A (P^o_A =100 torr) and B (P^o_B = 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) less than 200 torr (C) between 100 to 200 torr (D) 300 torr

7.✍ Given P-x curve for a non-ideal liquid mixture (Fig.). Identify the correct T-x curve for the same mixture.



(A)


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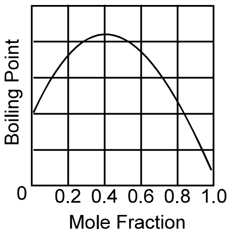

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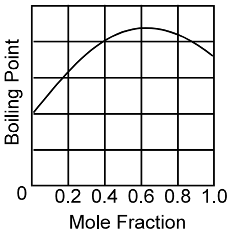

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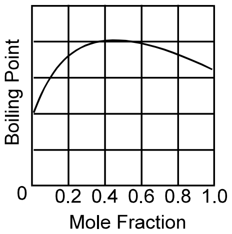


8.✍ If vapour pressures of pure liquids 'A' & 'B' are 300 and 800 torr respectively at 25°C. When these two liquids are mixed at this temperature to form a solution in which mole percentage of 'B' is 92, then the total vapour pressure is observed to be 0.95 atm. Which of the following is true for this solution.
(A) $\Delta V_{mix} > 0$ (B) $\Delta H_{mix} < 0$ (C) $\Delta V_{mix} = 0$ (D) $\Delta H_{mix} = 0$

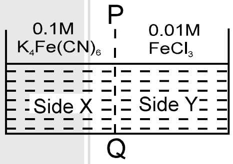
9.✍ Barium ions, CN^- and Co^{2+} form an ionic complex. If that complex is supposed to be 75% ionised in water with vant Hoff factor 'i' equal to four, then the coordination number of Co^{2+} in the complex can be:
(A) Six (B) Five (C) Four (D) Six and Four both

10. In the following aqueous solutions (a) 1 m sucrose, (b) 1 m potassium ferricyanide and (c) 1 m potassium sulphate
Maximum value of vapour pressure of solution is that of :
(A) a (B) b (C) c (D) equal

11.✍ When only a little quantity of $HgCl_2(s)$ is added to excess KI(aq) to obtain a clear solution, which of the following is true for this solution? (no volume change on mixing).
The reaction is $4KI(aq.) + HgCl_2(s) \longrightarrow K_2[HgI_4]\ (aq.) + 2KCl\ (aq.)$
(A) Its boiling and freezing points remain same
(B) Its boiling point is lowered
(C) Its vapour pressure become lower
(D) Its boiling point is raised
(E) Its freezing point is lowered.

12.✍ x mole of KCl and y mole of $BaCl_2$ are both dissolved in 1 kg of water. Given that x + y = 0.1 and K_f for water is 1.85 K/molal, what is the observed range of ΔT_f, if the ratio of x to y is varied ?
(A) 0.37° to 0.555° (B) 0.185° to 0.93° (C) 0.56° to 0.93° (D) 0.37° to 0.93°

13.✍ $FeCl_3$ on reaction with $K_4[Fe(CN)_6]$ in aq. solution gives blue colour. These are separated by a semipermeable membrane PQ as shown. Due to osmosis there is-



(A) blue colour formation in side X
(B) blue colour formation in side Y
(C) blue colour formation in both of the sides X and Y
(D) no blue colour formation

14.✍ Two beakers, one containing 20 ml of a 0.05 M aqueous solution of a non volatile, non electrolyte and the other, the same volume of 0.03 M aqueous solution of NaCl, are placed side by side in a closed enclosure. What are the volumes in the two beakers when equilibrium is attained ? Volume of the solution in the first and second beaker are respectively.
(A) 21.8 ml and 18.2 mL (B) 18.2 mL and 21.8 mL
(C) 20 mL and 20 mL (D) 17.1 mL and 22.9 mL

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1.✍ What volume of 98% sulphuric acid (in ml) should be mixed with water to obtain 200 mL of 15% solution of sulphuric acid by weight ? Given density of $H_2O = 1.00\ g\ cm^{-3}$, sulphuric acid (98%) = $1.88\ g\ cm^{-3}$ and sulphuric acid (15%) = $1.12\ g\ cm^{-3}$.

2.✍ At 300 K, 40 mL of O_3 (g) dissolves in 100 g of water at 1.0 atm. What mass of ozone (in gram) dissolved in 1600 g of water at a pressure of 4.0 atm at 300 K?

3.✍ An ideal aqueous solution containing liquid A(M.Wt. = 128) 64% by weight has a vapour pressure of 145 mm Hg. If the vapour pressure of A is x mm of Hg and that of water is 155 mm Hg at the same temperature. Then find x/5. The solutions is ideal.

4. A and B form ideal solutions; at 50ºC, P_A^o is half P_B^o. A solution containing 0.2 mole of A and 0.8 mole of B has a normal bolling point of 50ºC. Find 18 × P_B^o. (P_B^o is in atm)

5. The vapour pressure of pure liquid A at 300 K is 577 Torr and that of pure liquid B is 390 Torr. These two compounds form ideal liquid and gaseous mixtures. Consider the equilibrium composition of a mixture in which the mole fraction of A in the vapour is 0.35. Find the mole % of A in liquid.

6. How many facts related to $CHCl_3$ + ethylmethylketone solution are correct ?
(a) It shows negative derivation.
(b) It forms maximum boiling azeotropic mixture
(c) $\Delta S > 0$
(d) $\Delta G < 0$
(e) Components can be separated by fractional distillation.

7. How many of the following solutions show negative deviation from Raoult's Law ?

	Liquid A	+	Liquid B
(i)	$(CH_3)_2CO$	+	CS_2
(ii)	CCl_4	+	C_6H_6
(iii)	CCl_4	+	$CHCl_3$
(iv)	H_2O	+	C_2H_5OH
(v)	$(C_2H_5)_2O$	+	$(CH_3)_2CO$
(vi)	CH_3COOH	+	C_5H_5N (pyridine)
(vii)	$C_6H_5NH_2$	+	$(CH_3)_2CO$
(viii)	C_6H_5Cl	+	C_6H_5Br
(ix)	Cyclohexane	+	Ethanol

8. 0.1 mole XY_2 is dissolved in 2L water, where it ionizes to give X^{2+} and Y_2^{2-}. Observed osmotic pressure is 3 atm. Molar mass of X is 24 and Y is 32. Find $M_{observed} + 2i$ (where $M_{observed}$ is observed molar mass of XY_2). (Use R = 1/12 L-atm/mol.K and temperature is 87°C)

9. How many grams of sucrose ($C_{12}H_{22}O_{11}$) must be dissolved in 90 g of water to produce a solution over which the relative humidity is 80%? Assume the solution is ideal. Give your answer after dividing by 10.

10. 1.22 g of a monobasic acid is dissolved in 100 g of benzene. Boiling point of solution increases by 0.13ºC with respect to pure benzene. Find the molecular mass of acid in benzene solvent (in u). Report your answer after dividing it by 100 and Round it off to nearest integer.
(K_b of benzene = 2.6 K kg mol^{-1}).

11. 1 g of a monobasic acid dissolved in 200 g of water lowers the freezing point by 0.186ºC. On the other hand when 1 g of the same acid is dissolved in water so as to make the solution 200 mL, this solution requires 125 mL of 0.1 M NaOH for complete neutralization. Calculate % dissociation of acid ? (K_f $=1.86\,\frac{K-kg}{mol}$)

12. At 27ºC, a 1.2% solution (wt./vol.) of glucose is isotonic with 4.0 g/litre of solution of solute X. Find the molar mass of X, if the molar mass of glucose is 180. (R = 0.082 L atm mol^{-1} K^{-1}, Molar mass of glucose = 180 g/mole)

13. 10 g of solute A and 20 g of solute B both are dissolved in 500 ml. of water. The solution has the same osmotic pressure as 6.67 g of A and 30 g of B are dissolved in the same volume of water at the same temperature. If the ratio of molar masses of A and B is x/y, find x + y.

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. We have 100 mL of 0.1 M KCl solution. To make it 0.2 M,
(A) evaporate 50 mL water (B) evaporate 50 mL solution
(C) add 0.1 mol KCl (D) add 0.01 mol KCl

2. Which of the following concentration factors can be calculated if the mole fraction and density of an aqueous solution of HCl are known ?
(A) Molality (B) Molarity (C) Percent by mass (D) Normality

3. The vapour pressure of a dilute solution of a solute is influenced by :
(A) Temperature of solution (B) Mole fraction of solute
(C) M.pt. of solute (D) Degree of dissociation of solute

4. According to Henry's law, the partial pressure of gas (P'_g) is directly proportional to mole fraction of gas in dissolved state , i.e., $P_{gas}' = K_H . X_{gas}$ where K_H is Henry's constant. Which are correct ?
(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 increases with temperature

5.✍ Select correct statements :
(A) Gases which have high value of van der Waals constant ‘a’ are easily liquefied
(B) Easily liquefiable gases are water soluble
(C) Gases which forms ions in a solvent are soluble in that solvent
(D) Under same conditions, NH_3 has low solubility in water than that of CO_2.

6.✍ Two liquids X and Y are perfectly immiscible. If X and Y have molecular masses in ratio 1 : 2, the total vapour pressure of a mixture of X and Y prepared in weight ratio 2 : 3 should be (P_x^0 = 400 torr, P_y^0 = 200 torr)
(A) 600 torr (B) 400 torr (C) 800 torr (D) 1000 torr

7.✍ Which is/are true about ideal solutions ?
(A) The volume change on mixing is zero (B) The enthalpy of mixing is zero
(C) The entropy of mixing is zero (D) The enthalpy of mixing is negative

8. At 40ºC, vapour pressure in Torr of methanol and ethanol solution is P = 119x + 135 where x is the mole fraction of methanol. Hence
(A) vapour pressure of pure methanol is 119 Torr
(B) vapour pressure of pure ethanol is 135 Torr
(C) vapour pressure of equimolar mixture of each is 127 Torr
(D) mixture is completely immiscible

9. Which is/are correct statement(s) ?
(A) When mixture is more volatile than both pure components, there is positive deviation from Raoult’s law.
(B) When mixture is less volatile than both pure components, there is negative deviation from Raoult’s law.
(C) Ethanol and water form ideal solution
(D) $CHCl_3$ and water form ideal solution

10.✍ At 35°C, the vapour pressure of CS_2 is 512 mm Hg, and of acetone is 344 mm Hg. A solution of CS_2 and acetone in which the mole fraction of CS_2 is 0.25, has a total vapour pressure of 600 mm Hg. Which of the following statements is/are correct ?
(A) A mixture of 100 mL of acetone and 100 mL of CS_2 has a volume of 200 mL
(B) When acetone and CS_2 are mixed at 35°C, heat must be absorbed in order to produce a solution at 35°C.
(C) Process of mixing is exothermic
(D) Entropy of mixing is zero

11. For the given electrolyte A_xB_y, the degree of dissociation 'α' can be given as
(A) $\alpha = \frac{i-1}{x+y-1}$ (B) $i = (1-\alpha) + x\alpha + y\alpha$ (C) $\alpha = \frac{1-i}{1-x-y}$ (D) None

12.✍ In which of the following pairs of solutions will the values of the vant Hoff factor be the same?
(A) 0.05 M $K_4[Fe(CN)_6]$ and 0.10 M $FeSO_4$
(B) 0.10 M $K_4[Fe(CN)_6]$ and 0.05 M $FeSO_4\,(NH_4)_2SO_4.\,6H_2O$
(C) 0.20 M NaCl and 0.10 M $BaCl_2$
(D) 0.05 M $FeSO_4\,(NH_4)_2SO_4.6H_2O$ and 0.02 M $KCl.MgCl_2.6H_2O$

13. 2 g of non-volatile hydrocarbon solute dissolved in 100 g of hypothetical organic solvent (molar mass = 50) was found to lower vapour pressure from 75.50 to 75 mm of Hg at 20°C. Given that hydrocarbon contains 96% of C. Then which of the following are true ?
(A) molecular wt of solute = 150 (B) molecular formula = $C_{12}H_6$
(C) molecular wt. of solute = 132 (D) none of these

14.✍ In the depression of freezing point experiment, it is found that the :
(A) Vapour pressure of the solution is less than that of pure solvent
(B) Vapour pressure of the solution is more than that of pure solvent
(C) Only solute molecules solidify at the freezing point
(D) Only solvent molecules solidify at the freezing point

15. Consider following solutions :
I : 1 M aqueous glucose solution
II : 1M aqueous sodium chloride solution
III : 1M aqueous ammonium phosphate solution
IV : 1M benzoic acid in benzene
Select correct statements for the above solutions :
(A) All are isotonic solutions
(B) III is hypertonic of I, II and IV
(C) IV is hypotonic of I, II and III
(D) II is hypotonic of III but hypertonic of I and IV

16. Which facts are true when we use van't Hoff equation PV = nST for osmotic pressure P of dilute solutions?
(A) The equation is identical to that of ideal gas equation
(B) The solute particles in solution are analogous to the gas molecules and the solvent is analagous to the empty space between the gas molecules
(C) Solute molecules are dispersed in the solvent the way the gas molecules are dispersed in empty space
(D) The equation is not identical to that of ideal gas equation

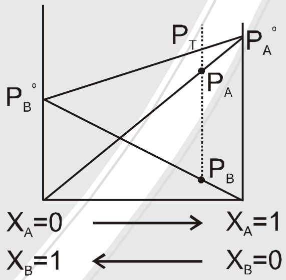
PART - IV : COMPREHENSIONS

Read the following passage carefully and answer the questions.

Comprehension # 1

$P_A = x_A P_A^{\circ}$ & $P_B = x_B P_B^{\circ}$

$P_T = x_A P_A^{\circ} + x_B P_B^{\circ}$ (Note : $P_A^{\circ} > P_B^{\circ}$; A is more volatile than B)



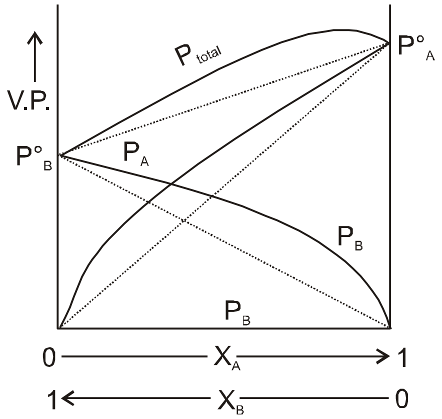
Vapour pressure of mixtures of Benzene (C_6H_6) & toluene (C_7H_8) at 50ºC are given by $P_M = 179\ X_B + 92$, where X_B is mole fraction of C_6H_6.

1. What is vapour pressure of pure liquids ?
(A) $P_B^{\circ} = 92$ mm, $P_T^{\circ} = 179$ mm
(B) $P_B^{\circ} = 271$ mm, $P_T^{\circ} = 92$ mm
(C) $P_B^{\circ} = 180$ mm, $P_T^{\circ} = 91$ mm
(D) none of these

2. Vapour pressure of liquid mixture obtained by mixing 936 g C_6H_6 & 736 g tolene is :
(A) 300 mm Hg (B) 250 mm Hg (C) 199.4 mm Hg (D) 180.6 mm Hg

Comprehension # 2

Answer the questions (given below) which are based on the following diagram. Consider some facts about the above phase diagram: Vapour pressure diagram for real solutions of two liquids A and B that exhibit a positive deviation from Raoult's law. The vapour pressure of both A and B are greater than predicted by Raoult's law. The dashed lines represented the plots for ideal solutions.



3.✍ A : This is observed when A...B attractions are greater than average of A...A and B...B attraction:
B : ΔH_{mix} = +ve, ΔV_{mix} = +ve
C : Boiling point is smaller than expected such that vaporisation is increased
D : Mixture can form azeotropic mixture
Select correct facts
(A) A, B, C (B) B, C, D (C) A, C, D (D) A, B, C, D

4.✍ Total vapour pressure of mixture of 1 mol of volatile component A (p°_A = 100 mm Hg) and 3 mol of volatile component B (p°_B = 60 mm Hg) is 75 mm. 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.

Comprehension # 3

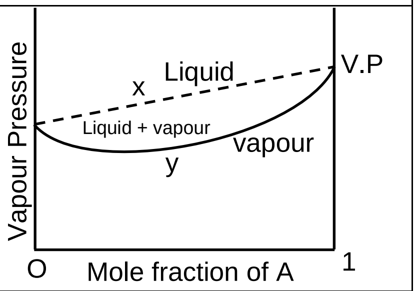
Addition of non-volatile solute to a solvent always increases the colligative properties such as osmotic pressure, ΔP, ΔT_b and ΔT_f. All these colligative properties are directly proportional to molality if solutions are dilute. The increases in colligative properties on addition of non-volatile solute is due to increase in number of solute particles.

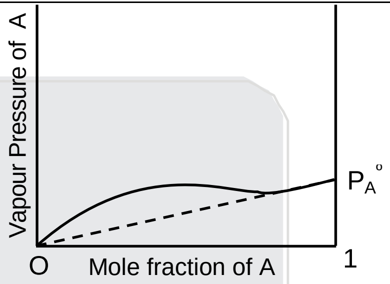
5.✍ For different aqueous solutions of 0.1 M NaCl, 0.1 M urea, 0.1 M Na_2SO_4 and 0.1 M Na_3PO_4 solution at 27ºC, the correct statements are : (Consider the solutions to be dilute)
1. The order of osmotic pressure is, NaCl > Na_2SO_4 > Na_3PO_4 > urea
2. $\pi = \frac{\Delta T_b}{K_b} \times ST$ for urea solution
3. Addition of salt on ice increases its melting point
4. Addition of salt on ice brings in melting of ice earlier
(A) 2, 3, 4 (B) 2, 4 (C) 1, 2, 3 (D) 3, 4

6.✍ 1 g mixture of glucose and urea present in 250 mL aqueous solution shows the osmotic pressure of 0.74 atm at 27ºC. Assuming solution to be dilute, which are correct ?
1. Percentage of urea in mixture is 17.6.
2. Relative lowering in vapour pressure of this solution is 5.41×10^{-4}.
3. The solution will boil at 100.015ºC, if K_b of water is 0.5 K molality^{-1}.
4. If glucose is replaced by same amount of sucrose, the solution will show higher osmotic pressure at 27ºC.
5. If glucose is replaced by same amount of NaCl, the solution will show lower osmotic pressure at 27ºC.
(A) 1, 2, 3 (B) 1, 2, 3, 5 (C) 2, 4, 5 (D) 1, 4, 5

Comprehension # 4

Let us consider a binary solution of two volatile liquids 'A' and 'B', when taken in a closed container. Both the components would evaporate and an equilibrium would be established between vapour phase and liquid phase. Let the total vapour pressure at this stage be p_{total} and p_A and p_B are partial pressures of A and B. Mole fractions of these components in liquid solution are x_A and x_B, that of vapour phase are y_A and y_B respectively p^o_A & p^o_B are vapour pressure of pure A & pure B.

Column-I	Column-II	Column-III
(i) Ideal solution	(a) $p_T = p^o_A x_A + p^o_B x_B$	(P) 

(ii) Non ideal solution (Positive deviation)	(b) $\left.\begin{array}{l}\text{A—A interactions}\\ \text{B—B interactions}\end{array}\right] \neq$ A—B interactions	(Q) $P_T = P°_A + P°_B$
(iii) Non ideal solution (negative deviation)	(c) Form azeotropic mixture	(R) $\Delta S_{surrounding}$ = +ve
(iv) Immiscible liquids	(d) solution having vapours of fixed composition	(S) 

7. For Hexane + Heptane → solution correct set is :
(A) (i) (a) (R) (B) (ii) (b) (P) (C) (ii) (d) (R) (D) (i) (a) (P)

8. For water + ethanol → solution correct set is :
(A) (ii) (b) (Q) (B) (ii) (c) (S) (C) (iv) (d) (S) (D) (iv) (c) (R)

9. For water + H_2SO_4 → solution correct set is
(A) (i) (a) (P) (B) (ii) (b) (Q) (C) (iii) (b) (R) (D) (iv) (c) (P)

10. For a mixture of water and chlorobenzene correct set is
(A) (i) (a) (P) (B) (ii) (b) (Q) (C) (iii) (b) (R) (D) (iv) (d) (Q)

Exercise-3

*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. In the depression of freezing point experiment, it is found that : **[JEE 1999, 3/80]**
I. The vapour pressure of the solution is less than that of pure solvent.
II. The vapour pressure of the solution is more than that of pure solvent.
III. Only solute molecules solidify at the freezing point.
IV. Only solvent molecules solidify at the freezing point.
(A) I, II (B) II, III (C) I, IV (D) I, II, III.

2. The van't Hoff factor for 0.1 M $Ba(NO_3)_2$ solution is 2.74. The degree of dissociation is : **[JEE 1999, 3/80]**
(A) 91.3% (B) 87% (C) 100% (D) 74%

3. To 500 cm^3 of water, 3.0×10^{-3} kg of acetic acid is added. If 23% of acetic acid is dissociated, what will be the depression in freezing point? k_f and density of water are 1.86 K $kgmole^{-1}$ and 0.997 g cm^{-3} respectively **[JEE 2000, 3/35]**

4. During depression of freezing point in a solution, the following are in equilibrium : **[JEE 2003, 3/84]**
(A) Liquid solvent-solid solvent (B) Liquid solvent-solid solute
(B) Liquid solute-solid solute (D) Liquid solute-solid solvent

5. A 0.004 M solution of Na_2SO_4 is isotonic with 0.010 M solution of glucose at same temperature. The apparent percentage dissociation of Na_2SO_4 is : **[JEE 2004, 3/84]**
(A) 25% (B) 50% (C) 75% (D) 85%

6. 1.22 g of benzoic acid is dissolved in 100 g of acetone and 100 g of benzene separately. Boiling point of the solution in acetone increases by 0.17ºC, while that of, in the benzene increases by 0.13ºC ; K_b for acetone and benzene is 1.7 K kg mol^{-1} and 2.6 K kg mol^{-1}. Find molecular weight of benzoic acid in two cases and justify your answer. **[JEE 2004, 4/60]**

7. The elevation in boiling point of a solution of 13.44 g of $CuCl_2$ in 1kg of water using the following information, will be (Molecular weight of $CuCl_2$ = 134.4 and K_b = 0.52 K $molal^{-1}$) : **[JEE 2005, 3/84]**
(A) 0.16 (B) 0.05 (C) 0.1 (D) 0.2

8. When 20 g of naphthoic acid ($C_{11}H_8O_2$) is dissolved in 50 g of benzene (K_f = 1.72 K kg mol^{-1}), a freezing point depression of 2 K is observed. The van't Hoff factor (i) is : **[JEE-2007, 3/162]**
(A) 0.5 (B) 1 (C) 2 (D) 3

Comprehension #

Properties such as boiling point, freezing point and vapour pressure of a pure solvent change when solute molecules are added to get homogeneous solution. These are called colligative properties. Application of colligative properties are very useful in day-to-day life. One of its example is the use of ethylene glycol and water mixture as anti-freezing liquid in the radiator of automobiles

A solution **M** is prepared by mixing ethanol and water. The mole fraction of ethanol in the mixture is 0.9

Given : Freezing point depression constant of water (K_f^{water}) = 1.86 K kg mol^{-1}
Freezing point depression constant of ethanol ($K_f^{ethanol}$) = 2.0 K kg mol^{-1}
Boiling point elevation constant of water (K_b^{water}) = 0.52 K kg mol^{-1}
Boiling point elevation constant of ethanol ($K_b^{ethanol}$) = 1.2 K kg mol^{-1}
Standard freezing point of water = 273 K
Standard freezing point of ethanol = 155.7 K
Standard boiling point of water = 373 K
Standard boiling point of ethanol = 351.5 K
Vapour pressure of pure water = 32.8 mm Hg
Vapour pressure of pure ethanol = 40 mm Hg
Molecular weight of water = 18 g mol^{-1}
Molecular weight of ethanol = 46 g mol^{-1}

In answering the following questions, consider the solution to be ideal dilute solutions and solutes to be non-volatile and non-dissociative.

9. The freezing point of the solution **M** is **[JEE 2008, 3/163]**
(A) 268.7 K (B) 268.5 K (C) 234.2 K (D) 150.9 K

10. The vapour pressure of the solution **M** is **[JEE 2008, 3/163]**
(A) 39.3 mm Hg (B) 36.0 mm Hg (C) 29.5 mm Hg (D) 28.8 mm Hg

11. Water is added to the solution **M** such that the mole fraction of water in the solution becomes 0.9. The boiling point of this solution is **[JEE 2008, 3/163]**
(A) 380.4 K (B) 376.2 K (C) 375.5 K (D) 354.7 K

12. The Henry's law constant for the solubility of N_2 gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.8. The number of moles of N_2 from air dissolved in 10 moles of water of 298 K and 5 atm pressure is : **[JEE 2009, 3/160]**
(A) 4×10^{-4} (B) 4.0×10^{-5} (C) 5.0×10^{-4} (D) 4.0×10^{-6}

13. The freezing point (in ºC) of a solution containing 0.1 g of $K_3[Fe(CN)_6]$ (Mol. Wt. 329) in 100 g of water (K_f = 1.86 K kg mol^{-1}) is : **[JEE 2011, 3/180]**
(A) -2.3×10^{-2} (B) -5.7×10^{-2} (C) -5.7×10^{-3} (D) -1.2×10^{-2}

14. For a dilute solution containing 2.5 g of a non- volatile non- electrolyte solute in 100 g of water, the elevation in boiling point at 1 atm pressure is 2ºC. Assuming concentration of solute is much lower than the concentration of solvent, the vapour pressure (mm of Hg) of the solution is (take K_b = 0.76 K kg mol^{-1}) **[IIT 2012, 3/136]**
(A) 724 (B) 740 (C) 736 (D)718

15.* Benzene and naphthalene form an ideal solution at room temperature. For this process, the true statement(s) is (are) : **[JEE(Advanced) 2013, 4/120]**

(A) ΔG is positive
(B) ΔS_{system} is positive
(C) $\Delta S_{surroundings} = 0$
(D) $\Delta H = 0$

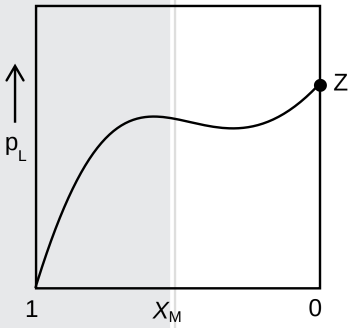
16. **MX_2** dissociates into **M^{2+}** and **X** ions in an aqueous solution, with a degree of dissociation (α) of 0.5. The ratio of the observed depression of freezing point of the aqueous solution to the value of the depression of freezing point in the absence of ionic dissociation is **[JEE(Advanced) 2014, 3/120]**

17. If the freezing point of a 0.01 molal aqueous solution of a cobalt(III) chloride-ammonia complex (which behaves as a strong electrolyte) is –0.0558ºC, the number of chloride(s) in the coordination sphere of the complex is [K_f of water = 1.86 K kg mol^{-1}] **[JEE(Advanced) 2015 4/168]**

18*. Mixture(s) showing positive deviation from Raoult's law at 35ºC is(are) **[JEE(Advanced) 2016, 4/124]**

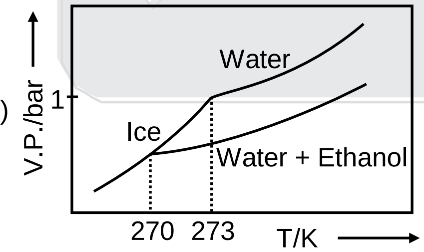
(A) carbon tetrachloride + methanol
(B) carbon disulphide + acetone
(C) benzene + toluene
(D) phenol + aniline

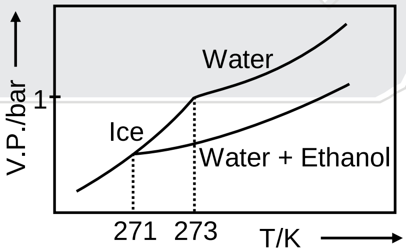
19.* For a solution formed by mixing liquids **L** and **M**, the vapour pressure of **L** plotted against the mole fraction of **M** in solution is shown in the following figure. Here x_L and x_M represent mole fractions of **L** and **M**, respectively, in the solution. The correct statement(s) applicable to this system is (are) **[JEE(Advanced) 2017, 4/122]**

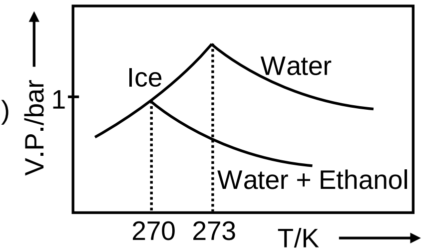


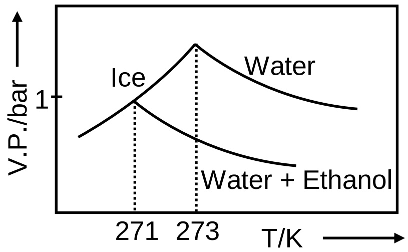
(A) The point **Z** represents vapour pressure of pure liquid **M** and Raoult's law is obeyed from $x_L = 0$ to $x_L = 1$.
(B) Attractive intermolecular interactions between **L-L** in pure liquid **L** and **M-M** in pure liquid **M** are stronger than those between **L-M** when mixed in solution
(C) The point **Z** represents vapour pressure of pure liquid **M** and Raoult's law is obeyed when $x_L \to 0$
(D) The point **Z** represents vapour pressure of pure liquid **L** and Raoult's law is obeyed when $x_L \to 1$

20. Pure water freezes at 273 K and 1 bar. The addition of 34.5 g of ethanol to 500 g of water changes the freezing point of the solution. Use the freezing point depression constant of water as 2 K kg mol^{-1}. The figures shown below represent plots of vapour pressure (V.P.) versus temperature (T). [molecular weight of ethanol is 46 g mol^{-1}] **[JEE(Advanced) 2017, 3/122]**
Among the following, the option representing change in the freezing point is

(A)


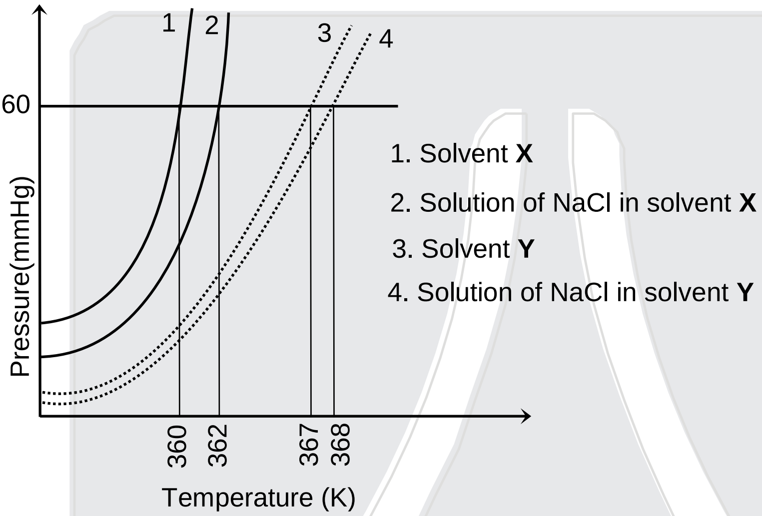
(B)


(C)


(D)


21. Liquids **A** and **B** form ideal solution over the entire range of composition. At temperature T, equimolar binary solution of liquids **A** and **B** has vapour pressure 45 Torr. At the same temperature, a new solution of **A** and **B** having mole fractions x_A and x_B, respectively, has vapour pressure of 22.5 Torr. The value of x_A / x_B in the new solution is ____. **[JEE(Advanced) 2018, 3/120]**
(given that the vapour pressure of pure liquid **A** is 20 Torr at temperature T)

22. The plot given below shows P–T curves (where P is the pressure and T is the temperature) for two solvents X and Y and isomolal solutions of NaCl in these solvents. NaCl completely dissociates in both the solvents.



On addition of equal number of moles of a non-volatile solute **S** in equal amount (in kg) of these solvents, the elevation of boiling point of solvent **X** is three times that of solvent **Y**. Solute **S** is known to undergo dimerization in these solvents. If the degree of dimerization is 0.7 in solvent **Y**, the degree of dimerization in solvent **X** is ____. **[JEE(Advanced) 2018, 3/120]**

23. On dissolving 0.5 g of a non-volatile non-ionic solute to 39 g of benzene, its vapor pressure decreases from 650 mm Hg to 640 mm Hg. The depression of freezing point of benzene (in K) upon addition of the solute is ______ (Given date : Molar mass and the molal freezing point depression constant of benzene are 78 g mol^{-1} and 5.12 K kg mol^{-1}, respectively) **[JEE(Advanced) 2019, 3/124]**

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

OFFLINE PROBLEMS

1. 6.02×10^{20} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is: **[AIEEE-2004, 3/225]**
(1) 0.001 M (2) 0.01 M (3) 0.02 M (4) 0.1 M.

2. Which one of the following aqueous solutions will exhibit highest boiling point? **[AIEEE-2004, 3/225]**
(1) 0.01 M Na_2SO_4 (2) 0.01 M KNO_3 (3) 0.015 M urea (4) 0.015 M glucose

3. If α is the degree of dissociation of Na_2SO_4, the vant Hoff's factor (i) used for calculating the molecular mass is : **[AIEEE-2005], 1½/225]**
(1) $1 + \alpha$ (2) $1 - \alpha$ (3) $1 + 2\alpha$ (4) $1 - 2\alpha$.

4. Equimolar solutions in the same solvent have : **[AIEEE-2005], 3/225]**
(1) same boiling point but different freezing point (2) same freezing point but different boiling point
(3) same boiling and same freezing points (4) differnet boiling and freezing points

5. Benzene and toluene form nearly ideal solutions. At 20ºC, the vapour pressure of benzene is 75 torr and that of toluene is 22 torr. The partial vapour pressure of benzene at 20 ºC for a solution containing 78 g of benzene and 46 g of toluene in torr is : **[AIEEE-2005], 3/225]**
(1) 50 (2) 25 (3) 37.5 (4) 53.5

6. A mixture of ethyl alcohol and propyl alcohol has a vapour pressure of 290 mm at 300 K. The vapour pressure of propyl alcohol is 200 mm. If the mole fraction of ethyl alcohol is 0.6, its vapour pressure (in mm) at the same temperature will be : **[AIEEE-2007, 3/120]**
(1) 700 (2) 360 (3) 350 (4) 300

7. A 5.25% solution of a substance is isotonic with a 1.5% solution of urea (molar mass = 60g mol^{-1}) in the same solvent. If the densities of both the solutions are assumed to be equal to 1.0 g cm^{-3}, molar mass of the substance will be **[AIEEE-2007, 3/120]**
(1) 105.0 g mol^{-1} (2) 210.0 g mol^{-1} (3) 90.0 g mol^{-1} (4) 15.0 g mol^{-1}

8. The vapour pressure of water at 20ºC is 17.5 mm Hg. If 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2g of water at 20°C, the vapour pressure of the resulting solution will be : **[AIEEE-2008, 3/105]**
(1) 15.750 mm Hg (2) 16.500 mm Hg (3) 17.325 mm Hg (4) 17.675 mm Hg

9. At 80ºC, the vapour pressure of pure liquid 'A' is 520 mm Hg and that of pure liquid 'B' is 1000 mm Hg. If a mixture solution of 'A' and 'B' boils at 80ºC and 1 atm pressure, the amount of 'A' in the mixture is (1 atm = 760 mm Hg) **[AIEEE-2008, 3/105]**
(1) 34 mol percent (2) 48 mol percent (3) 50 mol percent (4) 52 mol percent

10. A binary liquid solution is prepared by mixing n-heptane and ethanol. Which one of the following statement is correct regarding the behaviour of the solution ? **[AIEEE-2009, 4/144]**
(1) The solution is non-ideal, showing +ve deviation from Raoult's Law.
(2) The solution in non-ideal, showing –ve deviation from Raoult's Law.
(3) n-heptane shows +ve deviation while ethanol shows –ve deviation from Raoult's Law.
(4) The solution formed is an ideal solution.

11. Two liquids X and Y form an ideal solution. At 300K, vapour pressure of the solution containing 1 mol of X and 3 mol of Y is 550 mmHg. At the same temperature, if 1 mol of Y is further added to this solution, vapour pressure of the solution increases by 10 mmHg. Vapour pressure (in mmHg) of X and Y in their pure states will be, respectively : **[AIEEE-2009, 8/144]**
(1) 300 and 400 (2) 400 and 600 (3) 500 and 600 (4) 200 and 300

12. If sodium sulphate is considered to be completely dissociated into cations and anions in aqueous solution, the change in freezing point of water (ΔT_f), when 0.01 mole of sodium sulphate is dissolved in 1 kg of water, is (K_f = 1.86 K kg mol^{-1}) **[AIEEE-2010, 4/144]**
(1) 0.0372 K (2) 0.0558 K (3) 0.0744 K (4) 0.0186 K

13. On mixing, heptane and octane form an ideal solution. At 373 K, the vapour pressures of the two liquid components (heptane and octane) are 105 kPa and 45 kPa respectively. Vapour pressure of the solution obtained by mixing 25.0 g of heptane and 35 g of octane will be (molar mass of heptane = 100 g mol^{-1} and of octane = 114 g mol^{-1}) **[AIEEE-2010, 4/144]**
(1) 72.0 kPa (2) 36.1 kPa (3) 96.2 kPa (4) 144.5 kPa

14. K_f for water is 1.86 K kg mol^{-1}. If your automobile radiator holds 1.0 kg of water, how may grams of ethylene glycol ($C_2H_6O_2$) must you add to get the freezing point of the solution lowered to –2.8ºC ? **[AIEEE 2012, 4/120]**
(1) 72 g (2) 93 g (3) 39 g (4) 27 g

15. Consider separate solution of 0.500 M $C_2H_5OH(aq)$, 0.100 M $Mg_3(PO_4)_2(aq)$, 0.250 M KBr(aq) and 0.125 M $Na_3PO_4(aq)$ at 25°C. Which statement is **true** about these solution, assuming all salts to be strong electrolytes ? **[AIEEE 2014, 4/120]**
(1) They all have the same osmotic pressure.
(2) 0.100 M $Mg_3(PO_4)_2(aq)$ has the highest osmotic pressure.
(3) 0.125 M $Na_3PO_4(aq)$ has the highest osmotic pressure.
(4) 0.500 M $C_2H_5OH(aq)$ has the highest osmotic pressure.

16. The vapour pressure of acetone at 20ºC is 185 torr. When 1.2 g of a non-volatile substance was dissolved in 100 g of acetone at 20ºC, its vapour pressure was 183 torr. The molar mass (g mol^{-1}) of the substance is: **[JEE(Main) 2015, 4/120]**
(1) 32 (2) 64 (3) 128 (4) 488

17. 18 g glucosse ($C_6H_{12}O_6$) is added to 178.2 g water. The vapor pressure of water (in torr) for this aqueous solution is. **[JEE(Main) 2016, 4/120]**
(1) 76.0 (2) 752.4 (3) 759.0 (4) 7.6

18. The freezing point of benzene decreases by 0.45ºC when 0.2 g of acetic acid is added to 20 g of benzene. If acetic acid associates to form a dimer in benzene, percentage association of acetic acid in benzene will be : (K_f for benzene = 5.12 K kg mol^{-1}) **[JEE(Main) 2017, 4/120]**
(1) 80.4% (2) 74.6% (3) 94.6% (4) 64.6%

19. For 1 molal aqueous solution of the following compounds, which one will show the highest freezing point ? **[JEE(Main) 2018, 4/120]**
(1) $[Co(H_2O)_4Cl_2]Cl.2H_2O$ (2) $[Co(H_2O)_3Cl_3].3H_2O$
(3) $[Co(H_2O)_6]Cl_3$ (4) $[Co(H_2O)_5Cl]Cl_2.H_2O$

ONLINE PROBLEMS

1. Choose the correct statement with respect to the vapour pressure of a liquid among the following : **[JEE(Main) 2014 Online (19-04-14), 4/120]**
(1) Increases linearly with increasing temperature
(2) Increase non-linearly with increasing temperature
(3) Decreases linearly with increasing
(4) Decreases non-linearly with increasing temperature

2. The observed osmotic pressure for a 0.10 M solution of $Fe(NH_4)_2(SO_4)_2$ at 25ºC is 10.8 atm experimental (observed) and theoritical values of Van't Hoff factor (i) will be respectively : (R = 0.082 L atm k^{-1} mol^{-1}) **[JEE(Main) 2014 Online (19-04-14), 4/120]**
(1) 5 and 4.42 (2) 4 and 4.00 (3) 5 and 3.42 (4) 3 and 5.42

3. For an ideal solution of two components A and B, which of the following is true ? **[JEE(Main) 2014 Online (19-04-14), 4/120]**
(1) $\Delta H_{mixing} < 0$ (zero)
(2) $\Delta H_{mixing} > 0$ (zero)
(3) A–B interaction is stronger than A–A and B–B interactions
(4) A–A, B–B and A–B interactions are identical

4. A solution at 20ºC is composed of 1.5 mol of benzene and 3.5 mol of toluene. If the vapour pressure of pure benzene and pure toluene at this temperature are 74.7 torr and 22.3 torr, respectively, then the total vapour pressure of the solution and the benzene mole fraction in equilibrium with it will be, respectively : **[JEE(Main) 2015 Online (10-04-15), 4/120]**
(1) 35.0 torr and 0.480 (2) 30.5 torr and 0.389 (3) 38.0 torr and 0.589 (4) 35.8 torr and 0.280

5. Determination of the molar mass of acetic acid in benzene using freezing point depression is affected by : **[JEE(Main) 2015 Online (10-04-15), 4/120]**
(1) partial ionization (2) dissociation (3) complex formation (4) association

6. The solubility of N_2 in water at 300 K and 500 torr partial pressure is 0.01 g L^{-1}. The solubility (in g L^{-1}) at 750 torr partial pressure is : **[JEE(Main) 2016 Online (09-04-16), 4/120]**
(1) 0.02 (2) 0.015 (3) 0.0075 (4) 0.005

7. An aqueous solution of a salt MX_2 at certain temperature has a van’t Hoff factor of 2. The degree of dissociation for this solution of the salt is : **[JEE(Main) 2016 Online (10-04-16), 4/120]**
(1) 0.67 (2) 0.33 (3) 0.80 (4) 0.50

8. 5 g of Na_2SO_4 are was dissolved in x g of H_2O. The change in freezing point was found to be 3.82ºC. If Na_2SO_4 is 81.5% ionised, the value of x (K_f for water = 1.86ºC kg mol^{-1}) is approximately :
(molar mass of S = 32 g mol^{-1} and that of Na = 23 g mol^{-1}) **[JEE(Main) 2017 Online (08-04-17), 4/120]**
(1) 45 g (2) 65 g (3) 25 g (4) 15 g

9. A solution is prepared by mixing 8.5 g of CH_2Cl_2 and 11.95 g of $CHCl_3$. If vapour pressure of CH_2Cl_2 and $CHCl_3$ at 298 K are 415 and 200 mmHg respectively, the mole fraction of $CHCl_3$ in vapour form is :
(Molar mass of Cl = 35.5 g mol^{-1}) **[JEE(Main) 2017 Online 09-04-17), 4/120]**
(1) 0.675 (2) 0.162 (3) 0.486 (4) 0.325

10. Two 5 molal solutions are prepared by dissolving a non-electrolyte non-volotatile solute separately in the solvents X and Y. The molecular weights of the solvents are M_X and M_Y, respectively where $M_X = \frac{3}{4} M_Y$. The relative lowering of vapour pressure of the solution in X is "m" times that of the solution in Y. Given that the number of moles of solute is very small in comparison to that of solvent, the value of "m" is : **[JEE(Main) 2018 Online 15-04-18), 4/120]**
(1) $\frac{4}{3}$ (2) $\frac{3}{4}$ (3) $\frac{1}{2}$ (4) $\frac{1}{4}$

11. The mass of a non-volatile, non-electrolyte solute (molar mass = 50 g mol^{-1}) needed to be dissolved in 114 g octane to reduce its vapour pressure to 75 %, is : **[JEE(Main) 2018 Online 16-04-18), 4/120]**
(1) 37.5 g (2) 75 g (3) 150 g (4) 50 g

12. Which one of the following statements regarding Henry's law is not correct ?
[JEE(Main) 2019 Online 09-01-19), 4/120]
(1) Different gases have different K_H (Henry' law constant) values at the same temperature.
(2) The value of K_H increases with increase of temperature and K_H is function of the nature of the gas
(3) The partial pressure of the gas in vapour phase is proportional to the mole fraction of the gas in the solution.
(4) Higher the value of K_H at a given pressure, higher is the solubility of the gas in the liquids.

13. A solution containing 62 g ethylene glycol in 250 g water is cooled to –10ºC. If K_f for water is 1.86 K kg mol^{-1}, the amount of water (in g) separated as ice is: **[JEE(Main) 2019 Online 09-01-19), 4/120]**
(1) 16 (2) 32 (3) 48 (4) 64

14. Liquids A and B form an ideal solution in the entire composition range. At 350 K, the vapor pressures of pure A and pure B are 7×10^3 Pa and 12×10^3 Pa, respectively. The composition of the vapor in equilibrium with a solution containing 40 mole percent of A at this temperature is :
[JEE(Main) 2019 Online 10-01-19), 4/120]
(1) $x_A = 0.28$; $x_B = 0.72$ (2) $x_A = 0.76$; $x_B = 0.24$
(3) $x_A = 0.37$; $x_B = 0.63$ (4) $x_A = 0.4$; $x_B = 0.6$

15. Elevation in the boiling point for 1 molal solution of glucose is 2 k. The depression in the freezing point for 2 molal solution of glucose in the same solvent is 2 k. the relation between k_b and K_f is :
[JEE(Main) 2019 Online 10-01-19), 4/120]
(1) $K_b = 0.5K_f$ (2) $K_b = K_f$ (3) $K_b = 1.5\ K_f$ (4) $k_b = 2\ k_f$

16. The freezing point of a diluted milk sample is found to be –0.2°C, while it should have been –0.5°C for pure milk. How much water has been added to pure milk to make the diluted sample ?
[JEE(Main) 2019 Online 11-01-19), 4/120]
(1) 1 cup of water to 3 cups of pure milk (2) 1 cup of water of 2 cups of pure milk
(3) 2 cups of water to 3 cups of pure milk (4) 3 cups of water to 2 cups of pure milk

17. K_2HgI_4 is 40% ionised in aqueous solution. The value of its van't Hoff factor (i) is :
[JEE(Main) 2019 Online 11-01-19), 4/120]
(1) 1.8 (2) 1.6 (3) 2.0 (4) 2.2

18. Freezing point of a 4% aqueous solution of X is equal to freezing point of 12% aqueous solution of Y. If molecular weight of X is A, then molecular weight of Y is: **[JEE(Main) 2019 Online 12-01-19), 4/120]**
(1) 4A (2) 2A (3) 3A (4) A

19. Molecules of benzoic acid (C_6H_5COOH) dimerise in benzene. ‘w’ g of the acid dissolved in 30 g of benzene shows a depression in freezing point equal to 2 K. If the percentage association of the acid to form dimer in the solution is 80, then w is : **[JEE(Main) 2019 Online 12-01-19), 4/120]**
(Given that K_f = 5 kg mol^{-1}, Molar mass of benzoic acid = 122 g mol^{-1})
(1) 2.4 g (2) 1.8 g (3) 1.0 g (4) 1.5 g

20. The vapour pressures of pure liquids A and B are 400 and 600 mmHg, respectively at 298 K. On mixing the two liquids, the sum of their initial volumes is equal to the volume of the final mixture. The mole fraction of liquid B is 0.5 in the mixture. The vapour pressure of the final solution, the mole fractions of components A and B in vapour phase, respectively are: **[JEE(Main) 2019 Online (08-04-19)S1, 4/120]**

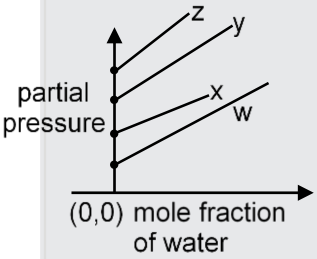
(1) 500 mm Hg, 0.4, 0.6 (2) 450 mmHg, 0.4, 0.6

(4) 500 mm Hg, 0.5, 0.5 (4) 450 mmHg, 0.5, 0.5

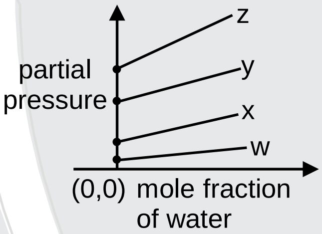
21. For the solution of the gases w, x, y and z in water at 298 K, the Henrys law constants (K_H) are 0.5, 2, 35 and 40 k bar, respectively. The correct plot for the given data is :

[JEE(Main) 2019 Online (08-04-19)S2, 4/120]

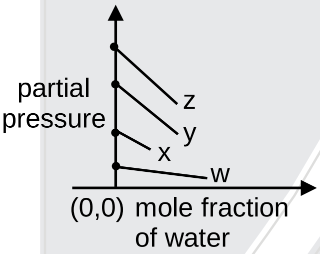
(1)



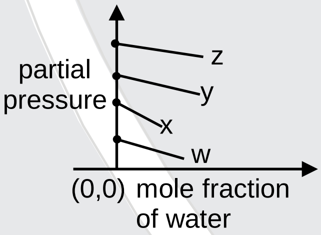
(2)



(3)



(4)



22. 0.27 g of a long chain fatty acid was dissolved in 100 cm^3 of hexane. 10 mL of this solution was added dropwise to the surface of water in a round watch glass. Hexane evaporates and a monolayer is formed. The distance from edge to cenre of the watch glass is 10 cm. What is the height of the monolayer? [Density of fatty acid = 0.9 g cm^{-3}, $\pi = 3$] **[JEE(Main) 2019 Online (08-04-19)S2, 4/120]**

(1) 10^{-2} m (2) 10^{-6} m (3) 10^{-8} m (4) 10^{-4} m

23. The osmotic pressure of a dilute solution of an ionic compound XY in water is four times that of a solution of 0.01 M $BaCl_2$ in water. Assuming complete dissociation of the given ionic compounds in water, the concentration of XY (in mol L^{-1}) in solution is: **[JEE(Main) 2019 Online (09-04-19)S1, 4/120]**

(1) 6×10^{-2} (2) 4×10^{-2} (3) 16×10^{-4} (4) 4×10^{-4}

24. Liquid 'M' and liquid 'N' form an ideal solution. The vapour pressures of pure liquids 'M' and 'N' are 450 and 700 mmHg, respectively, at the same temperature. Then correct statement is :

(x_M = Mole fraction of 'M' in solution; x_N = Mole fraction of 'N' in solution;
y_M = Mole fraction of 'M' in vapour phase; y_N = Mole fraction of 'N' in vapour phase)

[JEE(Main) 2019 Online (09-04-19)S1, 4/120]

(1) $\frac{x_M}{x_N} < \frac{y_M}{y_N}$ (2) $(x_M - y_M) < (x_N - y_N)$

(3) $\frac{x_M}{x_N} > \frac{y_M}{y_N}$ (4) $\frac{x_M}{x_N} = \frac{y_M}{y_N}$

25. Molal depression constant for a solvent is 4.0 K kg mol^{-1}.The depression in the freezing point of the solvent for 0.03 mol kg^{-1} solution of K_2SO_4 is : (Assume complete dissociation of the electrolyte)

[JEE(Main) 2019 Online (09-04-19)S2, 4/120]

(1) 0.12 K (2) 0.24 K (3) 0.36 K (4) 0.18 K

26. At room temperature, a dilute solution of urea is prepared by dissolving 0.60 g of urea in 360 g of water. If the vapour pressure of pure water at this temperature is 35 mm Hg, lowering of vapour pressure will be : (molar mass of urea = 60 g mol^{-1}) **[JEE(Main) 2019 Online (09-04-19)S1, 4/120]**

(1) 0.027 mmHg (2) 0.028 mmHg (3) 0.017 mmHg (4) 0.031 mmHg

27. 1 g of a non volatile non electrolyte solute is dissolved in 100 g of two different solvents A and B whose ebullioscopic constants are in the ratio of 1 : 5. The ratio of the elevation in their boiling points $\frac{\Delta T_b(A)}{\Delta T_b(B)}$ is : **[JEE(Main) 2019 Online (10-04-19)S2, 4/120]**

(1) 1 : 5 (2) 10 : 1 (3) 1 : 0.2 (4) 5 : 1

28. A solution is prepared by dissolving 0.6 g of urea (molar mass = 60g mol^{-1}) and 1.8g of glucose (molar mass = 180 g mol^{-1}) in 100 mL of water at 27°C. The osmotic pressure of the solution is: (R = 0.08206 L atm K^{-1} mol^{-1}) **[JEE(Main) 2019 Online (12-04-19)S2, 4/120]**

(1) 8.2 atm (2) 1. 64 atm (3) 2.46 atm (4) 4.92 atm

Answers

EXERCISE - 1

PART - I

A-1. Some of the characteristics of supersaturated solution are given below
(i) If a crystal of solute is added to supersaturated solution, crystallisation occurs rapidly.
(ii) Supersaturated solutions contain more solute than they should have at a particular temperature.

A-2. Certain compounds combine with the moisture of atmosphere and are converted into hydroxides or hydrates. Such substances are called hygroscopic. e.g., anhydrous $CuSO_4$, quick lime (CaO), anhydrous Na_2CO_3 etc.

A-3. The overall energy change associated with dissolution depends on the relative magnitude of the solute–solute, solvent–solvent and solute–solvent interactions. The process is exothermic if the new interaction release more energy than disrupting the old interactions requires, it is endothermic if opposite is true.

B-1. 0.04 g/mL **B-2.** (i) 30%, (ii) 0.046 (iii) $Na^+ = 5.42$ m, $S_2O_3^{2-} = 2.71$ m

B-3. Molality = 11.44 m, Molarity = 7.55 M

C-1. $P_{O_2} = 810$ mm Hg, $P_{H_2O} = 355$ mm Hg , $P_{total} = 1165$ mm Hg **C-2.** 2.4 atm

D-1. 7.62 bar **D-2.** 4 mmol. **E-1.** 5.15 g **E-2.** $\frac{W_W}{W_N} = 3.973$

F-1. $p_A{}^0 = 400$ mm of Hg, $p_B{}^0 = 600$ mm of Hg **F-2.** 27.3 mole %

F-3. $P_B{}^0 = 0.7$ atm & $P_A{}^0 = 1.9$ atm **F-4.** 14.16 mole percent benzene

F-5. $Y'_B = 0.932$. **G-1.** V < 80ml. **G-2.** There is positive deviation from Raoult's law, $\Delta S > 0$.

H-1.

Solute	Dissociation/association reaction	Degree of dissociation /association	n	i
KCl	$KCl \rightarrow K^+ + Cl^-$	1	2	2
H_2SO_4	$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$	1	3	3
CH_3COOH (in water)	$CH_3COOH \rightarrow H^+ + CH_3COO^-$	0.2	2	1.2
CH_3COOH (in benzene)	$2CH_3COOH \rightarrow (CH_3COOH)_2$	0.5	0.5	0.75
Urea	No association or dissociation	No association or dissociation	Not defined	1
NaBr	$NaBr \rightarrow Na^+ + Br^-$	0.8	2	1.8
A	$3A \rightarrow A_3$	1	0.33	0.33

H-2. 75% **I-1.** (a) 60 g/mol, (b) 333.3 g **I-2.** 746.2 mm of Hg

J-1. (a) M = 94.52, (b) m = 135 **J-2.** 232 **J-3.** S_8

J-4. 1.075, 7.5. **K-1.** (a) Urea < NaCl < Na_2SO_4 < Na_3PO_4 (b) 6.15 atm

K-2. $\alpha = 0.81$ **K-3.** 50% K_2SO_4 **K-4.** Volume must have been made 5 times

PART - II

A-1.	(B)	**A-2.**	(B)	**B-1.**	(B)	**C-1.**	(B)	**C-2.**	(C)
C-3.	(B)	**C-4.**	(B)	**D-1.**	(C)	**D-2.**	(A)	**D-3.**	(B)
D-4.	(D)	**D-5.**	(B)	**E-1.**	(C)	**F-1.**	(B)	**F-2.**	(C)
F-3.	(C)	**F-4.**	(A)	**F-5.**	(A)	**G-1.**	(C)	**G-2.**	(A)
G-3.	(A)	**G-4.**	(C)	**G-5.**	(A)	**G-6.**	(C)	**H-1.**	(C)

H-2.	(A)	**H-3.**	(B)	**H-4.**	(B)	**I-1.**	(B)	**I-2.**	(B)
I-3.	(B)	**I-4.**	(C)	**I-5.**	(B)	**I-6.**	(A)	**J-1.**	(D)
J-2.	(B)	**J-3.**	(A)	**J-4.**	(A)	**J-5.**	(C)	**J-6.**	(D)
J-7.	(A)	**J-8.**	(B)	**J-9.**	(B)	**K-1.**	(C)	**K-2.**	(A)
K-3.	(A)	**K-4.**	(A)						

PART - III

1. (A) – (r); (B) – (s); (C) – (q); (D) – (p)

2. (A) – (p,s,r); (B) – (p,q,t); (C) – (p); (D) – (p,q,t)

EXERCISE - 2

PART - I

1.	(C)	**2.**	(D)	**3.**	(B)	**4.**	(C)	**5.**	(D)
6.	(D)	**7.**	(B)	**8.**	(B)	**9.**	(B)	**10.**	(A)
11.	(B)	**12.**	(A)	**13.**	(D)	**14.**	(B)		

PART - II

1.	18	**2.**	5	**3.**	21	**4.**	20	**5.**	27
6.	4 (A,B,C,D)	**7.**	2	**8.**	48	**9.**	43	**10.**	2
11.	60	**12.**	60	**13.**	4				

PART - III

1.	(ABD)	**2.**	(ABCD)	**3.**	(ABD)	**4.**	(ABCD)	**5.**	(AC)
6.	(A)	**7.**	(AB)	**8.**	(B)	**9.**	(AB)	**10.**	(B)
11.	(ABC)	**12.**	(BD)	**13.**	(AB)	**14.**	(AD)	**15.**	(BCD)
16.	(ABC)								

PART IV

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

EXERCISE 3

PART - I

1.	(C)	**2.**	(B)	**3.**	0.228 K	**4.**	(A)	**5.**	(C)
6.	122, 224	**7.**	(A)	**8.**	(A)	**9.**	(D)	**10.**	(B)
11.	(B)	**12.**	(A)	**13.**	(A)	**14.**	(A)	**15.**	(BCD)
16.	2	**17.**	1	**18.**	(AB)	**19.**	(BD)	**20.**	(A)
21.	19	**22.**	0.05	**23.**	(1.02 or 1.03)				

PART II

JEE-MAIN (OFFLINE)

1.	(2)	**2.**	(1)	**3.**	(3)	**4.**	(3)	**5.**	(1)
6.	(3)	**7.**	(2)	**8.**	(3)	**9.**	(3)	**10.**	(1)
11.	(2)	**12.**	(2)	**13.**	(1)	**14.**	(2)	**15.**	(1)
16.	(2)	**17.**	(2)	**18.**	(3)	**19.**	(2)		

JEE-MAIN (ONLINE)

1.	(2)	**2.**	(1)	**3.**	(4)	**4.**	(3)	**5.**	(4)
6.	(2)	**7.**	(4)	**8.**	(1)	**9.**	(4)	**10.**	(2)
11.	(Bonus)	**12.**	(4)	**13.**	(4)	**14.**	(1)	**15.**	(4)
16.	(4)	**17.**	(1)	**18.**	(3)	**19.**	(1)	**20.**	(1)
21.	(3)	**22.**	(2)	**23.**	(1)	**24.**	(3)	**25.**	(3)
26.	(3)	**27.**	(1)	**28.**	(4)				