



EXERCISE # O-I

Concentration terms

- 1.** Calculate molarity of final solution obtained by mixing I and II HNO₃ solution.

I	II
% ^w	12.6 6.3

d (in g/mL) 1.5 1

Volume (in L) 5

- (A) 0.5 M (B) 1M (C) 2M (D) 2.5 M

- 2.** The molarity of 98% by wt. H_2SO_4 ($d = 1.8 \text{ g/ml}$) is

- (A) 6 M (B) 18 M (C) 10 M (D) 4 M

3. Mole fraction of A in H_2O is 0.2. The molality of A in H_2O is :

- (A) 13.9 (B) 15.5 (C) 14.5 (D) 16.8

Vapour pressure

4. 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

5. The vapour pressure of water depends upon :

- #### (A) Surface area of container

- (B) Volume of container

- (C) Temperature**

- (D) All

6. Which characterises the weak intermolecular forces of attraction in a liquid?

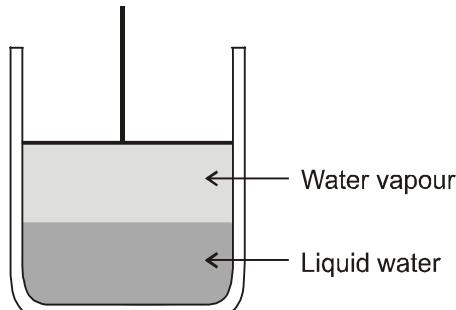
- (A) High boiling point

- (B) High vapour pressure

- (C) High critical temperature

- (D) High heat of vaporization

7. 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).



Completely miscible liquids : Raoult's law

- 12.** If Raoult's law is obeyed, the vapour pressure of the solvent in a solution is directly proportional to

(A) Mole fraction of the solvent (B) Mole fraction of the solute
(C) Mole fraction of the solvent and solute (D) The volume of the solution



- 13.** For a binary ideal liquid solution, the total pressure of the solution is given as :
- (A) $P_{\text{total}} = P_{\text{A}}^{\circ} + (P_{\text{A}}^{\circ} - P_{\text{B}}^{\circ}) X_{\text{B}}$ (B) $P_{\text{total}} = P_{\text{B}}^{\circ} + (P_{\text{A}}^{\circ} - P_{\text{B}}^{\circ}) X_{\text{A}}$
 (C) $P_{\text{total}} = P_{\text{B}}^{\circ} + (P_{\text{B}}^{\circ} - P_{\text{A}}^{\circ}) X_{\text{A}}$ (D) $P_{\text{total}} = P_{\text{B}}^{\circ} + (P_{\text{B}}^{\circ} - P_{\text{A}}^{\circ}) X_{\text{B}}$
- 14.** Two liquids A & B form an ideal solution. What is the vapour pressure of solution containing 2 moles of A and 3 moles of B at 300 K? [Given : At 300 K, Vapour pr. of pure liquid A (P_{A}°) = 100 torr, Vapour pr. of pure liquid B (P_{B}°) = 300 torr]
- (A) 200 torr (B) 140 torr (C) 180 torr (D) None of these
- 15.** Mole fraction of A vapours above the solution in mixture of A and B ($X_{\text{A}} = 0.4$) will be
[Given : $P_{\text{A}}^{\circ} = 100 \text{ mm Hg}$ and $P_{\text{B}}^{\circ} = 200 \text{ mm Hg}$]
- (A) 0.4 (B) 0.8 (C) 0.25 (D) none of these
- 16.** A solution has a 1 : 4 mole ratio of pentane to hexane. The vapour pressures of the pure hydrocarbons at 20°C are 440 mmHg for pentane and 120 mmHg for hexane. The mole fraction of pentane in the vapour phase would be :-
- (A) 0.200 (B) 0.478 (C) 0.549 (D) 0.786
- 17.** 1 mole of heptane (V. P. = 92 mm of Hg) was mixed with 4 moles of octane (V. P. = 31mm of Hg). The vapour pressure of resulting ideal solution is :
- (A) 46.2 mm of Hg (B) 40.0 mm of Hg (C) 43.2 mm of Hg (D) 38.4 mm of Hg
- 18.** The vapour pressure of a pure liquid 'A' is 70 torr at 270C. It forms an ideal solution with another liquid B. The mole fraction of B is 0.2 and total vapour pressure of the solution is 84 torr at 270C. The vapour pressure of pure liquid B at 270C is
- (A) 14 (B) 56 (C) 140 (D) 70
- 19.** At a given temperature, total vapour pressure in Torr of a mixture of volatile components A and B is given by

$$P_{\text{Total}} = 120 - 75 X_{\text{B}}$$

hence, vapour pressure of pure A and B respectively (in Torr) are

- (A) 120, 75 (B) 120, 195 (C) 120, 45 (D) 75, 45



- 20.** An ideal solution was obtained by mixing (MeOH) methanol and (EtOH) ethanol. If the partial vapour pressure of methanol and ethanol are 2 kPa and 3 kPa respectively over the solution, the composition of vapour (in terms of mole fraction) will be -
- (A) 0.4 MeOH, 0.6 EtOH (B) 0.6 MeOH, 0.4 EtOH
 (C) 0.5 MeOH, 0.5 EtOH (D) 0.2 MeOH, 0.3 EtOH
- 21.** At 88 °C benzene has a vapour pressure of 900 torr and toluene has a vapour pressure of 360 torr. What is the mole fraction of benzene in the mixture with toluene that will boil at 88 °C at 1 atm. pressure, benzene - tolueence form an ideal solution:
- (A) 0.416 (B) 0.588 (C) 0.688 (D) 0.740

- 22.** If two liquids A ($P^0_A = 100$ torr) and B ($P^0_B = 200$ 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

Relative lowering of vapour pressure

- 23.** Colligative properties of the solution depend upon
- (A) Nature of the solution (B) Nature of the solvent
 (C) Number of solute particles (D) Number of moles of solvent
- 24.** The exact mathematical expression of Raoult's law is (n = moles of non-volatile solute ; N = moles of solvent, P^0 = vapour pressure of pure solvent, P_s = Vapour pressure of solution)

$$(A) \frac{P^0 - P_s}{P^0} = \frac{n}{N} \quad (B) \frac{P^0 - P_s}{P^0} = \frac{N}{n} \quad (C) \frac{P^0 - P_s}{P_s} = \frac{n}{N} \quad (D) \frac{P^0 - P_s}{P^0} = \times N$$

- 25.** The vapour pressure of a solution having solid as solute and liquid as solvent is :
- (A) Directly proportional to mole fraction of the solvent
 (B) Inversely proportional to mole fraction of the solvent
 (C) Directly proportional to mole fraction of the solute
 (D) Inversely proportional to mole fraction of the solute
- 26.** One mole of non-volatile solute is dissolved in two moles of water. The vapour pressure of the solution relative to that of water is
- (A) 2/3 (B) 1/3 (C) 1/2 (D) 3/2



- 27.** The vapour pressure of a pure liquid solvent (X) is decreased to 0.60 atm. from 0.80 atm on addition of a non-volatile substance (Y). The mole fraction of (Y) in the solution is:-
- (A) 0.20 (B) 0.25 (C) 0.5 (D) 0.75
- 28.** The vapour pressure of a solvent decreased by 10 mm of Hg when a non-volatile solute was added to the solvent. The mole fraction of solute in solution is 0.2. What would be mole fraction of the solvent if decrease in vapour pressure is 20 mm of Hg
- (A) 0.2 (B) 0.4 (C) 0.6 (D) 0.8
- 29.** The vapour pressure of pure A is 10 torr and at the same temperature when 1 g of B is dissolved in 20 gm of A, its vapour pressure is reduced to 9.0 torr. If the molecular mass of A is 200, then the molecular mass of B is :
- (A) 100 (B) 90 (C) 75 (D) 120
- Elevation of Boiling Point & Depression of Freezing Point**
- 30.** When common salt is dissolved in water
- (A) Melting point of the solution increases
 (B) Boiling point of the solution increases
 (C) Boiling point of the solution decreases
 (D) Both Melting point and Boiling point is decreases
- 31.** What should be the freezing point of aqueous solution containing 17 gm of C_2H_5OH in 1000 gm of water (water $K_f = 1.86 \text{ deg} - \text{kg mol}^{-1}$)
- (A) -0.69°C (B) -0.34°C (C) 0.0°C (D) 0.34°C
- 32.** Elevation of boiling point of 1 molar aqueous glucose solution (density = 1.2 g/ml) is
- (A) K_b (B) $1.20 K_b$ (C) $1.02 K_b$ (D) $0.98 K_b$
- 33.** The boiling point of an aqueous solution of a non volatile solute is 100.15°C . What is the freezing point of an aqueous solution obtained by diluting the above solution with an equal volume of water ? The values of K_b and K_f for water are 0.512 and $1.86 \text{ K molality}^{-1}$:
- (A) -0.544°C (B) -0.512°C (C) -0.272°C (D) -1.86°C



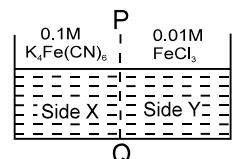
- 34.** A 5% solution (by mass) of cane sugar in water has freezing point of 271 K and freezing point of pure water is 273.15K. The freezing point of a 5% solution (by mass) of glucose in water is -
- (A) 271 K (B) 273.15 K (C) 269.07 K (D) 277.23 K

Osmotic Pressure

- 35.** As a result of osmosis, the volume of the concentrated solution
- (A) Gradually decreases (B) Gradually increases
 (C) Suddenly increases (D) None
- 36.** If mole fraction of the solvent in a solution containing non-volatile solute decreases, then :
- (A) Vapour pressure of solution increases (B) B. P. decreases
 (C) Osmotic pressure increases (D) All are correct
- 37.** 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) $P_2 > P_3 > P_1$
- 38.** The total concentration of dissolved particles inside red blood cells is approximately 0.30 M and the membrane surrounding the cells is semipermeable. The osmotic pressure (in atmosphere) inside the cell is
- (A) 7.34 atm (B) 1.78 atm (C) 2.34 atm (D) 0.74 atm
- 39.** 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
- 40.** 5%w/v solution of sucrose is isotonic with 1%w/v solution of a compound 'A' then the molecular weight of compound 'A' is -
- (A) 32.4 (B) 68.4 (C) 121.6 (D) 34.2
- 41.** If a 6.84% (wt. / vol.) solution of cane-sugar (mol. wt. 342) is isotonic with 1.52% (wt./vol.) solution of thiocarbamide, then the molecular wight of thiocarbamide is :
- (A) 152 (B) 76 (C) 60 (D) 180
- 42.** A solution containing 4 g of a non-volatile organic solute per 100 ml was found to have an osmotic pressure equal to 500 cm of mercury at 270C. The molecular weight of solute is :
- (A) 14.97 (B) 149.7 (C) 1697 (D) 1.497

43. Osmotic pressure of a solution of glucose is 1.20 atm and that of a solution of cane sugar is 2.5 atm. The osmotic pressure of the mixture containing equal volumes of the two solutions will be
 (A) 2.5 atm (B) 3.7 atm (C) 1.85 atm (D) 1.3 atm.

44. FeCl_3 on reaction with $\text{K}_4[\text{Fe}(\text{CN})_6]$ 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

Abnormal Colligative Properties DelP

Abnormal Colligative Properties delTb and delTf

Abnormal Colligative Properties Osmotic Pressure

45. 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) $\frac{i + 1 + \alpha}{1 - \alpha}$

46. 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:

$$(A) i = 1 - \alpha \quad (B) i = 1 + \frac{\alpha}{n} \quad (C) i = \frac{1 - \alpha + \frac{\alpha}{n}}{1} \quad (D) i = 1$$

47. The substance A when dissolved in solvent B shows the molecular mass corresponding to A_3 . The vant Hoff's factor will be-
 (A) 1 (B) 2 (C) 3 (D) 1/3

48. 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) $K[PtCl_3]$

49. For which of the following vant' Hoff's factor is not correctly matched -

Salt	Degree of dissociation (α)	i
(A) Na_2SO_4	50 %	2
(B) $K_3[Fe(CN)_6]$	75%	3.25
(C) $[Ag(NH_3)_2]Cl$	80 %	1.8
(D) $[Cr(NH_3)_5Cl]SO_4$	90 %	2.8

50. The Vant Hoff factor (i) for a dilute solution of $K_3[Fe(CN)_6]$ is (Assuming 100% ionisation) :

- (A) 10 (B) 4 (C) 5 (D) 0.25

51. 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

52. The lowering of vapour pressure of 0.1M aqueous solutions of $NaCl$, $CuSO_4$ and K_2SO_4 are:

- (A) All equal (B) In the ratio of 1 : 1 : 1.5
 (C) In the ratio of 3 : 2 : 1 (D) In the ratio of 1.5 : 1 : 2.5

53. Which of the following aqueous solution will show maximum vapour pressure at 300 K?

- (A) 1 M $NaCl$ (B) 1 M $CaCl_2$ (C) 1 M $AlCl_3$ (D) 1 M $C_{12}H_{22}O_{11}$

54. The correct relationship between the boiling points of very dilute solution if $AlCl_3$ (T_1K) and $CaCl_2$ (T_2K) having the same molar concentration is

- (A) $T_1 = T_2$ (B) $T_1 > T_2$ (C) $T_2 > T_1$ (D) $T_2 \leq T_1$

55. Which of the following has been arranged in order of decreasing freezing point?

- (A) 0.05 M $\text{KNO}_3 > 0.04 \text{ M CaCl}_2 > 0.140 \text{ M sugar} > 0.075 \text{ M CuSO}_4$
- (B) 0.04 M $\text{BaCl}_2 > 0.140 \text{ M sucrose} > 0.075 \text{ M CuSO}_4 > 0.05 \text{ M KNO}_3$
- (C) 0.075 M $\text{CuSO}_4 > 0.140 \text{ M sucrose} > 0.04 \text{ M BaCl}_2 > 0.05 \text{ M KNO}_3$
- (D) 0.075 M $\text{CuSO}_4 > 0.05 \text{ M NaNO}_3 > 0.140 \text{ M sucrose} > 0.04 \text{ M BaCl}_2$

56. 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

57. Assuming each salt to be 90 % dissociated, which of the following will have highest boiling point?

- (A) Decimolar $\text{Al}_2(\text{SO}_4)_3$
- (B) Decimolar BaCl_2
- (C) Decimolar Na_2SO_4
- (D) A solution obtained by mixing equal volumes of (B) and (C)

58. 1.0 molal aqueous solution of an electrolyte A_2B_3 is 60% ionised. The boiling point of the solution at 1 atm is ($= 0.52 \text{ K kg mol}^{-1}$)

- (A) 274.76 K
- (B) 377 K
- (C) 376.4 K
- (D) 374.76 K

59. The freezing point of 1 molal NaCl solution assuming NaCl to be 100% dissociated in water is: ($K_f = 1.86 \text{ K Molality}^{-1}$)

- (A) -1.86°C
- (B) -3.72°C
- (C) $+1.86^\circ\text{C}$
- (D) $+3.72^\circ\text{C}$

60. The molal elevation constant of water is 0.51. The boiling point of 0.1 molal aqueous NaCl solution is nearly :

- (A) 100.05°C
- (B) 100.1°C
- (C) 100.2°C
- (D) 101.0°C



61. What is the freezing point of a solution containing 8.1 gm of HBr in 100 gm water assuming the acid to be 90% ionised (K_f for water = 1.86 K molality⁻¹) :-

(A) 0.85°C (B) -3.53°C (C) 0°C (D) -0.35°C

62. The freezing point depression of a 0.1 M a solution of weak acid (HX) is -0.20°C.

What is the value of equilibrium constant for the reaction?



[Given : K_f for water = 1.8 kg mol⁻¹ K. & Molality = Molarity]

(A) 1.46×10^{-4} (B) 1.35×10^{-3} (C) 1.21×10^{-2} (D) 1.35×10^{-4}

63. Relative decrease in vapour pressure of an aqueous solution containing 2 moles $[\text{Cu}(\text{NH}_3)_3\text{Cl}] \text{Cl}$ 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

64. 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

65. The value of observed and calculated molecular weight of silver nitrate are 92.64 and 170 respectively. The degree of dissociation of silver nitrate is :

(A) 60% (B) 83.5 % (C) 46.7% (D) 60.23%

10-SCQ

Non-ideal Solutions

66. Among the following, that does not form an ideal solution is :

(A) C_6H_6 and $\text{C}_6\text{H}_5\text{CH}_3$	(B) $\text{C}_2\text{H}_5\text{Cl}$ and $\text{C}_6\text{H}_5\text{OH}$
(C) $\text{C}_6\text{H}_5\text{Cl}$ and $\text{C}_6\text{H}_5\text{Br}$	(D) $\text{C}_2\text{H}_5\text{Br}$ and $\text{C}_2\text{H}_5\text{I}$

67. Which of the following azeotropic solutions has the boiling point more than boiling point of the constituents A and B ?

(A) $\text{CH}_3\text{CH}_2\text{OH}$ and CH_3COCH_3	(B) CS_2 and CH_3COCH_3
(C) CHCl_3 and CH_3COCH_3	(D) CH_3CHO and CS_2



68. On mixing 10 mL of acetone with 40 mL of chloroform , the total volume of the solution is :
 (A) < 50 mL (B) > 50 mL (C) = 50 mL (D) Cannot be predicted
69. 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
70. Which of the following is less than zero for ideal solutions ?
 (A) ΔH_{mix} (B) ΔV_{mix} (C) ΔG_{mix} (D) ΔS_{mix}
71. 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) $\Delta V_{\text{mix}} > 0$ (B) $\Delta H_{\text{mix}} < 0$ (C) $\Delta V_{\text{mix}} = 0$ (D) $\Delta H_{\text{mix}} = 0$
72. When KCl dissolves in water (assume endothermic dissolution), then :
 (A) $\Delta H = + \text{ve}$, $\Delta S = + \text{ve}$, $\Delta G = + \text{ve}$ (B) $\Delta H = + \text{ve}$, $\Delta S = - \text{ve}$, $\Delta G = - \text{ve}$
 (C) $\Delta H = + \text{ve}$, $\Delta S = + \text{ve}$, $\Delta G = - \text{ve}$ (D) $\Delta H = - \text{ve}$, $\Delta S = - \text{ve}$, $\Delta G = + \text{ve}$
73. 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 ($P_A^{\circ} = 300$ torr, $P_B^{\circ} = 800$ torr) :
 (A) $\text{CHCl}_3 + \text{CH}_3\text{COCH}_3$ (B) $\text{C}_6\text{H}_5\text{Cl} + \text{C}_6\text{H}_5\text{Br}$
 (C) $\text{C}_6\text{H}_6 + \text{C}_6\text{H}_5\text{CH}_3$ (D) $n\text{-C}_6\text{H}_{14} + n\text{-C}_7\text{H}_{16}$
74. The vapour pressure of the solution of two liquids A($p^{\circ} = 80$ mm) and B($p^{\circ} = 120$ 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.



- 75.** An azeotropic solution of two liquids has a boiling point lower than either of them when it :
- shows negative deviation from Raoult's law
 - shows positive deviation from Raoult's law
 - shows ideal behaviour
 - is saturated

Solutions of Gases in Liquids

- 76.** The solubility of gases in liquids :
- increases with increase in pressure and temperature
 - decreases with increase in pressure and temperature
 - Increases with increase in pressure and decrease in temperature
 - decreases with increase in pressure and increase in temperature
- 77.** 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., $P_{\text{gas}}' = K_H \cdot X_{\text{gas}}$ where K_H is Henry's constant. Which are correct ?
- K_H is characteristic constant for a given gas-solvent system
 - Higher is the value of K_H , lower is solubility of gas for a given partial pressure of gas
 - K_H increases with temperature
 - All of these
- 78.** The solubility of $\text{N}_2(\text{g})$ 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 :
- 4.1×10^{-4} M
 - 6.8×10^{-4} M
 - 1500 M
 - 2400 M
- 79.** If a ground water contains H_2S at concentration of 2 mg/l, determine the pressure of H_2S in head space of a closed tank containing the ground water at 20°C . Given that for H_2S , Henry's constant is equal to 6.8×10^3 bar at 20°C .
- 720 Pa
 - 77×10^2 Pa
 - 553 Pa
 - 55×10^2 Pa

**EXERCISE # S-I****Concentration terms**

1. The density of 3M solution of sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) is 1.58 g/ml. Calculate
 - (i) amount of $\text{Na}_2\text{S}_2\text{O}_3$ in % w/w
 - (ii) mole fraction of $\text{Na}_2\text{S}_2\text{O}_3$
 - (iii) molality of Na^+ and $\text{S}_2\text{O}_3^{2-}$ ions.

2. 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).

Vapour Pressure

3. The vapour pressure of water at 80°C is 355 torr. A 100 ml vessel contained water-saturated oxygen at 80° 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.

4. 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)

Completely miscible liquids : Raoult's law

5. Two completely miscible liquids A & B form an ideal solution. What is the vapour pressure of solution containing 2 moles of A and 3 moles of B at 300K?

[Given: At 300 K, Vapour pressure of pure liquid A (P_A^0) = 100 torr

Vapour pressure of pure liquid B (P_B^0) = 300 torr]

6. The vapour pressure of ethanol and methanol are 44.5 mm and 88.7 mm Hg respectively. An ideal solution is prepared at the same temperature by mixing 60 g of ethanol with 40 g of methanol. Calculate total vapour pressure of the solution.



7. At 25°C, the vapour pressure of methyl alcohol is 96.0 torr. What is the mole fraction of CH_3OH in a solution in which the vapour pressure of CH_3OH is 23.0 torr at 25°C?
8. Benzene and toluene form two ideal solution A and B at 313 K. Solution A (total pressure P_A) contains equal mole of toluene and benzene. Solution B contains equal masses of both (total pressure P_B). The vapour pressure of benzene and toluene are 160 and 60 mm of Hg respectively at 313 K. Calculate the value of P_A/P_B .
9. 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.
10. 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 ?
11. 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.
12. 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.
13. A mixture contains 1 mole of volatile liquid A ($P_A^0 = 100 \text{ mm Hg}$) and 3 moles of volatile liquid B ($P_B^0 = 80 \text{ mm Hg}$). If solution behaves ideally, the total vapour pressure of the distillate is

Relative lowering of vapour pressure

14. The vapour pressure of pure liquid solvent A is 0.80 atm. When a nonvolatile substance B is added to the solvent its vapour pressure drops to 0.60 atm. What is the mole fraction of component B in the solution?



15. Calculate the relative lowering in vapour pressure if 100 g of a nonvolatile solute (mol.wt.100) are dissolved in 432 g water.
16. What weight of the non-volatile solute, urea needs to be dissolved in 100 g of water, in order to decrease the vapour pressure of water by 25%? What will be the molality of the solution?
17. The vapour pressure of pure benzene at 25° C is 639.7 mm of Hg and the vapour pressure of a solution containing non-volatile solute in C_6H_6 at the same temperature is 631.7 mm of Hg. Calculate molality of solution.
18. The vapour pressure of pure benzene at a certain temperature is 640 mm of Hg. A nonvolatile non-electrolyte solid weighing 2.175 gm is added to 39.0 gm of benzene. The vapour pressure of the solution is 600 mm of Hg. What is molecular weight of solid substance?
19. The vapour pressure of water is 17.54 mm Hg at 293 K. Calculate vapour pressure of 0.5 molal solution of a non volatile solute in it.
20. The vapour pressure of an aqueous solution of glucose is 750 mm Hg at 373 K. Calculate molality and mole fraction of solute.

Elevation of Boiling Point & Depression of Freezing Point

21. When 10.6 g of a nonvolatile substance is dissolved in 740 g of ether, its boiling point is raised 0.284°C. What is the molecular weight of the substance? Molal boiling point constant for ether is $2.11^{\circ}\text{C}\cdot\text{kg/mol}$.
22. The molecular weight of an organic compound is 58.0 g/mol. Compute the boiling point of a solution containing 24.0 g of the solute and 600 g of water, when the barometric pressure is such that pure water boils at 99.725°C. ($K_b = 0.512 \text{ kg mol } K^{-1}$)
23. An aqueous solution containing 288 gm of a non-volatile compound having the stoichiometric composition $C_xH_{2x}O_x$ in 90 gm water boils at 101.24 °C at 1 atm pressure. What is the molecular formula?

$$K_b(H_2O) = 0.512 \text{ K mol}^{-1} \text{ kg}$$

$$T_b(H_2O) = 100^{\circ}\text{C}$$



24. The freezing point of a solution containing 2.40 g of a compound in 60.0 g of benzene is 0.10°C lower than that of pure benzene. What is the molecular weight of the compound? (K_f is 5.12°C/m for benzene)
25. A solution of 0.643 g of an organic compound in 50ml of benzene (density ; 0.879 g/ml) lowers its freezing point from 5.51°C to 5.03°C. If K_f for benzene is 5.12 K, calculate the molecular weight of the compound.
26. Pure benzene freezes at 5.45°C. A solution containing 7.24 g of $C_2H_2Cl_4$ in 115.3 g of benzene was observed to freeze at 3.55°C. What is the molal freezing point constant of benzene?
27. The cryoscopic constant for acetic acid is 3.6 K kg/mol. A solution of 1 g of a hydrocarbon in 100 g of acetic acid freezes at 16.14°C instead of the usual 16.60°C. The hydrocarbon contains 92.3% carbon. What is the molecular formula?
28. Calculate the molal elevation constant, K_b for water and the boiling of 0.1 molal urea solution. Latent heat of vaporisation of water is 9.72 kcal mol⁻¹ at 373.15 K.

Osmotic Pressure

29. A 5% solution (w/v) of cane-sugar (Mol. weight = 342) is isotonic with 0.877%(w/v) of urea solution. Find molecular weight of urea.
30. Find the freezing point of a glucose solution whose osmotic pressure at 25°C is found to be 30 atm. $K_f(\text{water}) = 1.86 \text{ kg. mol}^{-1} \text{ K}$.

Abnormal colligative properties

31. A storage battery contains a solution of H_2SO_4 38% by weight. What will be the Van't Hoff factor if the $\Delta T_f(\text{experiment})$ in 29.08. [Given $K_f = 1.86 \text{ mol}^{-1} \text{ Kg}$]
32. The freezing point of a solution containing 0.2 g of acetic acid in 20.0g of benzene is lowered by 0.45°C. Calculate the degree of association of acetic acid in benzene.
(K_f for benzene = 5.12 K mol⁻¹ kg)
33. 2.0 g of benzoic acid dissolved in 25.0g of benzene shows a depression in freezing point equal to 1.62K. Molal depression constant (K_f) of benzene is 4.9 K.kg.mol⁻¹. What is the percentage association of the acid?

- 34.** 0.85 %w/v aqueous solution of NaNO_3 is apparently 90% dissociated at 27°C . Calculate its osmotic pressure. ($R = 0.082 \text{ l atm K}^{-1} \text{ mol}^{-1}$)

35. A Decimolar solution of potassium ferrocyanide is 50% dissociated at 300K . Calculate the osmotic pressure of the solution. ($R=8.314 \text{ JK}^{-1} \text{ mol}^{-1}$)

36. A 1.2% (w/v) solution of NaCl is isotonic with 7.2% (w/v) solution of glucose. Calculate degree of ionization and Van't Hoff factor of NaCl .

37. The degree of dissociation of $\text{Ca}(\text{NO}_3)_2$ in a dilute aqueous solution containing 7 g salt per 100 g of water at 100°C is 70%. If the vapour pressure of water at 100°C is 760 mm of Hg, calculate the vapour pressure of the solution.

38. 1 g of a monobasic acid dissolved in 200 g of water lowers the freezing point by 0.186°C . 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 ? ($K_f = 1.86$)

39. A certain mass of a substance, when dissolved in 100 g C_6H_6 , lowers the freezing point by 1.28°C . The same mass of solute dissolved in 100g water lowers the freezing point by 1.40°C . If the substance has normal molecular weight in benzene and is completely ionized in water, into how many ions does it dissociate in water? K_f for H_2O and C_6H_6 are 1.86 and $5.12 \text{ K kg mol}^{-1}$.

Non-ideal Solutions

**Solutions of Gases in Liquids**

42. 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 ?
43. If N₂ gas is bubbled through water at 293 K, how many millimoles of N₂ gas would dissolve in 1 litre of water, if N₂ exerts a partial pressure of 0.987 bar. Given that Henry's law constant for N₂ at 293 K is 76.48 kbar.
44. Calculate the concentration of CO₂ in a soft drink that is bottled with a partial pressure of CO₂ of 4 atm over the liquid at 25°C. The Henry's law constant for CO₂ in water at 25°C is 3.1×10^{-2} mol/litre-atm. Write answer after multiplying by 100.

EXERCISE # O-II

Single correct

1. Consider two liquids A & B having pure vapour pressures P_A° & P_B° forming an ideal solution.

The plot of $\frac{1}{X_A}$ v/s $\frac{1}{Y_A}$ (where X_A and Y_A are the mole fraction of liquid A in liquid and vapour phase respectively) is linear with slope and Y intercepts respectively :

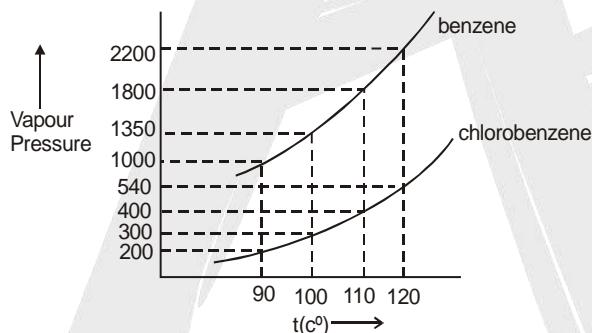
- $$(A) \frac{P_A^o}{P_B^o} \text{ and } \frac{(P_A^o - P_B^o)}{P_B^o}$$

- $$(B) \frac{P_A^o}{P_B^o} \text{ and } \frac{(P_B^o - P_A^o)}{P_B^o}$$

- $$(C) \frac{P_B^o}{P_A^o} \text{ and } \frac{(P_A^o - P_B^o)}{P_B^o}$$

- $$(D) \frac{P_B^o}{P_A^o} \text{ and } \frac{(P_B^o - P_A^o)}{P_B^o}$$

2. Assuming the formation of an ideal solution, determine the boiling point of a mixture containing 1560 g benzene (molar mass = 78) and 1125 g chlorobenzene (molar mass = 112.5) using the following against an external pressure of 1000 Torr.



- (A) 90°C (B) 100°C (C) 110° (D) 120°C

3. x mole of KCl and y mole of BaCl₂ 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°

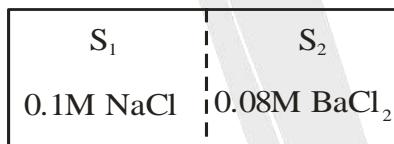
4. When only a little quantity of $\text{HgCl}_2(\text{s})$ is added to excess $\text{KI}(\text{aq})$ to obtain a clear solution, which of the following is true for this solution? (no volume change on mixing).

$$\text{The reaction is } 4\text{KI(aq.)} + \text{HgCl}_2(\text{s}) \longrightarrow \text{K}_2[\text{HgI}_4] \text{ (aq.)} + 2\text{KCl (aq.)}$$

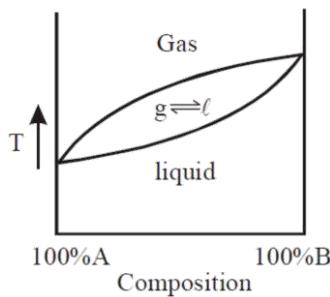
- (A) Its boiling and freezing points remain same (B) Its boiling point is lowered
(C) Its vapour pressure become lower (D) Its boiling point is raised

More than one may be correct

5. Vapour pressure of a liquid solution increases -
 (A) By increasing temperature
 (B) By increasing mole fraction of more volatile component
 (C) By increasing surface area of container
 (D) By increasing quantity of liquid solution
6. For an ideal binary liquid solution with $P_A^0 > P_B^0$, 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) $Y_A > X_A$ (C) $\frac{Y_A}{Y_B} > \frac{X_A}{X_B}$ (D) $\frac{Y_A}{Y_B} < \frac{X_A}{X_B}$
7. Which of the following plots represents an ideal binary mixture?
 (A) Plot of P_{total} v/s X_B is linear (X_B = mole fraction of 'B' in liquid phase).
 (B) Plot of P_{total} v/s Y_A is linear (Y_B = mole fraction of 'A' in vapour phase)
 (C) Plot of $\frac{1}{P_{\text{total}}}$ v/s Y_A is linear
 (D) Plot of $\frac{1}{P_{\text{total}}}$ v/s Y_B is non linear
8. Two solutions S_1 and S_2 containing 0.1M NaCl(aq.) and 0.08M BaCl₂(aq.) are separated by semipermeable membrane. Which among the following statement(s) is/are correct -



- (A) S_1 and S_2 are isotonic (B) S_1 is hypertonic and S_2 is hypotonic
 (C) S_1 is hypotonic and S_2 is hypertonic (D) Osmosis will take place from S_1 to S_2
9. Select the correct statement based on following graph at constant pressure for a liquid mixture-



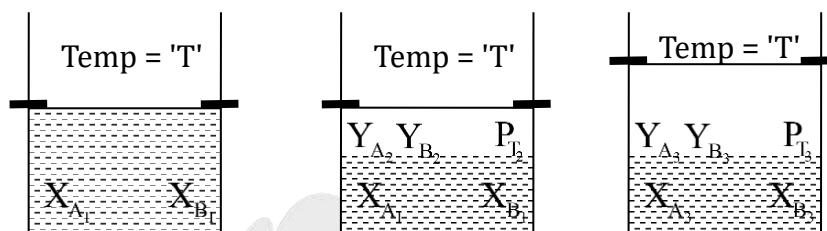
- (A) Graph shows positive deviation from Raoult's law
 (B) Liquid B is more volatile
 (C) Pure A can be obtained in distillate

- (D) Boiling point of the mixture is always in between boiling points of pure A & pure B.
- 10.** Binary liquid solution containing two miscible & volatile liquids 1 mol A & 4 mol & B
 (Given $P_A^0 = 200$ torr = P_B^0 , = 300 torr) if vapour pressure of solution is 240 torr then select correct statement for the solution -
- (A) It will form minimum boiling point azeotrope
 - (B) It will form maximum boiling point azeotrope
 - (C) Contraction occurs on mixing A & B
 - (D) Expansion occurs on mixing A & B
- 11.** Which of the following is correct for a non-ideal solution of liquids A and B, showing negative deviation?
- (A) $\Delta H_{\text{mix}} = -\text{ve}$
 - (B) $\Delta V_{\text{mix}} = -\text{ve}$
 - (C) $\Delta S_{\text{mix}} = +\text{ve}$
 - (D) $\Delta G_{\text{mix}} = -\text{ve}$
- 12.** 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 lowest vapour pressure than for any other composition.
 - (D) Composition of an azeotrope alters on changing the external pressure.
- 13.** Acetone and carbon disulphide form binary liquid solution showing positive deviation from Raoult's law. The normal boiling point (T_b) of pure acetone is less than that of pure CS_2 . Pick out the incorrect statements among the following.
- (A) Boiling temperature of mixture is always less than boiling temperature of acetone.
 - (B) Boiling temperature of Azeotropic mixture is always less than boiling temperature of pure CS_2 .

(C) When a small amount of CS_2 (less volatile component) is added to excess of acetone boiling point of resulting mixture increases.

(D) A mixture of CS_2 and CH_3COCH_3 can be completely separated by simple fractional distillation.

14. Using given information :



X_A, X_B = mol fraction of 'A' & 'B' in liquid, Y_A, Y_B = mol fraction of 'A' & 'B' in vapour

P_A^0, P_B^0 = vapour pressure of pure liquid A and pure liquid B respectively,

P_T = vapour pressure of solution, Given : $X_{A_1} = X_{B_1}$, $P_A^0 > P_B^0$,

Select the correct set/ sets of relation

(A) $Y_{A_2} > Y_{B_2}, P_{T_2} = P_{T_3}$

(B) $Y_{A_2} > Y_{A_3}, Y_{B_2} >$

(C) $Y_{A_2} > Y_{A_3}, P_{T_2} > P_{T_3}$

(D) $X_{A_2} < X_{B_2}, P_{T_2} < P_{T_3}$

Paragraph for Questions 15 and 16

Addition of non-volatile solute to a solvent always increases the colligative properties such as osmotic pressure, 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 increases in number of solute particles.

15. For different aqueous solutions of 0.1 N NaCl , 0.1 M urea, 0.1 N Na_2SO_4 and 0.1 N Na_3PO_4 solution at 27°C. The correct statements are:

(A) The order of osmotic pressure is, $\text{NaCl} > \text{Na}_2\text{SO}_4 > \text{Na}_3\text{PO}_4 >$ urea

(B) The order of osmotic pressure is, $\text{Na}_3\text{PO}_4 > \text{Na}_2\text{SO}_4 > \text{NaCl} >$ urea

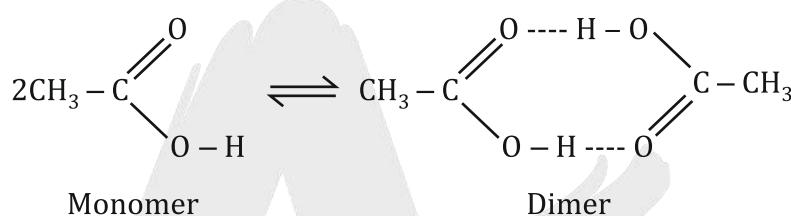
(C) The order of ΔT_b is, $\text{Na}_3\text{PO}_4 > \text{Na}_2\text{SO}_4 > \text{NaCl} >$ urea

(D) The order of freezing point is $\text{NaCl} > \text{Na}_2\text{SO}_4 > \text{Na}_3\text{PO}_4 >$ urea

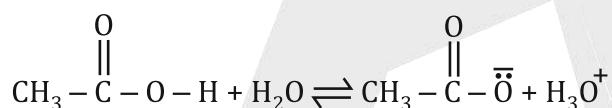
16. 6gm urea is present in 250 ml solution (molar mass of solvent = 10000g/mole) at 27°C. If $R = 0.08 \text{ lit-atm/mole-K}$ and density of solution is 1.024 g/ml then which of the following is incorrect-
- Osmotic pressure of solution is 9.6 atm
 - Relative lowering in vapour pressure is 0.8
 - Elevation in boiling point of solution is 2 Kelvin (K_b of solvent = 5 K-mole/kg)
 - If urea is replaced by same mass of glucose than solution formed will show higher osmotic pressure

Paragraph for question nos. 17 to 19

Acetic acid tends to form dimer due to the formation of intermolecular hydrogen bonding.



The equilibrium constant for this reaction is $1.5 \times 10^2 \text{ M}^{-1}$ in benzene solution and $3.6 \times 10^{-2} \text{ M}^{-1}$ in water. In benzene, monomer does not dissociate but in water, monomer dissociates simultaneously with acid dissociation constant $2.0 \times 10^{-5} \text{ M}$.



Dimer does not dissociate in benzene as well as in water

[Given : $\log 2 = 0.3$]

17. The molar ratio of dimer to monomer for 0.1 M acetic acid in benzene is equal to
- 150 : 1
 - 1 : 150
 - (C*) 5 : 2
 - 2 : 5
18. The molar ratio of dimer to monomer for 0.1 M acetic acid in water (neglecting the dissociation of acetic acid in water) is equal to
- 250 : 1
 - 1 : 250
 - (C*) 9 : 2500
 - 2500 : 9
19. The pH of 0.1 M acetic acid solution in water, considering the simultaneous acid dissociation is
- 1
 - (B*) 2.85
 - 5.7
 - 3.42



Match the column :

20. Column-I

- (A) Acetone + CHCl₃
- (B) Ethanol + Water
- (C) C₂H₅Br + C₂H₅I
- (D) Acetone + Benzene

Column-II

- (P) ΔS > 0
- (Q) ΔH > 0
- (R) ΔH > 0
- (S) Maximum boiling azeotropes
- (T) Minimum boiling azeotropes

21. Column-I

(Colligative properties)

(A) $\Delta T_f = 0.3 \times K_f$

(B) $\Delta T_b = 0.28 \times K_b$

(C) $p = 0.19 \times RT$

(d)
$$\frac{P^0 - P}{P^0} = \frac{\left(\frac{\Delta T_f}{K_f} \right)}{\left(\frac{1000}{18} \right) + \left(\frac{\Delta T_f}{K_f} \right)}$$

Column-II

(Aqueous solution)

(Assume m = M)

(P) 0.1 m – Ca(NO₃)₂

(Q) 0.14 m – NaBr

(R) 0.1 m – MgCl₂ ($\alpha = 0.9$)

(S) 0.28 m – Urea

(T) 0.1 m – HA (monobasic acid, $K_a = 0.81$)



EXERCISE # S-II

1. Vapour pressure of C_6H_6 and C_7H_8 mixture at $50^\circ C$ 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 936 g benzene and 736 g toluene and if vapours over this solution are removed and condensed into liquid and again brought to the temperature $50^\circ C$, what would be mole fraction of C_6H_6 in the vapour state. (At. wt. of C = 12, H = 1)

2. At $90^\circ C$, the vapour pressure of toluene is 400 torr and that of σ -xylene is 150 torr. What is the composition of the liquid mixture that boils at $90^\circ C$, when the pressure is 0.50 atm? What is the composition of vapour produced?

3. Calculate the amount of ice that will separate out of cooling a solution containing 50g of ethylene glycol in 200 g water to $-9.3^\circ C$. (K_f for water = $1.86 \text{ K mol}^{-1} \text{ kg}$)

4. A solution of crab hemocyanin, a pigmented protein extracted from crabs, was prepared by dissolving 0.750 g in 125 cm^3 of an aqueous medium. At $4^\circ C$ an osmotic pressure rise of 2.6 mm of the solution was observed. The solution had a density of 1.00 g/cm^3 . Determine the molecular weight of the protein.

5. 0.1 mol $K_4Fe(CN)_6$ is added to 1 litre of 0.2M $CuCl_2$ solution at $31^\circ C$, osmotic pressure (in atm) of the resulting solution.

6. The vapour pressure of a saturated solution of sparingly soluble salt (XCl_3) was 17.20 mm Hg at $27^\circ C$. If the vapour pressure of pure H_2O is 17.25 mm Hg at 300 K, what is the solubility of sparingly soluble salt XCl_3 in mole/Litre.

7. A complex is represented as $CoCl_3 \cdot xNH_3$. It's 0.1 molal solution in a solution shows $\Delta T_f = 0.558^\circ C$. K_f for H_2O is $1.86 \text{ K mol}^{-1} \text{ kg}$. Assuming 100% ionisation of complex and coordination no. of Co is six, calculate formula of complex.

8. Phenol associates in benzene to a certain extent to form a dimer. A solution containing 20×10^{-3} kg phenol in 1 kg of benzene has its freezing point depressed by 0.69 K. Calculate the fraction of phenol that has dimerised. K_f for benzene = $5.12 \text{ kg mol}^{-1} \text{ K}$.

9. Molar volume of liquid A($d = 0.8 \text{ gm/ml}$) increase by factor of 2000 when it vapourises at 200K. Vapour pressure of liquid A at 200K is [$R = 0.08 \text{ L-atm/mol-K}$]
(Molar mass of A = 80g/mol)



10. The molar volume of liquid benzene (density = 0.877 g ml^{-1}) increases by a factor of 2750 as it vaporizes at 20°C and that of liquid toluene (density = 0.867 g ml^{-1}) increases by a factor of 7720 at 20°C . A Solution of benzene & toluene has a vapour pressure of 46.0 torr. Find the mole fraction of benzene in the vapour above the solution.
11. Pressure over ideal binary liquid mixture containing 10 moles each of liquid A and B is gradually decreased isothermally. If $P_A^0 = 200 \text{ mmHg}$ and $P_B^0 = 100 \text{ mmHg}$, find the pressure at which half of the liquid is converted into vapour.
12. The vapour pressure of two pure liquids, A and B that form an ideal solution are 300 and 800 torr respectively, at temperature T. A mixture of the vapour of A and B for which the mole fraction of A is 0.25 is slowly compressed at temperature T. Calculate
(a) the composition of the first drop of the condensate,
(b) the total pressure when this drop is formed,
(c) the composition of the solution whose normal boiling point is T,
(d) the pressure when only the last bubble of vapour remains, and
(e) the composition of the last bubble.



EXERCISE # (JEE-MAIN)

- 1.** Which one of the following aqueous solutions will exhibit highest boiling point ? [AIEEE-2004]

(A) 0.01M Na_2SO_4 (B) 0.01M KNO_3 (C) 0.015M urea (D) 0.015M glucose

2. Which of the following liquid pairs shows a positive deviation from Raoult's law ? [AIEEE-2004]

(A) Water-hydrochloric acid (B) Benzene-methanol
(C) Water-nitric acid (D) Acetone-chloroform

3. Which one of the following statement is False ? [AIEEE-2004]

(A) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction
(B) The osmotic pressure (π) of a solution is given by the equation $\pi = MRT$ where M is the molarity of the solution
(C) The correct order of osmotic pressure for 0.01M aqueous solution of each compound is $\text{BaCl}_2 > \text{KCl} > \text{CH}_3\text{COOH} > \text{Sucrose}$
(D) Two sucrose solutions of same molality prepared in different solvent will have the same freezing point depression

4. If α is the degree of dissociation of Na_2SO_4 , the vant of Hoff's factor (i) used for calculating the molecular mass is [AIEEE-2005]

(A) $1 - \alpha$ (B) $1 + \alpha$ (C) $1 - 2\alpha$ (D) $1+2\alpha$

5. Benzene and toluene form nearly ideal solutions. At 20°C , the vapour pressure of benzene is 75 torr and that of toluene is 22 torr. The partial vapour pressure of benzene at 20°C for a solution containing 78 g of benzene and 46 g of toluene in torr is - [AIEEE-2005]

(A) 25 (B) 50 (C) 53.5 (D) 37.5

6. Two solutions of a substance (non electrolyte) are mixed in the following manner. 480 ml of 1.5 M first solution + 520 mL of 1.2 M second solution. What is the molarity of the final mixture ? [AIEEE-2005]

(A) 1.50 M (B) 1.20 M (C) 2.70 M (D) 1.344 M



7. Equimolar solutions in the same solvent have [AIEEE-2006]
- (A) Same freezing point but different boiling point
 - (B) Same boiling point but different freezing point
 - (C) Different boiling and different freezing point
 - (D) Same boiling and same freezing points
8. 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2g of water. The vapour pressure of water for this aqueous solution at $100^\circ C$ is [AIEEE-2006]
- (A) 7.60 Torr
 - (B) 76.00 Torr
 - (C) 752.40 Torr
 - (D) 759.00 Torr
9. 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]
- (A) 350
 - (B) 300
 - (C) 700
 - (D) 360
10. A 5.25% solution of a substance is isotonic with a 1.5% solution of urea (molar mass=60 $g\ mol^{-1}$) 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]
- (A) 90.0 $g\ mol^{-1}$
 - (B) 115.0 $g\ mol^{-1}$
 - (C) 105.0 $g\ mol^{-1}$
 - (D) 210.0 $g\ mol^{-1}$
11. At $80^\circ C$, the vapoure 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 $80^\circ C$ and 1 atm pressure, the amount of 'A' in the mixture is (1 atm = 760 mm Hg) [AIEEE-2008]
- (A) 52 mol %
 - (B) 34 mol %
 - (C) 48 mol %
 - (D) 50 mol %
12. The vapour pressure of water at $20^\circ C$ is 17.5 mm Hg. If 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g of water at $20^\circ C$, the vapour pressure of the resulting solution will be [AIEEE-2008]
- (A) 17.675 mm Hg
 - (B) 15.750 mm Hg
 - (C) 16.500 mm Hg
 - (D) 17.325 mm Hg
13. 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 mm Hg. At the same temperature, if 1 mol of Y is further added to this solution, vapour pressure of the solution increases by 10 mm Hg. Vapour pressure (in mmHg) of X and Y in their pure states will be, respectively : [AIEEE-2009]
- (A) 400 and 600
 - (B) 500 and 600
 - (C) 200 and 300
 - (D) 300 and 400

- 14.** A binary liquid solution is prepared by mixing n-heptane and ethanol. Which one of the following statements is correct regarding the behaviour of the solution ? [AIEEE-2009]
- (A) The solution is non-ideal, showing -ve deviation from Raoult's law
 (B) n-heptane shows +ve deviation while ethanol shows -ve deviation from Raoult's law
 (C) The solution formed is an ideal solution.
 (D) The solution is non-ideal, showing +ve deviation from Raoult's law
- 15.** 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 mol of sodium sulphate is dissolved in 1 kg of water, is ($K_f = 1.86 \text{ K kg mol}^{-1}$) : [AIEEE-2010]
- (A) 0.0186 K (B) 0.0372 K (C) 0.0558 K (D) 0.0744 K
- 16.** 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]
- (A) 144.5 kPa (B) 72.0 kPa (C) 36.1 kPa (D) 96.2 kPa
- 17.** The degree of dissociation (α) of a weak electrolyte, A_xB_y is related to van't Hoff factor (i) by the expression : [AIEEE-2011]
- (A) $\alpha = \frac{x+y-1}{i-1}$ (B) $\alpha = \frac{x+y+1}{i-1}$ (C) $\alpha = \frac{i-1}{(x+y-1)}$ (D) $\alpha = \frac{i-1}{(x+y+1)}$
- 18.** Ethylene glycol is used as an antifreeze in a cold climate. Mass of ethylene glycol which should be added to 4 kg of water to prevent it from freezing at -6°C will be : [AIEEE-2011]
 (K_f for water = $1.86 \text{ K kg mol}^{-1}$, and molar mass of ethylene glycol = 62 g mol^{-1})
- (A) 400.00 g (B) 304.60 g (C) 804.32 g (D) 204.30 g
- 19.** A 5% solution of cane sugar (molar mass 342) is isotonic with 1% of a solution of an unknown solute. The molar mass of unknown solute in g/mol is : [AIEEE-2011]
- (A) 136.2 (B) 171.2 (C) 68.4 (D) 34.2
- 20.** The molality of a urea solution in which 0.0100 g of urea, $[(\text{NH}_2)_2\text{CO}]$ is added to 0.3000 dm³ of water at STP is : [AIEEE-2011]
- (A) 0.555 m (B) $5.55 \times 10^{-4} \text{ m}$ (C) 33.3 m (D) $3.33 \times 10^{-2} \text{ m}$



- 21.** The freezing point of a 1.00 m aqueous solution of HF is found to be -1.91°C . The freezing point constant of water, K_f , is $1.86 \text{ K kg mol}^{-1}$. The percentage dissociation of HF at this concentration is
[JEE (MAIN)-2012 ONLINE]
- (A) 2.7% (B) 30% (C) 10% (D) 5.2%
- 22.** Liquids A and B form an ideal solution. At 30°C , the total vapour pressure of a solution containing 1 mol of A and 2 moles of B is 250 mm Hg. The total vapour pressure becomes 300 mm Hg when 1 more mol of A is added to the first solution. The vapour pressures of pure A and B at the same temperature are
[JEE (MAIN)-2012 ONLINE]
- (A) 450, 150 mm Hg (B) 250, 300 mm Hg (C) 125, 150 mm Hg (D) 150, 450 mm Hg
- 23.** A solution containing 0.85 g of ZnCl_2 in 125.0 g of water freezes at -0.23°C . The apparent degree of dissociation of the salt is :
[JEE (MAIN)-2012 ONLINE]
- (K_f for water = $1.86 \text{ K kg mol}^{-1}$, atomic mass ; Zn = 65.3 and Cl = 35.5)
- (A) 1.36% (B) 2.47% (C) 73.5% (D) 7.35%
- 24.** K_f for water is $1.86 \text{ K kg mol}^{-1}$. If your automobile radiator holds 1.0 kg of water, how many grams of ethylene glycol ($\text{C}_2\text{H}_6\text{O}_2$) must you add to get the freezing point of the solution lowered to -2.8°C ?
[AIEEE-2012]
- (A) 27 g (B) 72 g (C) 93 g (D) 39 g
- 25.** 12g of a nonvolatile solute dissolved in 108g of water produces the relative lowering of vapour pressure of 0.1. The molecular mass of the solute is :
[JEE (MAIN)-2013 ONLINE]
- (A) 60 (B) 80 (C) 40 (D) 20
- 26.** A molecule M associates in a given solvent according to the equation $\text{M} \longrightarrow (\text{M})_n$. For a certain concentration of M, the van't Hoff factor was found to be 0.9 and the fraction of associated molecules was 0.2. The value of n is :
[JEE (MAIN)-2013 ONLINE]
- (A) 2 (B) 4 (C) 5 (D) 3
- 27.** Vapour pressure of pure benzene is 119 torr and that of toluene is 37.0 torr at the same temperature. Mole fraction of toluene in vapour phase which is in equilibrium with a solution of benzene and toluene having a mole fraction of toluene 0.50, will be :
[JEE (MAIN)-2013 ONLINE]
- (A) 0.137 (B) 0.205 (C) 0.237 (D) 0.435



- 28.** How many grams of methyl alcohol should be added to 10 litre tank of water to prevent its freezing at 268 K ?
 (K_f for water is 1.86 K kg mol⁻¹) [JEE (MAIN)-2013 ONLINE]
 (A) 899.04 g (B) 886.02 g (C) 868.06 g (D) 880.07 g
- 29.** Consider separate solution of 0.500 M C₂H₅OH(aq), 0.100 M Mg₃(PO₄)₂(aq), 0.250 M KBr(aq) and 0.125 M Na₃PO₄(aq) at 25°C. Which statement is true about these solutions, assuming all salts to be strong electrolytes ? [JEE-MAIN-2014]
 (A) 0.125 M Na₃PO₄ (aq) has the highest osmotic pressure.
 (B) 0.500 M C₂H₅OH (aq) has the highest osmotic pressure.
 (C) They all have the same osmotic pressure.
 (D) 0.100 M Mg₃(PO₄)₂ (aq) has the highest osmotic pressure.
- 30.** For an ideal Solution of two components A and B, which of the following is true ?
 (A) ΔH_{mixing} < 0 (zero) [JEE(MAIN)-2014 ONLINE]
 (B) A – A, B – B and A – B interactions are identical
 (C) A – B interaction is stronger than A – A and B – B interactions
 (D) ΔH_{mixing} > 0 (zero)
- 31.** The observed osmotic pressure for a 0.10 M solution of Fe(NH₄)₂(SO₄)₂ at 25°C is 10.8 atm. The expected and experimental (observed) values of Van't Hoff factor (i) will be respectively :
 (R= 0.082 L atm k⁻¹ mol⁻¹) [JEE (MAIN)-2014 ONLINE]
 (A) 3 and 5.42 (B) 5 and 3.42 (C) 4 and 4.00 (D) 5 and 4.42
- 32.** The molarity of a solution obtained by mixing 750 mL of 0.5(M)HCl with 250 mL of 2(M)HCl will be :- [JEE (MAIN)-2013]
 (A) 0.875 M (B) 1.00 M (C) 1.75 M (D) 0.975 M
- 33.** The vapour pressure of acetone at 20°C is 185 torr. When 1.2 g of non-volatile substance was dissolved in 100 g of acetone at 20°C, its vapour pressure was 183 torr. The molar mass (g mol⁻¹) of the substance is : [JEE (MAIN)-2015]
 (A) 128 (B) 488 (C) 32 (D) 64



34. A solution at 20°C 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]**
- (A) 38.0 torr and 0.589 (B) 30.5 torr and 0.389
 (C) 35.8 torr and 0.280 (D) 35.0 torr and 0.480
35. Determination of the molar mass of acetic acid in benzene using freezing point depression is affected by : **[JEE (MAIN)-2015 ONLINE]**
- (A) association (B) dissociation (C) complex formation (D) partial ionization
36. 18 g glucose ($C_6H_{12}O_6$) is added to 178.2 g water. The vapour pressure of water (in torr) for this aqueous solution is : **[JEE (MAIN)-2016]**
- (A) 759.0 (B) 7.6 (C) 76.0 (D) 752.4
37. 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)]**
- (A) 0.02 (B) 0.005 (C) 0.015 (D) 0.0075
38. 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)]**
- (A) 0.50 (B) 0.80 (C) 0.67 (D) 0.33
39. The freezing point of benzene decreases by $0.45^\circ C$ 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: **[JEE (MAIN)- 2017]**
 $(K_f \text{ for benzene} = 5.12 \text{ K kg mol}^{-1})$
- (A) 64.6% (B) 80.4% (C) 74.6% (D) 94.6%
40. For 1 molal aqueous solution of the following compounds, which one will show the highest freezing point ? **[JEE (MAIN)-2018]**
- (A) $[\text{Co}(\text{H}_2\text{O})_3\text{Cl}_3] \cdot 3\text{H}_2\text{O}$ (B) $[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_3$
 (C) $[\text{Co}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$ (D) $[\text{Co}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}_2 \cdot \text{H}_2\text{O}$



- 41.** Which one of the following statements regarding Henry's law not correct ?

[JEE MAIN-2019(Jan.)]

- (A) The value of K_H increases with function of the nature of the gas
- (B) Higher the value of K_H at a given pressure, higher is the solubility of the gas in the liquids.
- (C) The partial pressure of the gas in vapour phase is proportional to the mole fraction of the gas in the solution.
- (D) Different gases have different K_H (Henry's law constant) values at the same temperature.

- 42.** 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(Jan.)]

- (A) $x_A = 0.76 ; x_B = 0.24$
- (B) $x_A = 0.28 ; x_B = 0.72$
- (C) $x_A = 0.37 ; x_B = 0.36$
- (D) $x_A = 0.4 ; x_B = 0.6$

- 43.** 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(Jan.)]

- (A) $K_b = 1.5 K_f$
- (B) $K_b = K_f$
- (C) $K_b = 0.5 K_f$
- (D) $K_b = 2 K_f$

- 44.** 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(Jan.)]

- (A) 2 cups of water to 3 cups of pure milk
- (B) 1 cup of water to 3 cups of pure milk
- (C) 3 cups of water to 2 cups of pure milk
- (D) 1 cup of water to 2 cups of pure milk

- 45.** Molecules of benzoic acid ($\text{C}_6\text{H}_5\text{COOH}$) dimerise in benzene. 'w' g of the acid dissolved in 30 g of benzene shows a depression in freezing point equal to 2K. If the percentage association of the acid to form dimer in the solution is 80, then w is : [JEE MAIN-2019(Jan.)]

(Given that $K_f = 5 \text{ K kg mol}^{-1}$, Molar mass of benzoic acid = 122 g mol^{-1})

- (A) 1.5 g
- (B) 1.0 g
- (C) 2.4 g
- (D) 1.8 g

- 46.** K_2HgI_4 is 40% ionised in aqueous solution. The value of its van't Hoff factor (i) is :-

[JEE MAIN-2019(Jan.)]

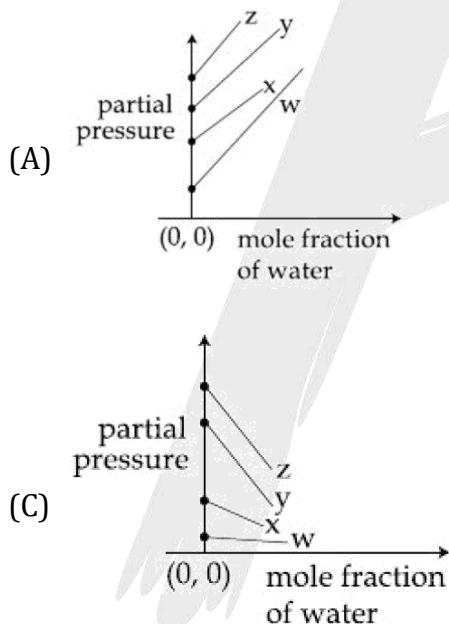
- (A) 1.6
- (B) 2.0
- (C) 2.2
- (D) 1.8

- 47.** 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 :

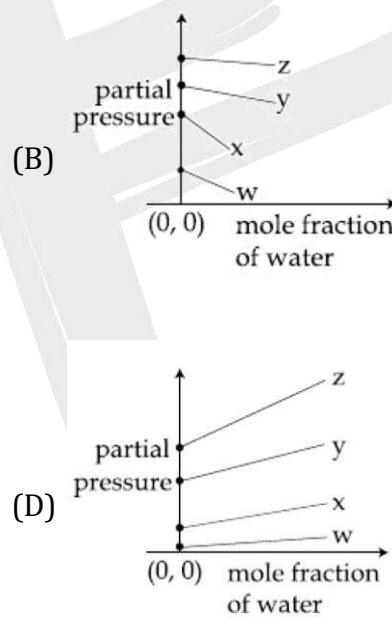
[JEE MAIN-2019(Jan.)]

- (A) 2A
- (B) A
- (C) 3A
- (D) 4A

[JEE MAIN-2019(April)]



[JEE MAIN-2019(April)]



51. 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(April)]

[JEE MAIN-2019(April)]

(A) $\frac{x_M}{x_N} > \frac{y_M}{y_N}$ (B) $(x_M - y_M) < (x_N - y_N)$ (C) $\frac{x_M}{x_N} < \frac{y_M}{y_N}$ (D) $\frac{x_M}{x_N} = \frac{y_M}{y_N}$



52. 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 BaCl₂ 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(April)]

- (A) 16×10^{-4} (B) 6×10^{-2} (C) 4×10^{-2} (D) 4×10^{-4}

53. Molal depression constant for a solvent is 4.0 kg mol⁻¹. The depression in the freezing point of the solvent for 0.03 mol kg⁻¹ solution of K₂SO₄ is :

[JEE MAIN-2019(April)]

(Assume complete dissociation of the electrolyte)

- (A) 0.12 K (B) 0.36 K (C) 0.24 K (D) 0.18 K

54. 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 mmHg, lowering of vapour pressure will be: (molar mass of urea = 60 g mol⁻¹)

[JEE MAIN-2019(April)]

- (A) 0.017 mmHg (B) 0.027 mmHg (C) 0.031 mmHg (D) 0.028 mmHg

55. 1g 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(April)]

- (A) 10 : 1 (B) 5 : 1 (C) 1 : 5 (D) 1 : 0.2

56. A solution is prepared by dissolving 0.6 g of urea (molar mass = 60 g mol⁻¹) and 1.8 g 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(April)]

- (A) 4.92 atm (B) 2.46 atm (C) 8.2 atm (D) 1.64 atm

57. Two open beakers one containing a solvent and the other containing a mixture of that solvent with a non volatile solute are together sealed in a container. Over time :

[Jee Main, 2020]

- (A) The volume of the solution decreases and the volume of the solvent increases
- (B) The volume of the solution increases and the volume of the solvent decreases
- (C) The volume of the solution does not change and the volume of the solvent decreases
- (D) The volume of the solution and the solvent does not change



58. If 250 cm^3 of an aqueous solution containing 0.73 g of a protein A is isotonic with one litre of another aqueous solution containing 1.65 g of a protein B, at 298 K , the ratio of the molecular masses of A and B is _____ $\times 10^{-2}$ (to the nearest integer). [Jee Main, 2020]

59. When 3.00 g of a substance 'X' is dissolved in 100 g of CCl_4 , it raises the boiling point by 0.60 K . The molar mass of the substance 'X' is _____ g mol^{-1} . (Nearest integer)
[Given K_b for CCl_4 is $5.0 \text{ K kg mol}^{-1}$] [JEE Main, July 2021]

60. 1 kg of 0.75 molal aqueous solution of sucrose can be cooled up to -4°C before freezing. The amount of ice (in g) that will be separated out is _____. (Nearest integer)
[Given : $K_f(\text{H}_2\text{O}) = 1.86 \text{ K kg mol}^{-1}$] [JEE Main, August 2021]

61. A 1 molal $\text{K}_4\text{Fe}(\text{CN})_6$ solution has a degree of dissociation of 0.4 . Its boiling point is equal to that of another solution which contains 18.1 weight percent of a non electrolytic solute A. The molar mass of A is ____ u.
(Round off to the Nearest Integer).
[Density of water = 1.0 g cm^{-3}] [JEE Main, March 2021]

62. The oxygen dissolved in water exerts a partial pressure of 20 kPa in the vapour above water. The molar solubility of oxygen in water is _____ $\times 10^{-5} \text{ mol dm}^{-3}$.
(Round off to the Nearest Integer)
[Given : Henry's law constant = $K_H = 8.0 \times 10^4 \text{ kPa}$ for O_2 .
Density of water with dissolved oxygen = 1.0 kg dm^{-3}] [JEE Main, March 2021]

63. A gaseous mixture of two substances A and B, under a total pressure of 0.8 atm is in equilibrium with an ideal liquid solution. The mole fraction of substance A is 0.5 in the vapour phase and 0.2 in the liquid phase. The vapour pressure of pure liquid A is ____ atm. (Nearest integer) [JEE Main, July 2022]

64. When a certain amount of solid A is dissolved in 100 g of water at 25°C to make a dilute solution, the vapour pressure of the solution is reduced to one-half of that of pure water. The vapour pressure of pure water is 23.76 mmHg . The number of moles of solute A added is _____.
(Nearest Integer) [JEE Main, July 2022]

65. The depression in freezing point observed for a formic acid solution of concentration 0.5 mL L^{-1} is 0.0405°C . Density of formic acid is 1.05 g mL^{-1} . The Van't Hoff factor of the formic acid solution is nearly: [Given for water $K_f = 1.86 \text{ K kg mol}^{-1}$] [JEE Main, July 2022]

(A) 0.8

(B) 1.1

(C) 1.9

(D) 2.4



EXERCISE # (JEE-ADVANCED)

1. A 0.004 M solution of Na_2SO_4 is isotonic with a 0.010 M solution of glucose at same temperature. The apparent degree of dissociation of Na_2SO_4 is [JEE 2004]

(A) 25% (B) 50% (C) 75% (D) 85%

2. 1.22 g of benzoic acid is dissolved in (i) 100 g acetone (K_b for acetone = 1.7) and (ii) 100 g benzene (K_b for benzene = 2.6). The elevation in boiling points T_b is 0.17°C and 0.13°C respectively. [JEE 2004]
 - What are the molecular weights of benzoic acid in both the solutions?
 - What do you deduce out of it in terms of structure of benzoic acid?

3. The elevation in boiling point, when 13.44 g of freshly prepared CuCl_2 are added to one kilogram of water, is [Some useful data, $K_b(\text{H}_2\text{O}) = 0.52 \text{ kg K mol}^{-1}$, mol. wt. of $\text{CuCl}_2 = 134.4 \text{ gm}$] [JEE 2005]

(A) 0.05 (B) 0.1 (C) 0.16 (D) 0.21

4. 72.5 g of phenol is dissolved in 1 kg of a solvent ($k_f = 14$) which leads to dimerization of phenol and freezing point is lowered by 7 kelvin. What percent of total phenol is present in dimeric form? [JEE 2006]

(A) 0.5 (B) 1 (C) 2 (D) 3

5. When 20 g of naphtholic acid ($\text{C}_{11}\text{H}_8\text{O}_2$) is dissolved in 50 g of benzene ($K_f = 1.72 \text{ K kg mol}^{-1}$), a freezing point depression of 2 K is observed. The van't Hoff factor (i) is [JEE 2007]

(A) 0.5 (B) 1 (C) 2 (D) 3

Paragraph for Question No. Q.6 to Q.8

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. Applications of colligative properties are very useful in day-to-day life. One of its examples 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 kg mol^{-1}

Freezing point depression constant of ethanol (K_f^{ethanol}) = $2.0 \text{ K kg mol}^{-1}$



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

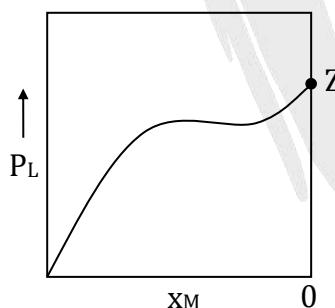
Molecular weight of ethanol = 46 g mol⁻¹

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

6. The freezing point of the solution M is [JEE 2008]
 (A) 268.7 K (B) 268.5 K (C) 234.2 K (D) 150.9 K
7. The vapour pressure of the solution M is [JEE 2008]
 (A) 39.3 mm Hg (B) 36.0 mm Hg (C) 29.5 mm Hg (D) 28.8 mm Hg
8. 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]
 (A) 380.4 K (B) 376.2 K (C) 375.5 K (D) 354.7 K
9. The Henry's law constant for the solubility of N₂ gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N₂ in air is 0.8. The number of moles of N₂ from air dissolved in 10 moles of water at 298 K and 5 atm pressure is- [JEE 2009]
 (A) 4.0×10^{-4} (B) 4.0×10^{-5} (C) 5.0×10^{-4} (D) 4.0×10^{-5}
10. The freezing point (in °C) of a solution containing 0.1 g of K₃[Fe(CN)₆] (Mol. Wt. 329) in 100 g of water ($K_f = 1.86$ K kg mol⁻¹) is [JEE 2011]
 (A) -2.3×10^{-2} (B) -5.7×10^{-2} (C) -5.7×10 (D) -1.2×10^{-2}

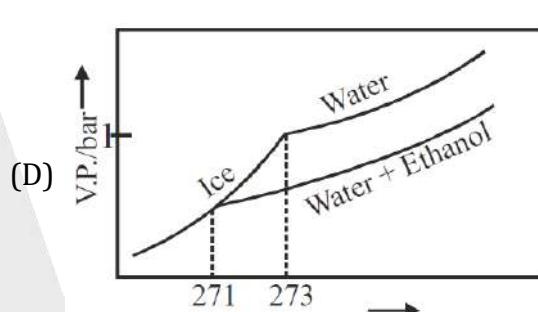
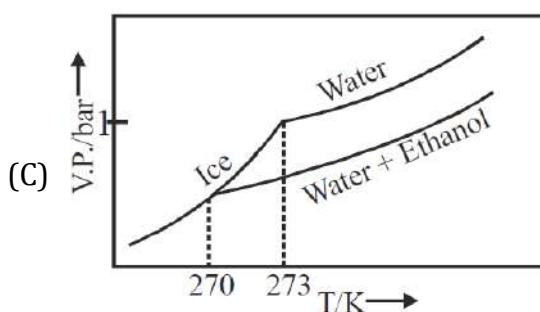
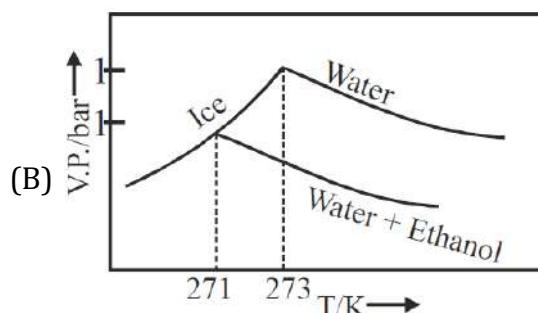
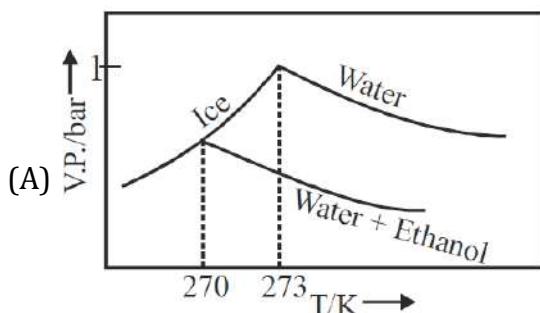


11. For a dilute solution containing 2.5 g of a non-volatile non-electrolyte solute in 100 g of water, the elevation in boiling point at 1 atm pressure is 2°C . Assuming concentration of solute is much lower than the concentration of solvent, the vapour pressure (mm of Hg) of the solution is: (take $K_b = 0.76 \text{ K kg mol}^{-1}$) [JEE 2011]
 (A) 724 (B) 740 (C) 736 (D) 718
12. Benzene and naphthalene form an ideal solution at room temperature. For this process, the true statement(s) is(are) [J-Adv. 2013]
 (A) ΔG is positive (B) ΔS_{system} is positive (C) $\Delta S_{\text{surroundings}} = 0$. (D) $\Delta H = 0$
13. A compound H_2X with molar weight of 80 g is dissolved in a solvent having density of 0.4 g mol^{-1} , Assuming no change in volume upon dissolution, the molality of a 3.2 molar solution is [JEE-Adv. 2014]
14. 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 -0.0558°C , the number of chloride (s) in the coordination sphere of the complex is [JEE-Adv. 2015]
 [K_f of water = $1.86 \text{ K kg mol}^{-1}$]
15. Mixture(s) showing positive deviation from Raoult's law at 35°C is (are) [JEE-Adv. 2016]
 (A) carbon tetrachloride + methanol (B) carbon disulphide + acetone
 (C) benzene + toluene (D) phenol + aniline
16. 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 solutions. The correct statement(s) applicable to this system is(are) [JEE Adv. 2017]



- (A) 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.
- (B) The point Z represents vapour pressure of pure liquid M and Raoult's law is obeyed when $x_L \rightarrow 0$
- (C) The point Z represents vapour pressure of pure liquid L and Raoult's law is obeyed when $x_L \rightarrow 1$
- (D) The point Z represents vapour pressure of pure liquid M and Raoult's law is obeyed when $x_L = 0$ $x_L = 1$

17. 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.). Among the following, the option representing change in the freezing point is

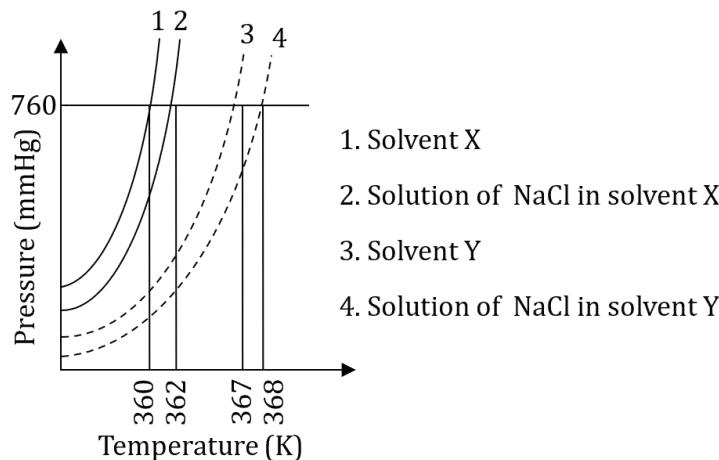


18. Liquids A and B form ideal solution over the entire range of composition. At temperature T, equimolar binary solution of liquids A and B has vapour pressure 45 Torr. At the same temperature, a new solution of A and B having mole fractions x_A and x_B respectively, has vapour pressure of 22.5 Torr. The value of x_A/x_B in the new solution is ____.

(given that the vapour pressure of pure liquid A is 20 Torr at temperature T) [JEE Adv. 2018]

19. 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 Adv. 2018]





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 ____.

- 20.** 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 ____ [JEE Adv. 2019]
(Given data: Molar mass and the molal freezing point depression constant of benzene are 78 g mol⁻¹ and 5.12 K kg mol⁻¹, respectively)
- 21.** Liquids A and B form ideal solution for all compositions of A and B at 25°C. Two such solutions with 0.25 and 0.50 mole fractions of A have the total vapor pressures of 0.3 and 0.4 bar, respectively. What is the vapor pressure of pure liquid B in bar? [JEE Adv. 2020]
- 22.** An aqueous solution is prepared by dissolving 0.1 mol of an ionic salt in 1.8 kg of water at 35°C. The salt remains 90% dissociated in the solution. The vapour pressure of the solution is 59.724 mm of Hg. Vapor pressure of water at 35°C is 60.000 mm of Hg. The number of ions present per formula unit of the ionic salt is [JEE Adv. 2022]
- 23.** 50 mL of 0.2 molal urea solution (density = 1.012 g mL⁻¹ at 300 K) is mixed with 250 mL of a solution containing 0.06 g of urea. Both the solutions were prepared in the same solvent. The osmotic pressure (in torr) of the resulting at 300 K is
Assume, $\Delta_{\text{mix}} H = 0, \Delta_{\text{mix}} V = 0$ [JEE Adv. 2023]



ANSWER KEY

EXERCISE # O-I

1. (C) 2. (B) 3. (C) 4. (B) 5. (C) 6. (B) 7. (B)
8. (B) 9. (B) 10. (B) 11. (C) 12. (A) 13. (B) 14. (D)
15. (C) 16. (B) 17. (C) 18. (C) 19. (C) 20. (B) 21. (D)
22. (D) 23. (C) 24. (C) 25. (A) 26. (A) 27. (B) 28. (C)
29. (B) 30. (B) 31. (A) 32. (D) 33. (C) 34. (C) 35. (B)
36. (C) 37. (C) 38. (A) 39. (A) 40. (B) 41. (B) 42. (B)
43. (C) 44. (D) 45. (A) 46. (C) 47. (D) 48. (B) 49. (D)
50. (B) 51. (A) 52. (B) 53. (D) 54. (B) 55. (A) 56. (A)
57. (A) 58. (D) 59. (B) 60. (B) 61. (B) 62. (B) 63. (A)
64. (B) 65. (B) 66. (B) 67. (C) 68. (A) 69. (A) 70. (C)
71. (B) 72. (C) 73. (A) 74. (C) 75. (B) 76. (C) 77. (D)
78. (B) 79. (A)



EXERCISE # S-I

1. ((i) 30%, (ii) 0.046 (iii) $\text{Na}^+ = 5.42 \text{ m}$, $\text{S}_2\text{O}_3^{2-} = 2.71 \text{ m}$)
2. (Molality = 11.44 m, Molarity = 7.55 M)
3. ($P_{\text{O}_2} = 810 \text{ mm Hg}$, $P_{\text{H}_2\text{O}} = 355 \text{ mm Hg}$, $P_{\text{total}} = 1165 \text{ mm Hg}$)
4. (2.4 atm)
5. 220
6. (66.13 mm Hg)
7. (0.24)
8. (0.964)
9. (27)
10. (27.3 mole %)
11. ($p_{\text{A}^0} = 400 \text{ mm of Hg}$, $p_{\text{B}^0} = 600 \text{ mm of Hg}$)
12. ($P_{\text{B}^0} = 0.7 \text{ atm}$ or $P_{\text{A}^0} = 1.9 \text{ atm}$)
13. 85.88
14. (0.25)
15. (0.04)
6. (111.1g, 18.52 molal)
17. (0.162 m)
18. (65.25)
19. (17.38)
20. (0.741 m, 0.013)
21. (106 g/mol)
22. (100.08°C)
23. ($\text{C}_{44}\text{H}_{88}\text{O}_{44}$)
24. (2048 g/mol)
25. (156.06)
6. (5.08°C/m)
27. (C_6H_6)
28. ($K_b = 0.512 \text{ kg mol K}^{-1}$, $T_b = 373.20 \text{ K}$)
29. (59.99)
30. ($T_f = -2.28^\circ\text{C}$)
31. (i = 2.5)
32. (94.5 %)
33. ($\alpha = 99.2\%$)
34. (4.64 atm)
35. ($7.482 \times 10^5 \text{ Nm}^{-2}$)
36. (0.95; 1.95)
37. (746.2 mm of Hg)
38. (60)
39. (3 ions)
40. 4 (A,B,C,D)
41. (There is positive deviation from Raoult's law, $\Delta S > 0$.)
42. (7.62 bar)
43. (0.716 mmol.)
44. (12 mol/litre.)

EXERCISE # O-II

1. (B)
2. (B)
3. (A)
4. (B)
5. (A, B)
6. (BC)
7. (AC)
8. (C,D)
9. (C, D)
10. (B, C)
11. (A,B,C,D)
12. (C,D)
13. (A,C,D)
14. (B,C)
15. (A)
16. (D)
17. (C)
18. (C)
19. (B)
20. (A) → P, R, S; (B) → P, Q, T; (C) → P; (D) → P, Q, T
21. ((A) → P; (B) → Q, R, S; (C) → T; (D) → P, Q, R, S, T)



EXERCISE # S-II

1. ($Y'_B = 0.932$) 2. (92 mol% toluene; 96.8 mol % toluene)
 3. (38.71 g) 4. (5.4×10^5 g/mol) 5. (20) 6. 4.04×10^{-2}
 7. ($[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$) 8. (0.7333) 9. 0.08 atm 10. (0.73)
 11. 141.4 mmHg
 12. (a) 0.47, (b) 565 torr, (c) $x_A = 0.08$, $x_B = 0.92$, (d) 675 torr, (e) $x'_A = 0.11$, $x'_B = 0.89$

EXERCISE # (JEE-MAIN)

1. (A) 2. (B) 3. (D) 4. (D) 5. (B) 6. (D) 7. (D)
 8. (C) 9. (A) 10. (D) 11. (D) 12. (D) 13. (A) 14. (D)
 15. (C) 16. (B) 17. (C) 18. (C) 19. (C) 20. (B) 21. (A)
 22. (A) 23. (C) 24. (C) 25. (D) 26. (A) 27. (C) 28. (C)
 29. (C) 30. (B) 31. (D) 32. (A) 33. (D) 34. (A) 35. (A)
 36. (D) 37. (C) 38. (A) 39. (D) 40. (A) 41. (B) 42. (B)
 43. (D) 44. (C) 45. (C) 46. (D) 47. (C) 48. (A) 49. (B)
 50. (C) 51. (A) 52. (B) 53. (B) 54. (A) 55. (C) 56. (A)
 57. (B) 58. (177) 59. (250) 60. (518) 61. (85) 62. (25) 63. (2)
 64. (3) 65. (C)

EXERCISE # (JEE-ADVANCED)

1. (C)
 2. ((a) 122, (b) It means that benzoic acid remains as it is in acetone while it dimerises in benzene)
 3. (C) 4. (35% (degree of asso = 70%)) 5. (A) 6. (D) 7. (B)
 8. (B) 9. (A) 10. (A) 11. (A) 12. (B,C,D)
 13. (8) 14. (1) 15. (A,B) 16. (A,C) 17. (C)
 18. (19) 19. (0.05) 20. (1.02) 21. (0.2) 22. (5) 23. (682)