Chapter 10

Solutions

1. 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]**

(1) The solution is non-ideal, showing +ve deviation from Raoult's Law

(2) The solution is 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

2. Two liquids X and Y from an ideal solution. At 300 K, 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]**

(1) 300 and 400 (2) 400 and 600

(3) 500 and 600 (4) 200 and 300

3. 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 K kg mol^{-1}) **[AIEEE-2010]**

(1) 0.0186 K (2) 0.0372 K

(3) 0.0558 K (4) 0.0744 K

4. On mixing, heptane and octane from 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]**

(1) 144.5 kPa (2) 72.0 kPa

(3) 36.1 kPa (4) 96.2 kPa

5. 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]**

(1) 34.2 (2) 136.2

(3) 171.2 (4) 68.4

6. K_f for water is 1.86 K kg mol^{-1}. If your automobile radiator holds 1.0 kg of water, how many grams of ethylene glycol ($C_2H_6O_2$) must you add to get the freezing point of the solution lowered to – 2.8°C? **[AIEEE-2012]**

(1) 93 g (2) 39 g

(3) 27 g (4) 72 g

7. Consider separate solutions 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 solutions, assuming all salts to be strong electrolytes? **[JEE (Main)-2014]**

(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.

8. The vapour pressure of acetone at 20°C is 185 torr. When 1.2 g of a 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]**

(1) 32 (2) 64

(3) 128 (4) 488

9. 18 g glucose ($C_6H_{12}O_6$) is added to 178.2 g water. The vapor pressure of water (in torr) for this aqueous solution is **[JEE (Main)-2016]**

(1) 76.0 (2) 752.4

(3) 759.0 (4) 7.6

10. 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]**

(1) 74.6% (2) 94.6%

(3) 64.6% (4) 80.4%

11. Which one of the following statements regarding Henry's law is not correct? **[JEE (Main)-2019]**

(1) Different gases have different K_H (Henry's 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.

12. 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]

(1) $x_A = 0.76; x_B = 0.24$ (2) $x_A = 0.37; x_B = 0.63$

(3) $x_A = 0.28; x_B = 0.72$ (4) $x_A = 0.4; x_B = 0.6$

13. 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]

(1) $K_b = 0.5\ K_f$ (2) $K_b = 2\ K_f$

(3) $K_b = 1.5\ K_f$ (4) $K_b = K_f$

14. 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]

(1) 3 cups of water and 2 cups of pure milk

(2) 1 cup of water and 2 cups of pure milk

(3) 2 cups of water to 3 cups of pure milk

(4) 1 cup of water to 3 cups of pure milk

15. K_2HgI_4 is 40% ionised in aqueous solution. The value of its van't Hoff factor (i) is **[JEE (Main)-2019]**

(1) 1.6 (2) 2.0

(3) 2.2 (4) 1.8

16. 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]**

(1) 2A (2) 3A

(3) A (4) 4A

(Since density of solutions are not given therefore assuming molality to be equal to molarity and given % as % W/V)

17. 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

(Given that K_f = 5 K kg mol^{-1}, Molar mass of benzoic acid = 122 g mol^{-1}) **[JEE (Main)-2019]**

(1) 1.5 g (2) 2.4 g

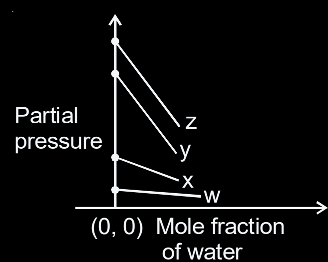
(3) 1.8 g (4) 1.0 g

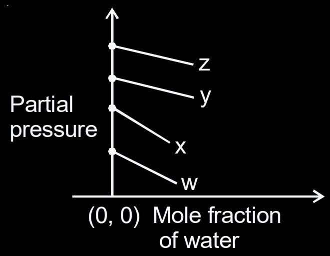
18. The vapour pressures of pure liquids A and B are 400 and 600 mmHg, respectively at 298 K. On mixing the two liquids, the sum of their initial volumes is equal to the volume of the final mixture. The mole fraction of liquid B is 0.5 in the mixture. The vapour pressure of the final solution, the mole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

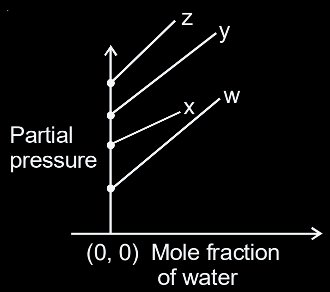
(1) 500 mmHg, 0.4, 0.6 (2) 500 mmHg, 0.5, 0.5

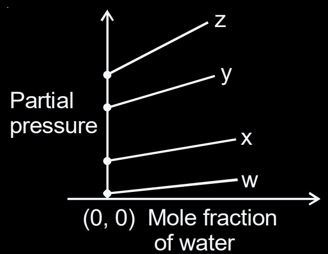
(3) 450 mmHg, 0.4, 0.6 (4) 450 mmHg, 0.5, 0.5

19. 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 kbar, respectively. The correct plot for the given data is : **[JEE (Main)-2019]**

(1) 

(2) 

(3) 

(4) 

20. 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]

(1) $\frac{x_M}{x_N} = \frac{y_M}{y_N}$

(2) $\frac{x_M}{x_N} > \frac{y_M}{y_N}$

(3) $\frac{x_M}{x_N} < \frac{y_M}{y_N}$

(4) $(x_M - y_M) < (x_N - y_N)$

21. 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]**

(1) 16×10^{-4} (2) 4×10^{-4}

(3) 6×10^{-2} (4) 4×10^{-2}

22. 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]

(1) 0.36 K (2) 0.18 K

(3) 0.12 K (4) 0.24 K

23. 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]

(1) 0.031 mmHg (2) 0.017 mmHg

(3) 0.028 mmHg (4) 0.027 mmHg

24. 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]**

(1) 1 : 5 (2) 10 : 1

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

25. 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]**

(1) 1.64 atm (2) 2.46 atm

(3) 8.2 atm (4) 4.92 atm

26. A solution containing 62 g ethylene glycol in 250 g water is cooled to –10°C. 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]**

(1) 64 (2) 32

(3) 16 (4) 48

27. At 35°C, the vapour pressure of CS_2 is 512 mm Hg and that of acetone is 344 mm Hg. A solution of CS_2 in acetone has a total vapour pressure of 600 mm Hg. The false statement amongst the following is **[JEE (Main)-2020]**

(1) Raoult's law is not obeyed by this system

(2) A mixture of 100 mL CS_2 and 100 mL acetone has a volume < 200 mL

(3) Heat must be absorbed in order to produce the solution at 35°C

(4) CS_2 and acetone are less attracted to each other than to themselves

28. 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]**

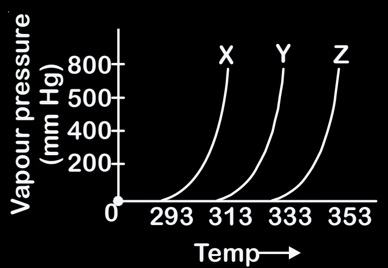
(1) The volume of the solution and the solvent does not change

(2) The volume of the solution increases and the volume of the solvent decreases

(3) The volume of the solution does not change and the volume of the solvent decreases

(4) The volume of the solution decreases and the volume of the solvent increases.

29. A graph of vapour pressure and temperature for three different liquids X, Y, and Z is shown below



The following inferences are made

(A) X has higher intermolecular interactions compared to Y.

(B) X has lower intermolecular interactions compared to Y

(C) Z has lower intermolecular interactions compared to Y.

The correct inferences is/are **[JEE (Main)-2020]**

(1) (B)

(2) (C)

(3) (A) and (C)

(4) (A)

30. An open beaker of water in equilibrium with water vapour is in a sealed container. When a few grams of glucose are added to the beaker of water, the rate at which water molecules **[JEE (Main)-2020]**

(1) Leaves the solution increases

(2) Leaves the vapour increases

(3) Leaves the vapour decreases

(4) Leaves the solution decreases

31. The size of a raw mango shrinks to a much smaller size when kept in a concentrated salt solution. Which one of the following processes can explain this? **[JEE (Main)-2020]**

(1) Osmosis

(2) Reverse osmosis

(3) Diffusion

(4) Dialysis

32. Henry's constant (in kbar) for four gases α, β, γ and δ in water at 298 K is given below

	α	β	γ	δ
K_H	50	2	2×10^{-5}	0.5

(density of water = 10^3 kg m^{-3} at 298 K)

This table implies that **[JEE (Main)-2020]**

(1) The pressure of a 55.5 molal solution of γ is 1 bar

(2) Solubility of γ at 308 K is lower than at 298 K

(3) α has the highest solubility in water at a given pressure

(4) The pressure of a 55.5 molal solution of δ is 250 bar

33. A set of solutions is prepared using 180 g of water as a solvent and 10 g of different non-volatile solutes A, B and C. The relative lowering of vapour pressure in the presence of these solutes are in the order [Given, molar mass of A = 100 g mol^{-1}; B = 200 g mol^{-1}; C = 10,000 g mol^{-1}]

[JEE (Main)-2020]

(1) A > C > B (2) C > B > A

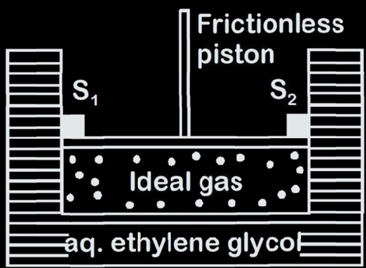
(3) A > B > C (4) B > C > A

34. How much amount of NaCl should be added to 600 g of water (ρ = 1.00 g/mL) to decrease the freezing point of water to –0.2°C? ________.

(The freezing point depression constant for water = 2 K kg mol^{-1}) **[JEE (Main)-2020]**

35. A cylinder containing an ideal gas (0.1 mol of 1.0 dm^3) is in thermal equilibrium with a large volume of 0.5 molal aqueous solution of ethylene glycol at its freezing point. If the stoppers S_1 and S_2 (as shown in the figure) are suddenly withdrawn, the volume of the gas in litres after equilibrium is achieved will be ________ .

(Given, K_f (water) = 2.0 K kg mol^{-1}, R = 0.08 dm^3 atm K^{-1} mol^{-1})



[JEE (Main)-2020]

36. 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 ___________ × 10^{-2} (to the nearest integer). **[JEE (Main)-2020]**

37. At 300 K, the vapour pressure of a solution containing 1 mole of n-hexane and 3 moles of n-heptane is 550 mm of Hg. At the same temperature, if one more mole of n-heptane is added to this solution, the vapour pressure of the solution increases by 10 mm of Hg. What is the vapour pressure in mm Hg of n-heptane in its pure state ______? **[JEE (Main)-2020]**

38. The osmotic pressure of a solution of NaCl is 0.10 atm and that of a glucose solution is 0.20 atm. The osmotic pressure of a solution formed by mixing 1 L of the sodium chloride solution with 2 L of the glucose solution is x × 10^{-3} atm. x is _____. (nearest integer)

[JEE (Main)-2020]

39. The elevation of boiling point of 0.10 m aqueous $CrCl_3.xNH_3$ solution is two times that of 0.05 m aqueous $CaCl_2$ solution. The value of x is ______.

[Assume 100% ionisation of the complex and $CaCl_2$, coordination number of Cr as 6, and that all NH_3 molecules are present inside the coordination sphere]

[JEE (Main)-2020]

40. A soft drink was bottled with a partial pressure of CO_2 of 3 bar over the liquid at room temperature. The partial pressure of CO_2 over the solution approaches a value of 30 bar when 44 g of CO_2 is dissolved in 1 kg of water at room temperature. The approximate pH of the soft drink is ______ × 10^{-1}.

(First dissociation constant of H_2CO_3 = 4.0 × 10^{-7}; log 2 = 0.3; density of the soft drink = 1 g mL^{-1}) **[JEE (Main)-2020]**

41. 10.30 mg of O_2 is dissolved into a liter of sea water of density 1.03 g/mL. The concentration of O_2 in ppm is __________ . **[JEE (Main)-2020]**

42. When 9.45 g of $ClCH_2COOH$ is added to 500 mL of water, its freezing point drops by 0.5°C. The dissociation constant of $ClCH_2COOH$ is x × 10^{-3}. The value of x is _______. (Rounded off to the nearest integer)

$[K_{f(H_2O)} = 1.86\ K\ kg\ mol^{-1}]$ **[JEE (Main)-2021]**

43. C_6H_6 freezes at 5.5°C. The temperature at which a solution of 10 g of C_4H_{10} in 200 g of C_6H_6 freeze is ____ °C. (The molal freezing point depression constant of C_6H_6 is 5.12°C/m.)

[JEE (Main)-2021]

44. 1 molal aqueous solution of an electrolyte A_2B_3 is 60% ionised. The boiling point of the solution at 1 atm is __________ K. (Rounded-off to the nearest integer)

[Given K_b for (H_2O) = 0.52 K kg mol^{-1}]

[JEE (Main)-2021]

45. If a compound AB dissociates to the extent of 75% in an aqueous solution, the molality of the solution which shows a 2.5 K rise in the boiling point of the solution is ____ molal. (Rounded-off to the nearest integer)

[K_b = 0.52 K kg mol^{-1}] **[JEE (Main)-2021]**

46. 224 mL of $SO_{2(g)}$ at 298 K and 1 atm is passed through 100 mL of 0.1 M NaOH solution. The non-volatile solute produced is dissolved in 36 g of water. The lowering of vapour pressure of solution (assuming the solution is dilute) $\left(P^{\circ}_{(H_2O)} = 24\ mm\ of\ Hg\right)$ is x × 10^{-2} mm of Hg, the value of x is _________. (Integer answer)

[JEE (Main)-2021]

47. When 12.2 g of benzoic acid is dissolved in 100 g of water, the freezing point of solution was found to be –0.93°C (K_f (H_2O) = 1.86 K kg mol^{-1}). The number (n) of benzoic acid molecules associated (assuming 100% association) is __________.

[JEE (Main)-2021]

48. AB_2 is 10% dissociated in water to A^{2+} and B^-. The boiling point of a 10.0 molal aqueous solution of AB_2 is __________°C. (Round off to the Nearest Integer)

[Given : Molal elevation constant of water K_b = 0.5 K kg mol^{-1} boiling point of pure water = 100°C]

[JEE (Main)-2021]

49. At 363 K, the vapour pressure of A is 21 kPa and that of B is 18 kPa. One mole of A and 2 moles of B are mixed. Assuming that this solution is ideal, the vapour pressure of the mixture is __________ kPa.

(Round off to the Nearest Integer]

[JEE (Main)-2021]

50. The mole fraction of a solute in a 100 molal aqueous solution is ____ × 10^{-2}.

(Round off to the Nearest Integer).

[Given : Atomic masses : H : 1.0 u, O : 16.0 u]

[JEE (Main)-2021]

51. 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 _________ × 10^{-5} mol dm^{-3}.

(Round off to the Nearest Integer).

[Given : Henry's law constant = K_H = 8.0 × 10^4 kPa for O_2.

Density of water with dissolved oxygen = 1.0 kg dm^{-3}]

[JEE (Main)-2021]

52. A 1 molal $K_4Fe(CN)_6$ 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)-2021]

53. 2 molal solution of a weak acid HA has a freezing point of 3.885°C. The degree of dissociation of this acid is _____ × 10^{-3}.

(Round off to the Nearest Integer).

[Given : Molal depression constant of water = 1.85 K kg mol^{-1}

Freezing point of pure water = 0°C]

[JEE (Main)-2021]

54. A solute A dimerizes in water. The boiling point of a 2 molal solution of A is 100.52°C. The percentage association of A is ______. (Round off to the Nearest Integer).

[Use : K_b for water = 0.52 K kg mol^{-1}

Boiling point of water = 100°C]

[JEE (Main)-2021]

55. At 20°C, the vapour pressure of benzene is 70 torr and that of methyl benzene is 20 torr. The mole fraction of benzene in the vapor phase at 20°C above an equimolar mixture of benzene and methyl benzene is ________ × 10^{-2}. **[JEE (Main)-2021]**

(Nearest integer)

56. The vapour pressures of A and B at 25°C are 90 mm Hg and 15 mm Hg respectively. If A and B are mixed such that the mole fraction of A in the mixture is 0.6, then the mole fraction of B in the vapour phase is x × 10^{-1}. The value of x is ________. (Nearest integer) **[JEE (Main)-2021]**

57. Which one of the following 0.06 M aqueous solutions has lowest freezing point?

[JEE (Main)-2021]

(1) KI
(2) $Al_2(SO_4)_3$
(3) $C_6H_{12}O_6$
(4) K_2SO_4

58. CO_2 gas is bubbled through water during a soft drink manufacturing process at 298 K. If CO_2 exerts a partial pressure of 0.835 bar then x m mol of CO_2 would dissolve in 0.9 L of water. The value of x is _______. (Nearest integer)

(Henry's law constant for CO_2 at 298 K is 1.67 × 10^3 bar) **[JEE (Main)-2021]**

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 K kg mol^{-1}]

[JEE (Main)-2021]

60. 1.46 g of a biopolymer dissolved in a 100 mL water at 300 K exerted an osmotic pressure of 2.42 × 10^{-3} bar.

The molar mass of the biopolymer is ________ × 10^4 g mol^{-1}. (Round off to the Nearest Integer)

[Use : R = 0.083 L bar mol^{-1} K^{-1}]

[JEE (Main)-2021]

61. In a solvent 50% of an acid HA dimerizes and the rest dissociates. The van't Hoff factor of the acid is ______ × 10^{-2}. (Round off to the Nearest Integer).

[JEE (Main)-2021]

62. Of the following four aqueous solutions, total number of those solutions whose freezing point is lower than that of 0.10 M C_2H_5OH is _______. (Integer answer) **[JEE (Main)-2021]**

(i) 0.10 M $Ba_3(PO_4)_2$ (ii) 0.10 M Na_2SO_4

(iii) 0.10 M KCl (iv) 0.10 M Li_3PO_4

63. 83 g of ethylene glycol dissolved in 625 g of water. The freezing point of the solution is ______ K. (Nearest integer) **[JEE (Main)-2021]**

[Use : Molal freezing point depression constant of water = 1.86 K kg mol^{-1},

Freezing point of water = 273 K,

Atomic masses : C : 12.0 u, O : 16.0 u, H : 1.0 u]

64. 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) **[JEE (Main)-2021]**

[Given : $K_f(H_2O)$ = 1.86 K kg mol^{-1}]

65. 40 g of glucose (Molar mass = 180) is mixed with 200 mL of water. The freezing point of solution is ______ K. (Nearest integer) **[JEE (Main)-2021]**

[Given : K_f = 1.86 K kg mol^{-1}; Density of water = 1.00 g cm^{-3}; Freezing point of water = 273.15 K]

66. Which one of the following 0.10 M aqueous solutions will exhibit the largest freezing point depression? **[JEE (Main)-2021]**

(1) Glycine (2) $KHSO_4$

(3) Hydrazine (4) Glucose

67. 1.22 g of an organic acid is separately dissolved in 100 g of benzene (K_b = 2.6 K kg mol^{-1}) and 100 g of acetone (K_b = 1.7 K kg mol^{-1}). The acid is known to dimerize in benzene but remain as a monomer in acetone. The boiling point of the solution in acetone increases by 0.17°C. The increase in boiling point of solution in benzene in °C is x × 10^{-2}. The value of x is _______. (Nearest integer)

[Atomic mass : C = 12.0, H = 1.0, O = 16.0]

[JEE (Main)-2021]

68. The osmotic pressure of blood is 7.47 bar at 300 K. To inject glucose to a patient intravenously, it has to be isotonic with blood. The concentration of glucose solution in gL^{-1} is _______. (Molar mass of glucose = 180 g mol^{-1}

R = 0.083 L bar K^{-1} mol^{-1}) (Nearest integer)

[JEE (Main)-2022]

69. A company dissolves 'x' amount of CO_2 at 298 K in 1 litre of water to prepare soda water. X = _____ × 10^{-3} g. (nearest integer)

(Given: partial pressure of CO_2 at 298 K = 0.835 bar.

Henry's law constant for CO_2 at 298 K = 1.67 kbar.

Atomic mass of H, C and O is 1, 12, and 6 g mol^{-1}, respectively) **[JEE (Main)-2022]**

70. Solute A associates in water. When 0.7 g of solute A is dissolved in 42.0 g of water, it depresses the freezing point by 0.2°C. The percentage association of solute A in water is :

[Given : Molar mass of A = 93 g mol^{-1}. Molal depression constant of water is 1.86 K kg mol^{-1}.]

[JEE (Main)-2022]

(1) 50% (2) 60%

(3) 70% (4) 80%

71. A 0.5 percent solution of potassium chloride was found to freeze at –0.24°C. The percentage dissociation of potassium chloride is ______. (Nearest integer)

(Molal depression constant for water is 1.80 K kg mol^{-1} and molar mass of KCl is 74.6 g mol^{-1})

[JEE (Main)-2022]

72. The osmotic pressure exerted by a solution prepared by dissolving 2.0 g of protein of molar mass 60 kg mol^{-1} in 200 mL of water at 27°C is _________ Pa. [Integer value]

(use R = 0.083 L bar mol^{-1} K^{-1}) **[JEE (Main)-2022]**

73. 2 g of a non-volatile non-electrolyte solute is dissolved in 200 g of two different solvents A and B whose ebullioscopic constants are in the ratio of 1 : 8. The elevation in boiling points of A and B are in the ratio $\frac{x}{y}$ (x : y). The value of y is ______. (Nearest Integer) **[JEE (Main)-2022]**

74. A solution containing 2.5×10^{-3} kg of a solute dissolved in 75×10^{-3} kg of water boils at 373.535 K. The molar mass of the solute is _____ g mol^{-1}. [nearest integer] (Given : $K_b(H_2O)$ = 0.52 K kg mol^{-1} and boiling point of water = 373.15 K)

[JEE (Main)-2022]

75. The vapour pressures of two volatile liquids A and B at 25°C are 50 Torr and 100 Torr, respectively. If the liquid mixture, contains 0.3 mole fraction of A, then the mole fraction of liquid B in the vapour phase is $\frac{x}{17}$. The value of x is _______. **[JEE (Main)-2022]**

76. 2.5 g of protein containing only glycine ($C_2H_5NO_2$) is dissolved in water to make 500 mL of solution. The osmotic pressure of this solution at 300 K is found to be 5.03×10^{-3} bar. The total number of glycine units present in the protein is _______.

(Given : R = 0.083 L bar K^{-1} mol^{-1})

[JEE (Main)-2022]

77. 1.2 mL of acetic acid is dissolved in water to make 2.0 L of solution. The depression in freezing point observed for this strength of acid is 0.0198°C. The percentage of dissociation of the acid is ____ . (Nearest integer)

[Given: Density of acetic acid is 1.02 g mL^{-1}

Molar mass of acetic acid is 60 g mol^{-1}

$K_f(H_2O)$ = 1.85 K kg mol^{-1}]

[JEE (Main)-2022]

78. Elevation in boiling point for 1.5 molal solution of glucose in water is 4 K. The depression in freezing point for 4.5 molal solution of glucose in water is 4 K. The ratio of molal elevation constant to molal depression constant (K_b/K_f) is ___.

[JEE (Main)-2022]

79. 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 k kg mol^{-1})

[JEE (Main)-2022]

(1) 0.8
(2) 1.1
(3) 1.9
(4) 2.4

80. Two solutions A and B are prepared by dissolving 1 g of non-volatile solutes X and Y, respectively in 1 kg of water. The ratio of depression in freezing points for A and B is found to be 1 : 4. The ratio of molar masses of X and Y is

[JEE (Main)-2022]

(1) 1 : 4
(2) 1 : 0.25
(3) 1 : 0.20
(4) 1 : 5

81. The elevation in boiling point for 1 molal solution of non-volatile solute A is 3 K. The depression in freezing point for 2 molal solution of A in the same solvent is 6 K. The ratio of K_b and K_f i.e., K_b/K_f is 1 : X. The value of X is [nearest integer]

[JEE (Main)-2022]

82. Boiling point of a 2% aqueous solution of a non-volatile solute A is equal to the boiling point of 8% aqueous solution of a non-volatile solute B. The relation between molecular weights of A and B is

[JEE (Main)-2022]

(1) $M_A = 4M_B$
(2) $M_B = 4M_A$
(3) $M_A = 8M_B$
(4) $M_B = 8M_A$

83. 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)-2022]**

84. 150 g of acetic acid was contaminated with 10.2 g ascorbic acid ($C_6H_8O_6$) to lower down its freezing point by $(x \times 10^{-1})$°C. The value of x is _______. (Nearest integer)

(Given : K_f = 3.9 K kg mol^{-1}; molar mass of ascorbic acid = 176 g mol^{-1}) **[JEE (Main)-2022]**

85. 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)-2022]

86. If O_2 gas is bubbled through water at 303 K, the number of millimoles of O_2 gas that dissolve in 1 litre of water is________. (Nearest integer)

(Given : Henry's Law constant for O_2 at 303 K is 46.82 k bar and partial pressure of O_2 = 0.920 bar)

(Assume solubility of O_2 in water is too small, nearly negligible) **[JEE (Main)-2022]**

87. 1.80 g of solute A was dissolved in 62.5 cm^3 of ethanol and freezing point of the solution was found to be 155.1 K. The molar mass of solute A is _____ g mol^{-1}.

[Given : Freezing point of ethanol is 156.0 K.

Density of ethanol is 0.80 g cm^{-3}.

Freezing point depression constant of ethanol is 2.00 K kg mol^{-1}] **[JEE (Main)-2022]**

❑ ❑ ❑

Chapter 10

Solutions

1. Answer (1)

   Ethanol has H-Bonding, n-heptane tries to break the H-bonds of ethanol, hence, V.P. increases. Such a solution shows positive deviation from Raoult's Law.

2. Answer (2)

   Let V. P. of pure $X = x$

   and V. P. of pure $Y = y$

   Then, $\frac{1}{4}x + \frac{3}{4}y = 550$ ...(i)

   and $\frac{1}{5}x + \frac{4}{5}y = 560$ ...(ii)

   Solving (i) and (ii), we get

   $x = 400$ mm

   and $y = 600$ mm

3. Answer (3)

   $\Delta T_f = i\ K_f m$

   i for Na_2SO_4 is 3(100% ionisation)

   $\Delta T_f = 3 \times 1.86 \times \frac{0.01}{1}$

   $\Delta T_f = 0.0558$ K

4. Answer (2)

   $P = X_A P_A^o + X_B P_B^o$

   $n_{heptane} = \frac{25}{100} = 0.25$

   $n_{octane} = \frac{35}{114} = 0.307$

   $P = \frac{0.25}{0.25+0.307} \times 105 + \frac{0.307}{0.25+0.307} \times 45$

   $= 47.127 + 24.84 = 71.96$

   ≈ 72 kPa

5. Answer (4)

   For isotonic solution

   $\pi_1 = \pi_2$

   $C_1 = C_2$

   $\frac{W_1}{M_1V_1} = \frac{W_2}{M_2V_2}$

   $\frac{5}{342 \times 100} = \frac{1}{M_2 \times 100}$

   $M_2 = 68.4$

6. Answer (1)

7. Answer (1)

   $\pi = iCRT$

   $\pi_{C_2H_5OH} = 1 \times 0.500 \times R \times T = 0.5RT$

   $\pi_{Mg_3(PO_4)_2} = 5 \times 0.100 \times R \times T = 0.5RT$

   $\pi_{KBr} = 2 \times 0.250 \times R \times T = 0.5RT$

   $\pi_{Na_3PO_4} = 4 \times 0.125 \times RT = 0.5RT$

8. Answer (2)

   Vapour pressure of pure acetone $P°_A = 185$ torr

   Vapour pressure of solution, $P_S = 183$ torr

   Molar mass of solvent, $M_A = 58$ g/mole

   as we know $\frac{P°_A - P_S}{P_S} = \frac{n_B}{n_A}$

   $\Rightarrow \frac{185-183}{183} = \frac{W_B}{M_B} \times \frac{M_A}{W_A}$

   $\Rightarrow \frac{2}{183} = \frac{1.2}{M_B} \times \frac{58}{100}$

   $\Rightarrow M_B = \frac{1.2}{2} \times \frac{58}{100} \times 183$

   $= 63.68$ g/mole

9. Answer (2)

$$\frac{p^o - p_s}{p_s} = \frac{n_{solute}}{n_{solvent}} = \frac{\frac{18}{180}}{\frac{178.2}{18}} = \frac{18}{17.82}$$

At normal boiling point of water V.P. = p° = 760 torr

$$\therefore \frac{760 - p_s}{p_s} = \frac{18}{1782}$$

or, 1800 p_s = 760 × 1782

p_s = 752.4 torr

10. Answer (2)

$$0.45 = i(5.12)\frac{0.2/60}{20} \times 1000$$

$\Rightarrow$ i = 0.527

$$\underset{1-\alpha}{2CH_3COOH} \rightleftharpoons \underset{\frac{\alpha}{2}}{(CH_3COOH)_2}$$

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

$$\Rightarrow 0.527 = 1 - \frac{\alpha}{2}$$

$$\Rightarrow \frac{\alpha}{2} = 0.473$$

$\Rightarrow$ α = 0.946

$\therefore$ % association = 94.6%

11. Answer (4)

Solubility decreases with the increase in value of K_H.

12. Answer (3)

$P_A^\circ = 7 \times 10^3$

$P_B^\circ = 12 \times 10^3$

$X_A = 0.4$

$X_B = 0.6$

$\therefore$ P = (7 × 0.4 + 12 × 0.6) × 10^3 = 10^4

$P_A = 2.8 \times 10^3$, $P_B = 7.2 \times 10^3$

$\therefore$ $Y_A = 0.28$, $Y_B = 0.72$

13. Answer (2)

$\Delta T_b = k_b m \Rightarrow k_b(1) = 2 \Rightarrow k_b = 2\ km^{-1}$

$\Delta T_f = k_f m \Rightarrow k_f(2) = 2 \Rightarrow k_f = 1\ km^{-1}$

$k_f = 0.5\ k_b \Rightarrow k_b = 2\ k_f$

14. Answer (1)

Freezing point of diluted milk = – 0.2°C

$$\Delta T_f' = 0.2°C$$

Freezing point of pure milk = – 0.5°C

$$\Delta T_f = 0.5°C$$

$$\frac{\Delta T_f}{\Delta T_f'} = \frac{k_f}{k_f}\frac{m}{m'}$$

$$\Rightarrow \frac{0.5}{0.2} = \frac{w_1'}{w_1}$$

$$\Rightarrow \frac{w_1'}{w_1} = \frac{5}{2}$$

2 cups of pure milk mixed with 3 cups of water overall 5 cups of diluted milk.

15. Answer (4)

$$K_2HgI_4 \rightleftharpoons 2K^+ + [HgI_4]^{2-}$$

n = 3

$$\because \quad \alpha = \frac{i-1}{n-1}$$

$$0.4 = \frac{i-1}{3-1}$$

i = 1.8

16. Answer (2)

$$\frac{4}{M_x} = \frac{12}{M_y}$$

$\Rightarrow$ $M_y = 3M_x$

$\therefore$ $M_y = 3A$

(Since density of solutions are not given therefore assuming molality to be equal to molarity and given % as % W/V)

17. Answer (2)

$$2C_6H_5COOH \longrightarrow (C_6H_5COOH)_2$$

t = 0   1   0

t $1 - 2\alpha$ α

Moles at equilibrium = $1 - 2\alpha + \alpha = 1 - \alpha$

$2\alpha = 0.8$, $\alpha = 0.4$

Moles at equilibrium = 0.6

i = 0.6

$$\Delta T_f = ik_f m \quad \Rightarrow \quad 2 = 0.6 \times 5 \times \left(\frac{\frac{w}{122}}{30}\right) \times 1000$$

w = 2.4 g

18. Answer (1)

$P = x_B p_B^\circ + x_A p_A^\circ$

$= 0.5 \times 600 + 0.5 \times 400 = 300 + 200 = 500$

$p_B = y_B P_{Total}$

$$y_B = \frac{p_B}{P_{Total}} = \frac{300}{500} = \frac{3}{5} = 0.6$$

$$y_A = \frac{p_A}{P_{Total}} = \frac{200}{500} = \frac{2}{5} = 0.4$$

19. Answer (1)

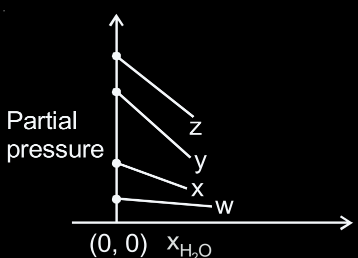
According to Henry's law,

$P = K_H \cdot X_{gas}$

$\because \quad x_{gas} = 1 - x_{H_2O}$

$\therefore \quad P = K_H - K_H \cdot X_{H_2O}$

$y = C + mx$



gas	K_H
w	0.5
x	2
y	35
z	50

20. Answer (2)

$P_M^o = 450$ mmHg, $P_N^o = 700$ mmHg

$P_M = P_M^o X_M = Y_M P_T$

$$\Rightarrow \quad P_M^o = \frac{Y_M}{X_M}(P_T)$$

$$\text{Similarly, } P_N^o = \frac{Y_N}{X_N}(P_T)$$

Given, $P_M^o < P_N^o$

$$\Rightarrow \quad \frac{Y_M}{X_M} < \frac{Y_N}{X_N}$$

$$\Rightarrow \quad \frac{Y_M}{Y_N} < \frac{X_M}{X_N}$$

21. Answer (3)

$\pi_{XY} = 4\pi_{BaCl_2}$

$\therefore \quad 2[XY] = 4 \times (0.01) \times 3$

$$[XY] = 0.06 = 6 \times 10^{-2}\ \frac{\text{mol}}{\text{L}}$$

22. Answer (1)

$$K_2SO_4 \longrightarrow 2K^+ + SO_4^{2-}$$

i (van't Hoff Factor) = 3

$\therefore \quad \Delta T_f = iK_f m$

$= 3 \times 4 \times 0.03$

$= 0.36$ K

23. Answer (2)

Relative lowering of VP is given by

$$\frac{P_B^\circ - P_B}{P_B^\circ} = x_A = \frac{n_A}{n_A + n_B} \simeq \frac{\mathbf{n_A}}{\mathbf{n_B}}$$

$$\frac{P_B^\circ - P_B}{35} = \frac{0.6 \times 18}{60 \times 360} = \frac{1}{2000}$$

On solving, $\Delta P_B = P_B^\circ - P_B = 0.017$

24. Answer (1)

$\Delta T_b = k_b \times m$

$$\frac{(k_b)_A}{(k_b)_B} = \frac{1}{5}$$

$$\therefore \quad \frac{(\Delta T_b)_A}{(\Delta T_b)_B} = \frac{(k_b)_A}{(k_b)_B} = \frac{1}{5}$$

25. Answer (4)

Osmotic pressure (π) = CRT

Solute : urea and glucose

$$\therefore \quad \pi = (C_1 + C_2)\,RT$$

$$= \left(\frac{0.6}{60\times 0.1} + \frac{1.8}{180\times 0.1}\right)\times 0.0821 \times 300$$

$$= 0.2 \times 0.0821 \times 300$$

$$= 4.926 \text{ atm}$$

26. Answer (1)

$\Delta T_f = K_f \times m$

$$\Rightarrow \quad 10 = 1.86 \times \frac{62\times 1000}{62\times w_A}$$

$$\Rightarrow \quad w_A = \frac{1.86\times 1000}{10}$$

$$= 186 \text{ g}$$

Given amount of H_2O is 250 g

$\therefore$ The amount of water separated as ice

= 250 – 186 = 64 g

27. Answer (2)

Since the vapour pressure of the solution is greater than individual vapour pressure of both pure components, the solution shows a positive deviation from Raoult's law.

28. Answer (2)

There will be lowering in vapour pressure for solution containing non-volatile solute. So, there will be transfer of solvent molecules from pure solvent to solution and hence, volume of beaker containing solvent (pure) will decrease and volume of beaker containing solution will increase.

29. Answer (1)

Vapour pressure of a liquid at a given temperature is inversely proportional to intermolecular force of attraction. At the same temperature, vapour pressure of X is higher than that of Y.

Therefore (X) has lower intermolecular interactions compared to Y. Statement (B) is correct.

30. Answer (4)

The rate at which water molecules leaves the solution decreases.

31. Answer (1)

Osmosis can explain the given process. There are many phenomena which we observed in nature or at home. Raw mango shrivel when pickled in brine.

The solvent molecules will flow through the membrane from pure solvent to the solution. This process of flow of the solvent is called osmosis.

32. Answer (2)

With temperature, the value of K_H (Henry's constant) increases and solubility of gas in liquid decreases

Ideally Henry's law is applicable for dilute solutions.

$\therefore$ 55.5 molal solution of δ at 250 bar will not follow Henry's law.

33. Answer (3)

Relative lowering in vapour pressure (RLVP)

$$= \frac{P - P_s}{P} = \frac{n}{n+N}$$

n $\rightarrow$ moles of solute

N $\rightarrow$ moles of solvent

$$n_A = \frac{10}{100}, n_B = \frac{10}{200}, n_C = \frac{10}{10000}$$

From the above relation

RLVP (A) > RLVP (B) > RLVP (C)

A > B > C

34. Answer (1.76)

$\Delta T_f = 0.2°C$

$\because \Delta T_f = ik_f \cdot m$

i = 2 for NaCl

$$\therefore 0.2 = 2\times 2\times \frac{W_{NaCl}\times 1000}{58.5\times 600}$$

$\Rightarrow \ W_{NaCl} = \frac{58.5 \times 600 \times 0.2}{4 \times 1000}$

= 1.755

= 1.76

35. Answer (2.18)

For aqueous solution

$\Delta T_f = K_f.m = 2 \times 0.5$

$\therefore$ Temperature of solution = –1°C = 272 K

$\therefore$ Final volume of ideal gas $= \frac{nRT}{P}$

$= \frac{0.1 \times 0.08 \times 272}{1}$

$\approx$ 2.18 L

36. Answer (177)

Isotonic solutions have the same osmotic pressure.

$$\pi_A = C_A RT; C_A = \frac{0.73 \times 1000}{M_A \times 250}$$

$$\pi_B = C_B RT; C_B = \frac{1.65}{M_B}$$

$$\pi_A = \pi_B \Rightarrow C_A = C_B$$

$$\therefore \ \frac{0.73 \times 1000}{M_A \times 250} = \frac{1.65}{M_B}$$

$$\frac{M_A}{M_B} = 1.77 = 177 \times 10^{-2}$$

37. Answer (600)

If X_1 and P_1° are the mole fraction and vapour pressure of n-hexane in solution and X_2 and P_2° are the mole fraction and vapour pressure of n-heptane in solution then

$$550 = X_1P_1^\circ + X_2P_2^\circ$$

$$= \frac{P_1^\circ}{4} + \frac{3P_2^\circ}{4} \Rightarrow P_1^\circ + 3P_2^\circ = 2200 \qquad \ldots(1)$$

On addition of 1 more mole of n-heptane

$$560 = X'_1P_1^\circ + X'_2P_2^\circ$$

$$= \frac{P_1^\circ}{5} + \frac{4P_2^\circ}{5} \Rightarrow P_1^\circ + 4P_2^\circ = 2800 \qquad \ldots(2)$$

From (1) and (2), $P_2^\circ = 600$ mm Hg

38. Answer (167.00)

For NaCl: $\pi_1 = iC_1RT \Rightarrow C_1 = \frac{0.10}{2\,RT}$

For Glucose: $\pi_2 = C_2RT \Rightarrow C_2 = \frac{0.20}{RT}$

When 1 L of NaCl solution and 2 L glucose solution are mixed.

$$\therefore \ C'_1 = \frac{0.10}{6\,RT} \text{ and } C'_2 = \frac{0.20 \times 2}{3\,RT} = \frac{0.40}{3\,RT}$$

$$\therefore \ \pi_{Total} = iC'_1RT + C'_2RT = \frac{0.10}{3} + \frac{0.40}{3} = \frac{0.50}{3}$$

$$\boxed{\pi_{Total} \simeq 167 \times 10^{-3} \text{ atm}}$$

39. Answer (5.00)

Molality of $CaCl_2$ solution = 0.05 m

$\Delta T_b = i\,K_b\,m = 3 \times K_b \times 0.05 = 0.15\,K_b$

Molality of $CrCl_3.xNH_3$ = 0.10 m

$\Delta T'_b = i\,K_b \times 0.10;\ \Delta T'_b = 2\Delta T_b$

$iK_b \times 0.10 = 2 \times 0.15\,K_b \Rightarrow i = 3$

Since, co-ordination number of Cr is 6.

$\therefore$ The complex is $[Cr(NH_3)_5Cl]Cl_2$

$\therefore$ x = 5

40. Answer (37)

At 30 bar pressure mass of CO_2 in 1 kg water = 44 gm

At 3 bar pressure mass of CO_2 in 1 kg water = 4.4 gm

Moles of CO_2 in 1 kg water = 0.1

$$\begin{array}{cccc} H_2CO_3 & \rightleftharpoons H^+ & + & HCO_3^- \\ 0.1(1-\alpha) & 0.1\alpha & & 0.1\alpha \end{array}$$

$$Ka_1 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$$

$$4 \times 10^{-7} = \frac{0.1\alpha^2}{1-\alpha} \simeq 0.1\alpha^2$$

$\alpha = 2 \times 10^{-3}$

$[H^+] = 0.1\,\alpha = 2 \times 10^{-4}$; pH = 3.7

$= 37 \times 10^{-1}$

41. Answer (10)

$$\text{ppm of } O_2 = \frac{\text{wt. of } O_2}{\text{wt. of } H_2O} \times 10^6$$

$$= \frac{10.3 \text{ mg}}{1.03 \times 10^6 \text{ mg}} \times 10^6$$

= 10 ppm

42. Answer (35)

$$\text{Moles of ClCH}_2\text{COOH} = \frac{9.45}{94.5} = 0.1 \text{ moles}$$

$$\begin{array}{llll} & ClCH_2COOH & \rightleftharpoons ClCH_2COO^- & + H^+ \\ \text{At eq}^m & C(1-\alpha) & C\alpha & C\alpha \end{array}$$

van't Hoff factor (i) = 1 + α

$$C = \frac{0.1}{0.5} = 0.2 \text{ M}$$

Assuming molarity = molality

$$\Delta T_f = ik_f \cdot m = (1+\alpha)1.86 \times 0.2$$

$$\Rightarrow \quad (1+\alpha) = \frac{0.5}{0.2 \times 1.86} = 1.344 \approx 1.34$$

$\Rightarrow \quad \alpha = 0.34$

$$K_a \text{ of (ClCH}_2\text{COOH)} = \frac{C\alpha \cdot C\alpha}{C(1-\alpha)}$$

$$= \frac{C\alpha^2}{1-\alpha} = \frac{0.2 \times (0.34)^2}{1-0.34}$$

= 35 × 10^{-3}

43. Answer (1)

$$\Delta T_f = ik_f m$$

$$i = 1 \text{ for } C_4H_{10}; \ T_f^o = 5.5°C$$

$$m = \frac{10 \times 1000}{58 \times 200} = \frac{50}{58}$$

$$K_f = 5.12°C / m$$

$$\Delta T_f = 5.12 \times \frac{50}{58} = 4.41°C$$

$$T_f^o - T_f = 4.41$$

$$T_f = 5.50 - 4.41 = 1.09 \simeq 1°C$$

44. Answer (375)

$$\begin{array}{llll} A_2B_3 \longrightarrow & 2A^{3+} & + \ 3B^{2-} & \text{(Assuming A – cation,} \\ 1-0.6 & 2 \times 0.6 & 3 \times 0.6 & \text{B – anion)} \end{array}$$

$\therefore$ van't Hoff factor = 1 – 0.6 + 1.2 + 1.8 = 3.4

ΔT_b = $ik_b \cdot m$

= 3.4 × 0.52 × 1

= 1.768

T_b = 373 + 1.768

= 374.77

$\approx$ 375

45. Answer (3)

$$\underset{1-\alpha}{AB} \rightleftharpoons \underset{\alpha}{A^{n+}} + \underset{\alpha}{B^{n-}}$$

i = 1 + α = 1 + 0.75 ($\because$ α = 0.75)

= 1.75

ΔT_b = i K_b m

$$m = \frac{2.5}{1.75 \times 0.52} = 2.75 \text{ mol / kg} \simeq 3$$

46. Answer (24)

$$n_{SO_2} = \frac{1 \times 0.224}{0.082 \times 298} \approx 0.0092 \approx 0.01 \text{ moles}$$

$NaOH + SO_2 \rightarrow NaHSO_3$

$$n_{NaHSO_3} = 0.01$$

$$NaHSO_3 \rightarrow Na^+ + HSO_3^-$$

Ignoring the dissociation of HSO_3^- into H^+ and SO_3^{2-}

van't Hoff factor (i) = 2

$$\frac{P_{H_2O}^o - P_S}{P_{H_2O}^o} = \frac{in_{NaHSO_3}}{n_{H_2O} + in_{NaHSO_3}}$$

$$\left(\text{as } n_{HSO_3^-} << n_{H_2O}\right)$$

Lowering in vapour presssure

$$= \frac{2 \times 0.01}{2 + 2 \times 0.01} \times 24$$

$$= 23.76 \times 10^{-2} \text{ mmHg} \approx 24 \times 10^{-2} \text{ mmHg}$$

47. Answer (02.00)

$$\Delta T_f = iK_f\ m$$

$$0.93 = i \times 1.86 \times \frac{12.2 \times 1000}{122 \times 100}$$

i = 0.5

n(Benzoic acid) $\longrightarrow$ (Benzoic acid)$_n$

$$i = \frac{\text{Total number of particles after association}}{\text{Number of particles before association}}$$

$$0.5 = \frac{1}{n}$$

n = 2

48. Answer (106)

$$AB_2 \rightleftharpoons A^{2+} + 2B^-$$

$1 - \alpha \qquad \alpha \qquad 2\alpha$

$i = 1 + \alpha$

i = 1.1

$\Delta T_b = T_s - T° = i \times K_b \times$ molality

$T_s - 100 = 1.1 \times 0.5 \times 10$

$T_s = 105.5$

$\approx 106°C$

49. Answer (19)

An ideal solution is prepared by mixing 1 mol of A and 2 moles of B

Using Raoult's law

$$P_s = \chi_A P_A^o + \chi_B P_B^o$$

$$= \frac{1}{3} \times 21 + \frac{2}{3} \times 18$$

= 19 kPa

50. Answer (64)

Molality of an aqueous solution of a solute = 100 m

Number of moles of solvent = $\frac{1000}{18}$

Mole fraction of solute = $\dfrac{100}{100 + \dfrac{1000}{18}} = \dfrac{100 \times 18}{2800}$

= 0.6428 = 64.28 × 10^{-2}

$\simeq 64$

51. Answer (25)

P_{O_2} (over water) = 20 kPa

K_H for O_2 = 8.0 × 10^4 kPa

If X_{O_2} is the mole fraction of O_2 in soution, then according to Henry's law

$$P_{O_2} = K_H (X_{O_2})$$

$$X_{O_2} = \frac{20}{8.0 \times 10^4} = 2.5 \times 10^{-4}$$

Mass of 1 kg of water containing O_2 = 1 L

$\therefore$ Molarity of O_2 in solution = 25 × 10^{-5} M

52. Answer (85)

i for $K_4[Fe(CN)_6]$ = 1 + (5 – 1) 0.4 = 2.6

$$\Delta T_{b_1} = 2.6 \times K_f \times 1$$

i for A = 1.

$$(\Delta T_b)_A = 1 \times \frac{18.1 \times 1000}{A \times 81.9} \times K_f$$

Equating these two

A = 85

53. Answer (50)

$$HA \rightleftharpoons H^+ + A^-$$

$1 - \alpha \qquad \alpha \qquad \alpha$

(α – degree of dissociation)

van't Hoff factor (i) = 1 + α

Assuming given freezing point is –3.885°C

$\Delta T_f = ik_f \cdot m$

$\Rightarrow$ 3.885 = (1 + α) × 1.85 × 2

$\Rightarrow$ (1 + α) = 1.05

α = 0.05

= 50 × 10^{-3}

54. Answer (100)

$$\begin{array}{ccc} 2A & \rightarrow & A_2 \\ 1-\alpha & & \frac{\alpha}{2} \end{array}$$

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

Also

$$\Delta T_b = iK_b m$$

0.52 = i × 0.52 × 2

$$i = \frac{1}{2}$$

$$\frac{1}{2} = 1-\alpha+\frac{\alpha}{2}$$

$$\Rightarrow 1-\frac{\alpha}{2} = \frac{1}{2}$$

% of association of A is 100%

55. Answer (78)

$$P_{Total} = X_B P_B^\circ + X_{MB} P_{MB}^\circ$$

X_B – mole fraction of benzene in solution phase

X_{MB} – mole fraction of methyl benzene in solution phase

$$Y_B P_{Total} = X_B P_B^\circ$$

Y_B – mole fraction of benzene in vapor phase

$$Y_B = \frac{0.5\times70}{0.5\times70+0.5\times20} = 0.7777$$

$= 77.77 \times 10^{-2}$

$\approx 78\times10^{-2}$

56. Answer (1)

$x_A = 0.6$

$P_T = x_A P_A^o + x_B P_B^o$

$= 0.6 \times 90 + 0.4 \times 15$

$= 54 + 6 = 60$

$x_A P_A^o = y_A P_T$

$0.6 \times 90 = y_A(60)$

$\Rightarrow y_A = 0.9$

$y_B = 0.1 = 1 \times 10^{-1}$

$\therefore$ x = 1

57. Answer (2)

$\Delta T_F \propto i$ (for equimolar solutions)

Solute	i
KI	2
$Al_2(SO_4)_3$	5
$C_6H_{12}O_6$	1
K_2SO_4	3

58. Answer (25)

According to Henry's law

$P_{gas} = X_{gas} \times K_H$

$$X_{gas} = \frac{0.835}{1.67\times10^3} = 5\times10^{-4}$$

$$X_{gas} = \frac{n_{gas}}{n_{gas}+n_{H_2O}} \approx \frac{n_{gas}}{n_{H_2O}}$$

$$n_{gas} = 5\times10^{-4}\times\frac{900}{18} = 0.025 \text{ mole}$$ or 25 mmol

59. Answer (250)

$\Delta T_b = K_b\, m$

$$0.60 = \frac{5.0\times3.00\times1000}{M\times100}$$

M = 250

Molecular weight of the substance = 250

60. Answer (15)

π = iCRT

$$2.42\times10^{-3} = \frac{1\times1.46\times1000\times0.083\times300}{M\times100}$$

M = 150223 g mol^{-1}

M = 15.0223×10^4 $gmol^{-1}$

61. Answer (125)

$$i = \frac{\text{total number of particle after dissociation / association}}{\text{total number of particle before dissociation / association}}$$

let 'a' is total moles of HA

$$\underset{0.5a}{HA} \longrightarrow \underset{0.5a}{H^+} + \underset{0.5a}{A^-}$$

$$\underset{0.5a}{HA} \longrightarrow \underset{\frac{0.5a}{2}}{(HA)_2}$$

$$i = \frac{\left(0.5+0.5+\frac{0.5}{2}\right)a}{a} = 1.25 = 125\times10^{-2}$$

62. Answer (4)

i for C_2H_5OH is 1.

$\Delta T_f = ik_fm$

$\Delta T_f \propto i$ (considering molarity = molality)

$Ba_3(PO_4)_2$	i = 5
Na_2SO_4	i = 3
KCl	i = 2
Li_3PO_4	i = 4

63. Answer (269)

$$\Delta T_f = (T_0 - T_s) = i \times \text{Molality} \times k_f$$

$$273 - T_s = 1 \times \frac{83 \times 1000}{62 \times 625} \times 1.86$$

$T_s = 269$

64. Answer (518)

Molality of sucrose solution = 0.75 m

Mass of sucrose = 0.75 × 342 g = 256.5 g

Mass of solutions = 1256.5 g

Mass of sucrose in 1 kg solution

$$= \frac{256.5 \times 1000}{1256.5} = 204.1\text{ g}$$

Mass of water in 1 kg solution = 1000 – 204.1

= 795.9 g

After colling the solution to –4°C

$$4 = \frac{1.86 \times 204.1 \times 1000}{342 \times w_B'}; w_B' = 277.5\text{ g}$$

(w_B' is the mass of water left)

Mass of ice separated = 795.9 – 277.5

$= 518.4 \simeq 518$ g

65. Answer (271)

Moles of glucose = $\frac{40}{180}$

$\Delta T_f = iK_fm$ (i = 1 for glucose)

$$= 1 \times 1.86 \times \frac{40 \times 1000}{180 \times 200}$$

$$\begin{pmatrix}\text{Mass of water = 200 g} \\ \text{as d = 1 g/mL}\end{pmatrix} = 2.06$$

$\therefore$ Freezing point $= T_f - \Delta T_f$

= 273.15 – 2.06

= 271.09

$\simeq 271$

66. Answer (2)

$\Delta T_f \propto i \times m$

greater the value of i, greater will be the ΔT_f value.

Solute	**i**
glycine	1
$KHSO_4$	3
hydrazine	1
glucose	1

67. Answer (13)

K_b (benzene) = 2.6 K kg mol^{-1}

K_b (acetone) = 1.7 K kg mol^{-1}

In acetone

$$0.17 = \frac{1 \times 1.7 \times 1.22 \times 1000}{M \times 100}$$

M = 122 g/mol

In benzene

$$\Delta T_b = \frac{1}{2} \times \frac{1.22}{122} \times 2.6 \times 10$$

= 0.13 ºC

= 13 × 10^{-2} ºC

68. Answer (54)

7.47 = C × 0.083 × 300

(π = CRT)

(Where C represents the concentration of glucose solution and π represents osmotic pressure)

$$C = \frac{7.47}{0.083 \times 300}(\text{mol L}^{-1})$$

which in gm/L = $\frac{7.47}{0.083 \times 300} \times 180$

= 54 gm/l

69. Answer (1221)

According to Henry's law, partial pressure of a gas is given by

$P_g = (K_H)\,X_g$

where X_g is mole fraction of gas in solution

$0.835 = 1.67 \times 10^3 \left(X_{CO_2}\right)$

$X_{CO_2} = 5 \times 10^{-4}$

Mass of CO_2 in 1 L water = 1221×10^{-3} g

70. Answer (4)

Since, $\Delta T_f = ik_f m$

$$m = \frac{0.7}{93} \times \frac{1000}{42}$$

$$0.2 = i \times 1.86 \times \frac{0.7 \times 1000}{93 \times 42}$$

i = 0.6

$$\alpha = \frac{i-1}{\frac{1}{n}-1} = \frac{0.6-1}{\frac{1}{2}-1} = 0.8$$

Hence, percentage association of solute A is 80%.

71. Answer (98)

$\Delta T_f = iK_b m$

$$i = \frac{0.24 \times 99.5 \times 74.6}{1.80 \times 0.5 \times 1000} = 1.98$$

$$\alpha = \frac{i-1}{n-1} = \frac{0.98}{1} = 0.98$$

72. Answer (415)

$\pi = i\,CRT$ (i = 1)

$$\pi = \frac{2 \times 1000}{60 \times 10^3 \times 200} \times .083 \times 300$$

π = .00415 atm

π = 415 Pa

73. Answer (8)

$\Delta T_b = k_b m$

$$\frac{(\Delta T_b)_A}{(\Delta T_b)_B} = \frac{(k_b)_A}{(k_b)_B}$$

$$= \frac{1}{8} = \frac{x}{y}$$

$\therefore \quad y = 8$

74. Answer (45)

$W_{solute} = 2.5 \times 10^{-3}$ kg

$W_{solvent} = 75 \times 10^{-3}$ kg

$\Delta T_b = 373.535 - 373.15$

= 0.385 K

$K_b(H_2O) = 0.52$ K kg mol^{-1}

$$\Delta T_b = \frac{K_b \times 10^3 \times W_{solute}}{M_{solute} \times W_{solvent}}$$

$$M_{solute} = \frac{0.52 \times 10^3 \times 2.5 \times 10^{-3}}{75 \times 10^{-3} \times 0.385}$$

= 45.02

≈ 45

75. Answer (14)

$P_T = P_A^0.x_A + P_B^0.x_B$

= 50 × 0.3 + 100 × 0.7

= 85 mm Hg

$$y_B = \frac{70}{85} = \frac{x}{17}$$

$$\frac{x}{17} = 14$$

76. Answer (330)

Since,

$\pi = icRT$

$$5.03 \times 10^{-3} = \frac{2.5}{M} \times \frac{1000}{500} \times 0.083 \times 300$$

Molar mass of protein = 24751.5 g/mol

Number of glycine units in protein = $\frac{24751.5}{75}$

= 330

77. Answer (5)

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

Moles of solute (acetic acid) = $\frac{1.2 \times 1.02}{60}$

As moles of solute are very less.

So, take molarity and molality same.

$0.0198 = i \times 1.85 \times \frac{1.2 \times 1.02}{60 \times 2}$

i = 1.05

$\alpha = \frac{i-1}{n-1} = \frac{0.05}{1} = 0.05$

78. Answer (3)

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

$\Delta T_f = i \times K_f \times m$ $\quad\quad$ $i = 1$

$4 = 1 \times K_b \times 1.5$

$4 = 1 \times K_f \times 4.5$

$\frac{K_b}{K_f} = 3$

79. Answer (3)

ΔT_f of formic acid = 0.0405°C

Concentration = 0.5 mL/L

and density = 1.05 g/mL

$\therefore$ Mass of formic acid in solution = 1.05 × 0.5 g

= 0.525 g

$\therefore$ According to Van't Hoff equation,

$\Delta T_f = ik_f \cdot m$

$0.0405 = i \times 1.86 \times \frac{0.525}{46 \times 1}$

(Assuming mass of 1 L water = kg)

$i = \frac{0.0405 \times 46}{1.86 \times 0.525} = 1.89 \approx 1.9$

80. Answer (2)

$\Delta T_f = i\, k_f \times m$

$\frac{\Delta T_{f(A)}}{\Delta T_{f(B)}} = \frac{1}{4}$

$\frac{i \times K_f \times \frac{1}{M_A} \times 1}{i \times K_f \times \frac{1}{M_B} \times 1} = \frac{1}{4}$

$\frac{M_B}{M_A} = \frac{1}{4}$

$M_A : M_B = 4 : 1$

81. Answer (1)

Molality of a solution of non volatile solute (A) = 1

Elevation in boiling point is given by

$\Delta T_b = K_b\, m$

$3 = K_b \times 1$ $\quad\quad$ ... (1)

Molality of (A) in the same solvent = 2

Depression in freezing point is given by

$\Delta T_f = K_f\, m$

$6 = K_f \times 2$ $\quad\quad$ ... (2)

Dividing (1) by (2)

$\frac{K_b}{K_f} = \frac{1}{X} = \frac{1}{1}$

$\therefore$ X = 1

82. Answer (2)

$(\Delta T_b)_A = (\Delta T_b)_B$

$K_b \cdot M_A = K_b \cdot M_B$

$\Rightarrow M_A = M_B$

$\Rightarrow \frac{\frac{2}{M_A}}{100} \times 1000 = \frac{\frac{8}{M_B}}{100} \times 1000$

$\Rightarrow M_B = 4M_A$

83. Answer (06.00)

$$\frac{P_o - P_s}{P_s} = \frac{n_A}{n_B}$$

$$1 = \frac{n_A}{n_B}$$

$$\boxed{n_A = n_B}$$

$\therefore$ Moles of solute added considering it as a non- electrolyte

$$= \frac{100}{18} \simeq 5.55$$

$\simeq 6$

84. Answer (15)

M.wt. of Acetic acid = 60 g

M.wt. of Ascorbic acid = 176 g

$$\Delta T_f = K_f\ m$$

$$\Delta T_f = \frac{3.9 \times 10.2 \times 1000}{176 \times 150}$$

$$\Delta T_f = 1.506$$

$= 15.06 \times 10^{-1}$

$= 15$

85. Answer (2)

Given that $X_A = 0.2$, $Y_A = 0.5$, $P_T = 0.8$ atm

We know that $P_A = Y_A \times P_T$

$$P_A = 0.5 \times 0.8 = 0.4$$

Now $P_A = X_A \times P_A^o \Rightarrow P_A^o = \frac{0.4}{0.2} = 2$ atm

86. Answer (1)

From Henry's law,

$$X(\text{oxygen}) = \frac{p(\text{oxygen})}{K_H} = \frac{0.920}{46.82 \times 10^3} = 1.96 \times 10^{-5}$$

As 1 litre of water contains 55.5 mol of it, therefore,
$\rightarrow$ n represents moles of O_2 in solution.

$$X(\text{oxygen}) = \frac{n}{n + 55.5} \simeq \frac{n}{55.5} (n << 55.5)$$

$$\frac{n}{55.5} = 1.96 \times 10^{-5}$$

$n = 108.8 \times 10^{-5} = 1.08 \times 10^{-3}$ moles

m moles of oxygen $= 1.08 \times 10^{-3} \times 10^3 = 1$ m mole

87. Answer (80)

$\Delta T_f = k_f\ m$

$$0.9 = \frac{2 \times 1.8 \times 1000}{62.5 \times 0.8 \times M}$$

$$M = \frac{2 \times 1800}{62.5 \times 0.8 \times 0.9}$$

= 80 g/mol

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