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| **Karan Arora** **R.L. Chemistry Classes M: 99968-68554**  **Class : XII**  **“SOLUTION”** |

**Assignment – I**

**(Based on Concentration Terms)**

1. Calculate the molality and mole fraction of 2.5 g of ethanoic acid (CH3COOH) in 75 g of benzene.
2. Calculate the molarity and normality of a solution containing 5 g of NaOH in 450 mL solution.
3. Calculate the molarity and normality of a solution containing 9.8 g of H2SO4 in 250 cm3 of the solution.
4. Calculate the mole fraction of ethylene glycol (C2H6O2) and water in a solution containing 20 % of C2H6O2 by mass.
5. Find the molarity and molality of a 15 % solution of H2SO4 (density of H2SO4 = 1.020 g/cm3). (At. mass : H = 1, O = 16 , S = 32 amu).
6. A solution contains 25 % water , 25 % ethanol and 50 % acetic acid by mass. Calculate the mole fraction of each component.
7. A solution of ethanol in water is 1.54 molal. How many grams of it are there in 2500 g of the solvent ?
8. Calculate the molality of a sulphuric acid solution in which the mole fraction of water is 0.85.
9. 20 mL of 10 N HCl are diluted with distilled water to form one litre of the solution. What is the normality of the diluted solution ?
10. The mole fraction of benzene in a solution in toluene is 0.50. Calculate the weight percent of benzene in the solution.
11. What is the mole fraction of a solute in 2.5 m aqueous solution ?
12. A 6.9 M solution of KOH in water contains 30 % by mass of KOH. Calculate the density of the KOH solution. (Molar mass of KOH = 56 g/mol)
13. Molarity of H2SO4 is 0.8 and its density is 1.06 g/cm3. What will be its concentration in terms of molality and mole fraction ?
14. Calculate the molality and mole fraction of the solute in aqueous solution containing 3 g of urea (molar mass = 60 g/mol) per 250 g of water.
15. A 10 cm3 sample of human urine was found to have 5 milligrams of urea on analysis. Calculate the molarity of given sample with respect to urea.
16. The concentration of H2SO4 in a bottle labelled “conc. Sulphuric acid” is 18 M. The solution has a density of 1.84 g/cm3. What is the mole fraction and weight percentage of H2SO4 in this solution ?
17. A 100 cm3 solution of sodium carbonate is prepared by dissolving 8.653 g of the salt in water. The density of solution is 1.0816 g per millilitre. What are the molarity and molality of the solution.
18. An aqueous solution of a dibasic acid (molar mass = 118) containing 35.4 g of the acid per litre of the solution has density 1.0077 g/cm3. Express the concentration of the solution in as many ways as you can.

SOLUTION Page No. 1

1. 4 g of NaOH is contained in one decilitre of a solution. Calculate the following in this solution.

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| (i) Mole fraction of NaOH | (ii) Molality of NaOH | (iii) Molarity of NaOH |

(Density of NaOH solution = 1.038 g/cm3).

1. The percentage composition (by weight) of a solution is 45 % X , 15 % Y , 40 % Z. Calculate the mole fraction of each component of the solution (Molar Mass : X = 18 , Y = 60 , Z = 60).
2. A sugar syrup of weight 214.2 g contains 34.2 g of sugar (C12H22O11). Calculate (i) molal concentration (ii) mole fraction of sugar in a syrup.
3. Calculate the molality of 1 L solution of 93 % H2SO4 (weight/volume). The density of the solution is 1.84 g/mL.
4. Concentrated sulphuric acid has a density of 1.9 g/ mL and is 99 % H2SO4 by weight. Calculate the molarity of H2SO4 in this acid.
5. Calculate the mass fraction and mole fraction of ethyl alcohol and water in a solution containing 9.2 g of alcohol in 18 g of water.
6. Calculate the mole fraction of ethanol and water in a sample of rectified spirit which contains 95 % of ethanol by weight.
7. Calculate the volume of 80% H2SO4 (density = 1.8 g/cc) required to prepare 1 L of 20 % H2SO4 (density = 1.25 g/cc).
8. Calculate the number of moles of methanol in 5 L of its 2 m solution, if the density of the solution is 0.981 kg/L. (Molar Mass of methanol = 32 g/mol).
9. H2SO4 used in lead storage cell is 38 % by mass and has a density of 1.3 g/cm3. Calculate its molarity.
10. If 20 cm3 of 1 M CaCl2 and 60 cm3 of 0.2 M CaCl2 are mixed, what will be the molarity of the final solution?
11. The density of a 3M Na2S2O3 (sodium thiosulphate) solution is 1.25 g/cm3. Calculate (i) percentage by weight of sodium thiosulphate (ii) the mole fraction of sodium thiosulphate (iii) the molality of Na+ and ions.
12. Determine the molarity of an antifreeze solution containing 250 g water mixed with 222 g ethylene glycol (C2H6O2). The density of the solution is 1.07 g/mL.

**Answers**

1. 0.556 mol/kg, 0.0416 2. 0.278 mol/L, 0.278 N 3. 0.4 M , 0.8 N 4. C2H6O2 = 0.068 , H2O = 0.932

5. 1.56 M , 1.8 m 6. Water = 0.503 , Ethanol = 0.196 , Acetic acid = 0.301 7. 177.10 g

8. 9.8 m 9. 0.2 N 10. 45.9 % 11. 0.043 12. 1.288 g/mL 13. 0.815 m , 0.014

14. 0.2 m , 0.00359 15. 0.0083 mol/L 16. 0.81 , 95.87 % 17. 0.816 M , 0.82 m

18. 0.3 M , 0.6 N , 0.31 m , x(solute) = 0.0055, x (solvent) = 0.9945 19. 0.0177 , 1 M , 1.002 m

20. X = 0.732 , Y = 0.073 , Z = 0.19 21. (i) 0.556 m (ii) 0.0099 22. 10.43 m 23. 19.19 M

24. C2H5OH : Mass fraction = 0.34 , Mole fraction = 0.17 ; H2O : Mass fraction = 0.66 , Mole fraction = 0.8

25. C2H5OH = 0.88 , H2O = 0.12 26. 173.6 cc 27. 9.22 28. 5 M 29. 0.40 M

30. (i) 37.92 % (ii) 0.065 (iii) 7.732 m , 3.866 m 31. 8.12 M

SOLUTION Page No. 2

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**Assignment – II**

**(Based on Henry’s Law)**

1. If N2 gas is bubbled through water at 293 K, how many millimoles of N2 gas would dissolve in 1 L of water? Assume that N2 exerts a partial pressure of 0.987 bar. Given that Henry’s law constant for N2 at 293 K is 76.48 K bar.
2. At what partial pressure, oxygen will have a solubility of 0.05 g/L in water at 293 K? Henry’s constant (KH) for O2 in water at 293 K is 34.86 K bar. Assume the density of the solution to be same as that of the solvent.
3. Air contains O2 and N2 in the ratio of 1 : 4. Calculate the ratio of solubilities in terms of mole fractions of O2 and N2 dissolved in water at atmospheric pressure and room temperature at which Henry’s constant for O2 and N2 are 3.30 x 107 torr and 6.60 x 107 torr respectively.
4. The Henry’s law constant for oxygen dissolved in water is 4.34 x 104 atm at 25˚C. If the partial pressure of oxygen in air is 0.2 atm under atmospheric conditions, calculate the concentration (in moles per litre) of dissolved oxygen in water in equilibrium with air at 25˚C.
5. The mole fraction of helium in a saturated solution at 20˚C is 1.2 x 10 – 6 . Find the pressure of helium above the solution. Given Henry’s constant at 20˚C = 144.97 K bar.
6. Calculate the solubility of H2 in water at 25˚C if its partial pressure above the solution is 1 bar. Given that Henry’s constant for H2 in water at 25˚C is 71.18 k bar.
7. Henry’s law constant for CO2 in water is 1.67 x 108 Pa at 298 K. Calculate the quantity of CO2 in 500 mL of soda water when packed under 2.5 atm CO2 pressure at 298 K.
8. The partial pressure of ethane over a saturated solution containing 6.56 x 10 – 2 g of ethane is 1 bar. If the solution contains 5 x 10 – 2 g of ethane, then what shall be the partial pressure of the gas?

**Answers**

1. 0.716 millimoles 2. 0.98 bar 3. : = 1 : 2 4. 2.55 x 10 – 4 mol/L

5. 0.174 bar 6. 7.79 x 10 – 4 mol/L 7. 1.854 g 8. 0.762 bar

SOLUTION Page No. 3

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**Assignment – III**

**(Based on Raoult’s Law)**

1. Vapour pressures of chloroform (CHCl3) and dichloromethane (CH2Cl2) at 298 K are 200 mm Hg and 415 mm Hg respectively. Calculate : (i) the vapour pressure of the solution prepared by mixing 25.5 g of CHCl3 and 40 g of CH2Cl2 at 298 K . (ii) the mole fraction of each component in vapour phase.
2. Two liquids X and Y on mixing form an ideal solution. At 30˚C, the vapour pressure of the solution containing 3 moles of X and 1 mole of Y is 550 mm Hg. But when 4 moles of X and 1 mole of Y are mixed, the vapour pressure of the solution thus formed is 560 mm Hg. What would be the vapour pressure of pure X and pure Y at this temperature ?
3. The mole fraction of ethyl alcohol in its solution with methyl alcohol is 0.8. The vapour pressure of ethyl alcohol at the temperature of the solution is 40 mm of Hg. What is its vapour pressure in solution if the solution is ideal ?
4. The vapour pressure of a pure liquid A is 40 mm Hg at 310 K. The vapour pressure of this liquid in solution with liquid B is 32 mmHg. Calculate the mole fraction of A in the solution if the mixture obeys Raoult’s law.
5. Benzene (C6H6) and toluene (C7H8) form a nearly ideal solution at 313 K. The vapour pressures of pure benzene and toluene are 160 mm of Hg and 60 mm of Hg respectively. Calculate the partial pressure of benzene and toluene and the total pressure over the following solutions : (i) containing equal weights of benzene and toluene. (ii) containing 1 moles of benzene and 4 moles of toluene. (iii) containing equal molecules of benzene and toluene.
6. Methanol and ethanol form nearly an ideal solution at 300 K. A solution is made by mixing 32 g methanol and 23 g of ethanol at 300 K. Calculate the partial pressures of its constituents and the total pressure of the solution. [ At 300 K : = 90 mm Hg ; = 51 mm Hg ].
7. The vapour pressures of benzene and toluene at 293 K are 75 mm and 22 mm Hg respectively. 23.4 g of benzene and 64.4 g of toluene are mixed. If the two form an ideal solution, calculate the mole fraction of benzene in the vapour phase assuming that the vapours are in equilibrium with the liquid mixture at this temperature.
8. Two liquids A and B on mixing form an ideal solution. Their vapour pressures in the pure state are 200 and 100 mm respectively. What will be mole fraction of B in the vapour phase in equilibrium with an equimolar solution of the two ?
9. The vapour pressure of ethyl acetate and ethyl propionate are 72.8 and 27.7 mm of Hg respectively. A solution is prepared by mixing 25 g ethyl acetate and 50 g ethyl propionate. Assuming the solution to be ideal, calculate the vapour pressure of the solution.
10. Benzene and toluene form nearly ideal solution. At a certain temperature, the vapour pressure of the pure benzene is 150 mm Hg and of pure toluene is 50 mm Hg. For this temperature, calculate the vapour pressure of solution containing equal weights of two substances. Also calculate their composition in the vapour phase.

SOLUTION Page No. 4

1. 0.75 mol of ethylene bromide were mixed with 0.25 mol of propylene bromide at 358 K to form nearly ideal solution. Vapour pressures of pure ethylene bromide and propylene bromide at 358 K are 2.77 x 104 N m – 2 and 1.73 x 104 N m – 2 respectively. Calculate the vapour pressure of the solution.

**Answers**

1. 347.9 mm , CHCl3 = 0.18 , CH2Cl2 = 0.82 2. X = 600 mm , Y = 400 mm 3. 32 mm 4. 0.8

5. (i) = 86.56 mm of Hg , = 27.54 mm of Hg , = 114.1 mm of Hg

(ii) = 32 mm of Hg , = 48 mm of Hg , = 80 mm of Hg

(iii) = 80 mm of Hg , = 30 mm of Hg , = 110 mm of Hg

6. = 60 mm ; = 17 mm ; = 77 mm 7. 0.59 8. 0.33 9. 44.3 mm 10. 104.1 mm , = 0.78 , = 0.22 11. 2.51 x 104 N m – 2

SOLUTION Page No. 5

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**Assignment – IV**

**(Based on Relative Lowering in Vapour Pressure)**

1. Vapour pressure of water at 293 K is 17.51 mm. lowering of vapour pressure of a sugar solution is 0.0614 mm. Calculate (i) Relative lowering of vapour pressure (ii) vapour pressure of the solution (iii) Mole fraction of water .
2. The vapour pressure of a 5 % aqueous solution of a non-volatile organic substance at 373 K is 745 mm. Calculate the molar mass of the solute.
3. The vapour pressure of pure benzene at a certain temperature is 0.85 bar. A non-volatile, non-electrolyte solid weighing 0.5 g is added to 39 g of benzene (Molar mass 78 g/mol). The vapour pressure of the solution then is 0.845 bar. What is the molar mass of the solid substance ?
4. The vapour pressure of 2.1 % of an aqueous solution of a non-electrolyte at 373 K is 755 mm. Calculate the molar mass of solute.
5. A solid containing 6 g of benzoic acid in 50 g of ether (C2H5OC2H5) has a vapour pressure of 410 mm of mercury at 293 K. Given that the vapour pressure of ether at the same temperature is 442 mm of Hg. Calculate the molecular mass of benzoic acid. (Assume that the solution is dilute)
6. The vapour pressure of water is 92 mm at 323 K. 18.1 g of urea are dissolved in 100 g of water. The vapour pressure is reduced by 5 mm. Calculate the molar mass of urea.
7. Calculate the vapour pressure at 295 K of a 0.1 M solution of urea. The density of the solution may be taken as 1 g/cm3. The vapour pressure of pure water at 295 K is 20 mm.
8. The vapour pressure of an aqueous solution of cane sugar (molar mass 342) is 756 mm at 373 K. How many grams of sugar are present in 1000 g of water ?
9. At 25˚C, the vapour pressure of pure water is 23.76 mm of Hg and that of an aqueous dilute solution of urea is 22.98 mm of Hg. Calculate the molality of this solution?
10. Vapour pressure of an aqueous solution of glucose is 750 mm of Hg at 373 K. Calculate the molality and mole fraction of solute.
11. How much urea (molar mass 60) should be dissolved in 50 g of water so that its vapour pressure at room temperature is reduced by 25 % . Calculate molality of the solution obtained.
12. At 50˚C, the vapour pressure of pure CS2 is 854 torr. A solution of 2 g of sulphur in 100 g of CS2 has vapour pressure of 848.9 torr. Determine the formula of sulphur molecule.
13. Urea forms an ideal solution in water. Determine the vapour pressure of an aqueous solution containing 10 % by mass of urea at 40˚C (vapour pressure of water at 40˚C = 55.3 mm Hg).
14. A 0.2 % aqueous solution of a non-volatile solute exerts a vapour pressure of 1.004 bar at 100˚C. What is the molar mass of the solute?(Given : vapour pressure of pure water at 100˚C is 1.013 bar)
15. What mass of naphthalene, C10H8, would have to be dissolved in 200 g of octane (C8H18) to lower the vapour pressure of pure octane to 20 % ?

SOLUTION Page No. 6

**Answers**

1. 0.00351 , 17.4486 mm , 0.99649 2. 48 g/mol 3. 170 g/mol 4. 58.7 5. 122.65 u

6. 56.7 g/mol 7. 19.96 mm 8. 100.5 g 9. 1.8 m 10. X2 = 0.013 , m = 0.73 m

11. 55.556 g , 18.52 m 12. S8 13. 53.52 mm 14. 4.06 g/mol 15. 56.14 g

SOLUTION Page No. 7

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**Assignment – V**

**(Based on Osmotic Pressure)**

1. Calculate the osmotic pressure at 273 K of a 5 % (w/v) solution of urea. (R = 0.0821 L atm/degree/mole).
2. A solution containing 10 g/L of sucrose has an osmotic pressure of 0.66 atm at 273 K. Calculate the value of the constant R.
3. Calculate the concentration in g/L of that solution of sugar which has osmotic pressure of 2.46 atmosphere at 300 K.
4. 200 cm3 of an aqueous solution of a protein contains 1.26 g of the protein. The osmotic pressure of this solution at 300 K is found to be 2.57 x 10 – 3 bar. Calculate the molar mass of the protein.
5. A 4 % solution of sucrose is isotonic with 3 % solution of an unknown organic substance. Calculate the molar mass of the unknown substance.
6. 10g of a substance were dissolved in water and the solution was made up to 250 cm3. The osmotic pressure of the solution was found to be 8 x 105 N m – 2 (pascals) at 288 K. Find the molar mass of the solute.
7. An aqueous solution of glucose has an osmotic pressure of 2.72 atmospheres at 298 K. How many moles of glucose were dissolved per litre of the solution? (R = 0.082 L atm/degree/mole).
8. A solution of sucrose is prepared by dissolving 68.4 g of it per litre of solution. What is its osmotic pressure at 300 K? (R = 0.082 L atm/degree/mole).
9. Calculate the osmotic pressure of a solution containing 17.1 g of cane sugar in 500 g of water at 300 K. (R = 0.082 L atm/degree/mole). Density of the solution is 1.034 g/cm3.
10. A 5 % solution of cane sugar is isotonic with 0.877 % solution of urea. Find the molecular weight of urea.
11. At 298 K, 100 cm3 of a solution containing 3.002 g of an unidentified solute exhibits an osmotic pressure of 2.55 atmospheres. What is the molar mass of solute?
12. 1 Litre aq solution of sucrose weighing 1015 g is found to record an osmotic pressure of 4.82 atm at 293 K. What is the molality of the sucrose solution?
13. The osmotic pressure of blood is 8.21 atm at 37˚C. How much glucose would be used for an injection that is at the same osmotic pressure as blood?
14. A solution containing 10.2 g glycerine per litre of a solution is found to be isotonic with 2 % solution of glucose. Calculate the molecular mass of glycerine.
15. The osmotic pressure of 0.2 g of haemoglobin in 20 ml of solution is 2.88 torr at 25˚C. Calculate the molecular weight of haemoglobin.
16. At 300 K, 36 g of glucose present per litre in its solution has an osmotic pressure of 4.98 bar. If osmotic pressure of the solution is 1.52 bar at the same temperature, what would be its concentration?
17. A solution prepared by dissolving 8.95 mg of a gene fragment in 35 ml of water has an osmotic pressure of 0.335 torr at 25˚C. Assuming that the gene fragment is a non-electrolyte, calculate its molar mass.
18. 100 mg of a protein is dissolved in just enough water to make 10 ml of solution. If this solution has an osmotic pressure of 13.3 mm Hg at 25˚C, what is the molar mass of the protein ?

SOLUTION Page No. 8

**Answers**

1. 18.68 atm 2. 0.0827 L atm/K/mol 3. 34.2 g/L 4. 61039 g/mol 5. 256.5 g/mol

6. 119.7 g/mole 7. 0.1113 mole 8. 4.92 atm 9. 2.46 atm 10. 60 u

11. 288 g/mole 12. 0.2112 m 13. 58.14 g/L 14. 91.8 u 15. 64562 u

16. 10.98 g/L 17. 14193.3 g/mole 18. 13980.4 g/mol

SOLUTION Page No. 9

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**Assignment – VI**

**(Based on Elevation in Boiling Point)**

1. Calculate the molal elevation constant of water, it being given that 0.1 molal aqueous solution of a substance boiled at 100.052˚C.
2. The boiling point of benzene is 353.23 K. When 1.8 g of a non-volatile solute was dissolved in 90 g of benzene, the b.p. is raised to 354.11 K. Calculate the molar mass of the solute. (Kb for benzene = 2.53 K/m).
3. 18 g of glucose is dissolved in 1 kg of water in a saucepan. At what temperature will the water boil at 1.013 bar pressure? Kb for water = 0.52 K Kg/mol.
4. Calculate the boiling point of a solution containing 0.456 g of camphor (molar mass = 152) dissolved in 31.4 g of acetone (b.p. = 56.3˚C), if the molecular elevation constant per 100 g of acetone is 17.2˚C.
5. A solution containing 0.5126 g naphthalene (molar mass = 128) in 50 g of carbon tetrachloride yields a boiling point elevation of 0.402˚C while a solution of 0.6216 g of an unknown solute in the same weight of the same solvent gives a boiling point elevation of 0.647˚C. Find the molecular mass of unknown solute.
6. A solution containing 6 g of a solute dissolved in 250 cm3 of water gave an osmotic pressure of 4.5 atm. at 27˚C. Calculate the boiling point of the solution. The molal elevation constant for water is 0.52˚C per 1000g
7. Calculate the molal boiling point constant for chloroform from the fact that its boiling point is 61.2˚C and 0.1 molal solution of an organic substance in chloroform boiled at 61.579˚C.
8. When 1.8 g of non-volatile compound is dissolved in 25 g of acetone, the solution boils at 56.86˚C while pure acetone boils at 56.38˚C under the same atmospheric pressure. Calculate the molar mass of the compound. The molal elevation constant for acetone is 1.72˚C.
9. A solution containing 36 g of solute dissolved in 1 L of water gave an osmotic pressure of 6.75 atm. at 27˚C. The molal elevation constant of water is 0.52˚C. Calculate the boiling point of the solution.
10. The vapour pressure of an aqueous solution of cane sugar is 732 mm at 100˚C. Calculate the boiling point of the solution. Kb for water = 0. 52˚C
11. Calculate the molar mass of a substance 1.3 g of which when dissolved in 169 g of water gave a solution boiling at 100.025˚C at a pressure of one atmosphere. Kb for water = 0. 52 K/m.
12. On dissolving 3.24 g of sulphur in 40 g of benzene, boiling point of solution was higher than that of benzene by 0.81 K. Kb for benzene = 2.53 K Kg/mol. What is the molecular formula of sulphur.
13. 0.9 g of a non-electrolyte was dissolved in 87.9 g of benzene. This raised the boiling point of benzene by 0.25˚C. If the molar mass of non-electrolyte is 103 g/mol. Calculate the Kb for benzene.
14. A solution of an organic compound is prepared by dissolving 68.4 g in 1000 g of water. Calculate the molecular mass of the compound and osmotic pressure of the solution at 293 K when elevation in b.pt. is 0.104 and Kb for water is 0. 52 K/m.

SOLUTION Page No. 10

1. A solution prepared by dissolving 1.25 g of oil of winter green (methyl salicylate) in 99 g of benzene has a boiling point of 80.31˚C. Determine the molar mass of this compound (B.P. for pure benzene = 80.1˚C and Kb for benzene = 2.53 ˚C Kg/mol.
2. A solution of glycerol (C3H8O3), in water was prepared by dissolving some glycerol in 500 g of water. This solution has a b.p. of 100.42˚C. What mass of glycerol was dissolved to make this solution. Kb for water = 0.512 K Kg/mol.

**Answers**

1. 0.52˚C/m 2. 57.5 g/mol 3. 373.202 K 4. 56.46˚C 5. 96.46 g/mol 6. 100.095˚C

7. 3.79 K/m 8. 258 g/mol 9. 100.1425˚C 10. 101.064˚C 11. 160 g/mol 12. S8

13. 2.515 K/m 14. 342 g/mol , 4.5 atm 15. 152 g/mol 16. 37.7 g

SOLUTION Page No. 11

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**Assignment – VII**

**(Based on Depression in Freezing Point)**

1. A solution containing 34.2 g of cane sugar dissolved in 500 cm3 of water froze at – 0.374˚C. Calculate the freezing point depression constant of water.
2. 1 g of a non- electrolyte solute dissolved in 50 g of benzene lowered the freezing point of benzene by 0.4 K. The freezing point depression constant of benzene is 5.12 K/m. Find the molar mass of solute.
3. 45 g of ethylene glycol (C2H6O2) is mixed with 600 g of water. Calculate (a) freezing point depression (b) freezing point of the solution. (Kf for water = 1.86 K/m)
4. A solution of urea in water has a boiling point of 100.128˚C. Calculate the freezing point of the same solution. Molal constant for water Kf and Kb are 1.86˚C and 0.512˚C respectively.
5. The average osmotic pressure of human blood is 7.7 atm at 40˚C. (a) what would be the total concentration of the various solutes in the blood? (b) Assuming the concentration to be essentially the same as the molality, find the freezing point of blood. (Kf for water = 1.86˚C)
6. A solution containing 2.56 g of sulphur dissolved in 100 g of naphthalene whose melting point is 80.1˚C gave a freezing point lowering of 0.680˚C. Calculate the formula of sulphur (Kf for naphthalene = 6.8 K/m)
7. Normal freezing point of a solvent is 15˚C. A 0.5 molal solution of urea in the above solvent causes a freezing point depression of two degrees. Calculate the molal depression constant.
8. Calculate the temperature at which a solution containing 54 g of glucose in 250 g of water will freeze. (Kf for water = 1.86 K/m)
9. Water is used in car radiators. In winter season, ethylene glycol is added to water so that water may not freeze. Assuming ethylene glycol to be non-volatile, calculate the minimum amount of ethylene glycol that must be added to 6 kg of water to prevent it from freezing at – 0.3˚C. The molal depression constant of water is 1.86 K/m
10. Two aqueous solutions, containing respectively 7.5 g of urea and 42.75 g substance X in 100 g of water freeze at the same temperature. Calculate the molar mass of X.
11. Pure solvent A has freezing point 16.5˚C. On dissolving 0.4 g of B in 200 g of A, the solution freezes at 16.4˚C and on dissolving 2.24 g of C in 100 g of A, the solution has freezing point of 16.0˚C. If the molar mass of B is 74 g/mol, what is the molar mass of C ?
12. An aqueous solution freezes at – 0.2˚C. What is the molality of the solution? Determine also (i) elevation in the boiling point (ii) Lowering of vapour pressure at 298 K . Given that Kf and Kb for water are 1.86 ˚C /m and 0.512 ˚C /m respectively and vapour pressure of water at 298 K is 23.756 mm.
13. An aqueous solution contains 5 % by weight of urea and 10 % by weight of glucose. What will be its freezing point ? Kf for water = 1.86 ˚C

SOLUTION Page No. 12

1. Addition of 0.643 g of a compound to 50 mL of benzene (density = 0.879 g/mL) lowers the freezing point from 5.51˚C to 5.03˚C. If Kf for benzene is 5.12, calculate the molecular weight of the compound.
2. 68.4 g of sugar is dissolved in 1000 g of water. What is (a) freezing point (b) boiling point (c) vapour pressure at 20˚C (d) osmotic pressure of the solution at 20˚C ? The density of the solution at 20˚C is 1.024 g/cm3. The vapour pressure of water at 20˚C is 17.633 mm. The Kf and Kb for water are 1.873˚ and 0.516˚ respectively
3. The temperature at a hill station is – 10˚C. Will it be suitable to add ethylene glycol (molar mass = 62) to water in the radiator so that the solution is 30 % by mass? Kf for water = 1.86 K/m
4. The molal freezing point depression constant of benzene is 4.90 K/m. Selenium exists as a polymer of the type SeX. When 3.26 g of selenium is dissolved in 226 g of benzene, the observed freezing point is 0.112˚C lower than for pure benzene. Deduce the molecular formula for selenium (molar mass = 78.8 g/mol).
5. A solution of an organic compound is prepared by dissolving 34.2 g in 500 g of water. Calculate the molar mass of the compound and freezing point of the solution. Given that Kb for water are 0.52 K/m and B. Pt. of solution = 100.104˚C. Kf for water = 1.87 K/m.
6. A 0.1539 molal aqueous solution of cane sugar (molar mass 342) has a freezing point of 271 K while the freezing point of pure water is 273.15 K. What will be the freezing point of an aqueous solution containing 5 g of glucose per 100 g of solution?
7. What mass of ethylene glycol must be added to 5.5 kg of water to lower the freezing point of water from 0˚C to – 10˚C. Kf for water = 1.86 K/m
8. 15 g of an unknown molecular substance was dissolved in 450 g of water. The resulting solution freezes at – 0.34˚C. What is the molar mass of the substance ? Kf for water = 1.86 K/m

**Answers**

1. 1.87 K/m 2. 256 g/mol 3. 2.25 K , 270.9 K 4. – 0.465˚C 5. 0.3 mol/L , - 0.558˚C

6. S8 7. 4 K/m 8. – 2.23˚C 9. 60 g 10. 342 g/mol

11. 165.8 g/mol 12. m = 0.1075, (i) 0.055˚C (ii) 0.046 mm 13. – 3.03˚C 14. 156 u

15. (a) – 0.375 (b) 100.103˚C (c) 17.569 mm (d) 4.6 atm 16. Yes 17. Se8

18. 342 g/mol , - 0.374˚C 19. 269.27 K 20. 1.833 kg 21. 182.35 g/mol

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**Assignment – VIII**

**(Based on Van’t Hoff Factor)**

1. Assuming complete dissociation of the salts, calculate the molality of sodium chloride solution whose elevation in boiling point is numerically equal to the depression in freezing point of 0.2 m Aluminium sulphate solution in water (Kb and Kf for water are 0.52 and 1.86 K kg/mol respectively).
2. KI and sucrose solution with 0.1 M concentration have osmotic pressure of 0.465 atm and 0.245 atm respectively. Find the Van’t Hoff of KI and its degree of dissociation.
3. Calculate the boiling point of a 1 molar aqueous solution (density = 1.04 g/mL) of potassium chloride (Kb for water is 0.52 K kg/mol ; Atomic masses : K = 39 , Cl = 35.5)
4. 0.5 g KCl was dissolved in 100 g of water and the solution originally at 20˚C, froze at – 0.24˚C. Calculate the percentage ionization of salt. Kf per 1000 g of water = 1.86˚C.
5. The freezing point depression of 0.1 m NaCl solution is 0.372˚C. What conclusion would you draw about its molecular state? Kf for water = 1.86 K kg/mol.
6. Which of the following solution will have the highest and which have the lowest freezing point and why? (i) 0.1 M NaCl solution (ii) 0.1 M glucose solution (iii) 0.1 M BaCl2 solution
7. Calculate the amount of NaCl which must be added to 100 g of water so that the freezing point is depressed by 2 K. Kf for water = 1.86 K kg/mol.
8. Calculate the Van’t Hoff factor of CdSO4 (molecular mass 208.4) if the dissolution of 5.21 g of CdSO4 in half litre water gives a depression in freezing point of 0.168˚C. Kf for water = 1.86 K kg/mol.
9. Determine the osmotic pressure of a solution prepared by dissolving 2.5 x 10 – 2 g of K2SO4 in 2L of water at 25˚C, assuming that it is completely dissociated. ((R = 0.0821 L atm K – 1 mol – 1 , molar mass of K2SO4 = 174 g/mol).
10. 3.9 g of benzoic acid dissolved in 49 g of benzene shows a depression in freezing point of 1.62 K. Calculate the Van’t Hoff factor and predict the nature of solute (dissociated or associated).

(Molar mass of benzoic acid = 122 g/mol ; Kf for benzene = 4.9 K kg/mol.)

1. 0.01 m aqueous solution of K3 [Fe(CN)6] freezes at – 0.062˚C. What is the apparent percentage of dissociation? Kf for water = 1.86 K kg/mol.
2. Phenol associates in benzene to a certain extent to form dimer. A solution containing 2 x 10 – 2 kg of phenol on 1 kg of benzene has its freezing point decreased by 0.69 K. Calculate the degree of association of phenol. Kf for benzene = 5.12 K kg/mol.
3. Out of the following three solutions, which has the highest freezing point and why?

(i) 0.1 M urea (ii) 0.1 M Barium phosphate (iii) 0.1 M Sodium sulphate

1. Out of the following three solutions, which has the highest boiling point and why?

(i) 1 M Glucose (ii) 1 M Potassium chloride (iii) 1 M Aluminium nitrate

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1. A decimolar solution of potassium Ferrocyanide is 50 % dissociated at 300 K. Calculate the osmotic pressure of the solution. (R = 8.314 J K – 1 mol – 1 ).
2. On a certain hill station, pure water is found to boil at 95˚C. How many grams of NaCl must be added to 2 kg of water so that it boils at 100˚C?
3. Calculate the freezing point depression expected for 0.0711 m aqueous solution of Na2SO4. If this solution actually freezes at – 0.320˚C, what would be the value of Van’t Hoff factor? Kf for water = 1.86 K kg/mol.
4. Calculate the boiling point of a solution containing 0.61 g of benzoic acid in 50 g of carbon disulphide assuming 84 % dimerization of the acid. The boiling point and Kb of CS2 are 46.2˚C and 2.3 K kg/mol respectively.
5. Calculate the freezing point of a solution containing 8.1 g of HBr in 100 g of water, assuming the acid to be 90 % ionized. [Given : Molar mass of Br = 80 g/mol ; Kf for water = 1.86 K kg/mol].
6. Calculate the freezing point of a solution containing 0.5 g KCl (Molar mass = 74.5 g/mol) dissolved in 100 g water, assuming KCl to be 92 % ionized. [Kf for water = 1.86 K kg/mol].

**Answers**

1. 1.788 mol/kg 2. 1.898 , 89.8% 3. 101.078˚C 4. 92 %

5. NaCl dissociated completely 6. Glucose will have highest and BaCl2 lowest freezing point

7. 3.147 g 8. 1.806 9. 5.27 x 10 – 3 atm 10. 0.506 , associated

11. 77.7 % 12. 0.734 13. 0.1 M Urea 14. 1 M Al(NO3)3 15. 7.389 atm

16. 562.5 g 17. 0.132˚C , 2.42 18. 46.333˚C 19. 269.47 K

20. – 0.24˚C

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