PHYSICAL CHEMISTRY

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Meq. Approach

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Topic: Colligative Property

01) Calculate osmotic pressure of a decimolar solution of glucose at 30ºC.

Ans : 2.488 atm

02) The osmotic pressure of a non volatile solute in C_6H_6 at 25ºC is 20.66 Nm^{-2}. If the solution had a concentration of 2 g/dm^3, what is mol. wt. of solute ?

Ans : 239.84 kg $mole^{-1}$

03) At what temperature will a 5% solution (weight/vol.) of glucose develops an osmotic pressure of 7 atmosphere ?

Ans : 33.94ºC

04) At 27ºC, 36 g of glucose per litre has an O.P. of 4.92 atm. If the osmotic pressure of solution is 1.5 atm at the same temperature, what should be its concentration ?

Ans : 0.061 mole/litre

05) Calculate the osmotic pressure at 17ºC of an aqueous solution containing 1.75 g of sucrose per 150 mL solution.

Ans : 0.812 atm

06) A solution of sucrose (molar mass 342 g/mole) is prepared by dissolving 68.4 g of it per litre of the solution. What is its osmotic pressure at 300 K ? (R =0.082 lit.atm.$deg.^{-1}$ mol^{-1})

Ans : 4.92 atm

07) A 5% solution (wt./vol.) of cane sugar is isotonic with 0.877% (wt./vol.) of urea solution. Find m. wt. of urea, if m. wt. of sugar is 342.

Ans : 59.98

08) How many g of glucose must be present in 0.5 litre of a solution for its osmotic pressure to be same as that of solution of 9.2 g glucose per litre ?

Ans : 4.60 g

09) 20 g sucrose solution in one litre is isotonic with a solution of boric acid containing 1.63 g of boric acid in 450 mL. Find the m. wt. of boric acid.

Ans : 61.94

10) An aqueous solution containing liquid A (M. wt. = 128) 64% by weight has a V.P. of 145 mm. Find the V.P. of A, if that of water is 155 mm at the same temperature.

Ans : 105 mm

11) A mixture of ethyl alcohol and propyl alcohol has a V.P. of 290 mm at 27ºC. If mole fraction of ethyl alcohol is 0.65, calculate the vapour pressure of ethyl alcohol, if vapour pressure of propyl alcohol is 210 mm.

Ans : 333.1 mm

12) At 300 K, the vapour pressure of an ideal solution containing one mole of A and 3 moles of B is 550 mm Hg. At the same temperature, if one mole of B is added to this solution, the vapour pressure of solution increases by 10mm of Hg. Calculate the V.P. of A and B in their pure state

Ans : 400 mm & 600 mm

13) Cyclohexane and ethanol at a particular temperature have vapour pressure of 280 mm and 168 mm respectively. If these two solutions having mole fraction value of cyclohexane equal to 0.32 are mixed and the mixture has a total vapour pressure of 376 mm, will the mixture be an ideal solution ?

Ans : 203.84 mm (Solution is not ideal)

14) Vapour pressure of C_6H_6 and C_7H_8 mixture at 50ºC are given by P = 179XB + 92, where XB is mole fraction of C_6H_6. Calculate (in mm):

(a) Vapour pressure of pure liquids.

(b) Vapour pressure of liquid mixture obtained by mixing 936 g C_6H_6 and 736 g toluene.

(c) If the vapours are removed and condensed into liquid and again brought to the temperature of 50ºC, what would be mole fraction of C_6H_6 in vapour state ?

Ans : (a) V.P of pure C_6H_6 = 271 mm, V.P of pure C_7H_8 = 92 mm

(b) 199.4 mm

(c) XC_6H_6 in vapour state = 0.928, XC_7H_8 in vapour state = 0.072

15) 10 g of a certain non-volatile solute were dissolved in 100 g water at 20ºC. The vapour pressure was lowered from 17.3555 mm to 17.2350 mm, calculate M. wt. of solute.

Ans : 257.45

16) Calculate vapour pressure of a solution at 100ºC having 3.42 g of cane sugar in 180 g water.

Ans : 759.2 mm

17) The vapour pressure of water at 20ºC is 17.54 mm. When 20 g of solute was added in 100 g water, the V.P. was found to lower by 0.30 mm. Calculate M. wt. of solute.

Ans : 206.88

18) Find the molality of a solution containing a non-volatile solute if the vapour pressure is 2% below the vapour pressure of pure water.

Ans : 1.133

19) Calculate the relative lowering in V.P. if 10 g of a solute (m. wt. 100) are dissolved in 180 g water.

Ans : 0.0099

20) Benzene and toluene form two ideal solutions A and B at 313 K. Solution A contains 4 moles of toluene and one mole of C_6H_6. Solution B contains equal masses of toluene and benzene. Calculate total pressure in each case. The vapour pressure of C_6H_6 and toluene are 160 and 60 mm respectively at 313 K.

Ans : A : 80 mm & B: 114.117 mm

21) What weight of non volatile solute, urea (NH_2CONH_2) 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 solution ?

Ans : 18.52 m

22) An aqueous solution of glucose containing 12 g in 100 g of water was found to boil at 100.34ºC. Calculate Kb for water in K $mole^{-1}$ kg.

Ans : 0.51 K $mole^{-1}$ kg

23) What will be the boiling point of bromine when 174.5 mg of octa atomic sulphur is added to 78 g of bromine. K'b for Br_2 is 5.2 K $mole^{-1}$ kg and b. pt. of Br_2 is 332.15 K.

Ans : 332.195 K

24) At 90ºC, the vapour pressure of toluene is 400 mm and that of xylene is 150 mm. What is the composition of liquid mixture that will boil at 90ºC when the pressure of mixture is 0.5 atm ?

Ans : XToluene = 0.92, XXylene = 0.08

25) An aqueous solution of glucose boils at 100.01ºC. The molal elevation constant for water is 0.5 K $mole^{-1}$ kg. What is the number of glucose molecules in the solution containing 100 g water.

Ans : 1.2×10^{21} molecules

26) The molal freezing point constant of C_6H_6 is 4.90 and its melting point is 5.51ºC. A solution of 0.816 g of a compound A dissolved in 7.5 g of benzene freezes at 1.59ºC. Calculate molecular weight of compound A.

Ans : 136

27) Two solutions containing respectively 0.75 g of urea (m. wt. 60) and 1.5 g of compound A in 100 g water, freeze at the same temperature. Calculate molecular weight of A.

Ans : 120

28) What weight of glycerol would have to be added in 1000 g of water in order to lower its freezing point by 10ºC ? K_f for water is 1.86 K $mole^{-1}$ kg.

Ans : 494.6 g

29) An aqueous solution containing 5% by weight of urea and 10% by weight of glucose. What will be its freezing point ? K'_f for H_2O is 1.86º $mole^{-1}$ kg.

Ans : –3.04ºC

30) Calculate the depression in freezing point caused by the addition of 0.5309 g of solid (m.wt.30.63) in 40 g water. The molal depression constant is 1.85º $mole^{-1}$ kg.

Ans : 0.802º

31) A solution of 0.643 g of an organic compound in 50 mL of benzene (density 0.879 g/mL) lowered its freezing point from 5.51ºC to 5.03ºC. Calculate the molecular weight of solid. K_f for benzene is 5.12 K $mole^{-1}$ kg.

Ans : 156.06

32) Calculate the amount of ice that will separate out on cooling a solution containing 50 g of ethylene glycol in 200 g water to –9.3ºC. (K_f for water = 1.86 K $mole^{-1}$ kg)

Ans : 38.71 g

33) An aqueous solution was found to have an osmotic pressure of 2.51 atm at 25ºC. What will be the freezing point of solution if K'_f for water is 1.86 K mole^{-1} kg ? Assume molarity and molality are same.

Ans : 0.19ºC

34) Calculate the freezing point of an aqueous solution of non electrolyte having an osmotic pressure 2.0 atm at 300 K. K'_f = 1.86 K mole $^{-1}$ kg and S = 0.0821 litre atm K^{-1} mole $^{-1}$.

Ans : 0.151ºC

35) A decimolar solution of potassium ferrocyanide is 50% dissociated at 300 K. Calculate osmotic pressure of the solution. Given S = 8.314 JK^{-1} mole^{-1}.

Ans : 7.842×10^5 Nm^{-2}

36) A 1% (wt./vol.) KCl solution is ionised to the extent of 82%. What would be its osmotic pressure at 18ºC ?

Ans : 5.842 atm

37) 7.6 g KBr in 1250 mL solution was found to have an osmotic pressure of 1.804 atm at 27ºC. Calculate degree of ionisation and vant Hoff factor.

Ans : α = 43.4%, i = 1.434

38) Calculate the osmotic pressure of 20% (wt./vol.) anhydrous $CaCl_2$ solution at 0ºC assuming 100% ionisation.

Ans : 121.14 atm

39) A certain mass of a substance when dissolved in 100 g C_6H_6 lowers the freezing point by 1.28ºC. The same mass of solute dissolved in 100 g of water lowers the freezing point by 1.40ºC. If the substance has normal molecular weight in benzene and is completely dissociated 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 K mole^{-1} kg respectively.

Ans : Number of ions given = 3

40) Calculate osmotic pressure of a decinormal solution of $BaCl_2$ at 27ºC showing 80% degree of ionisation.

Ans : 3.20 atm

41) A 1.2 % solution (wt./volume) of NaCl is isotonic with 7.2% solution (wt./volume) of glucose. Calculate degree of ionisation and vant Hoff factor of NaCl.

Ans : i = 1.95, α = 0.95

42) The vapour pressure of a solution containing 2 g of an electrolyte BA in 100 g water, which dissociates in one B^+ and one A^- ion in water, is 751 mm, at 100ºC. Calculate degree of ionisation of BA if its mol.wt. is 56.

Ans : α = 0.8641

43) When 11.7 g of NaCl are dissolved in 200 g of water the depression in freezing point is doubled than the depression caused by 342 g of cane sugar in 1000 g of water. From this information what do you infer about the nature of solute particles of NaCl in solution.

Ans : α = 1, That is NaCl is 100% ionised in solution

44) A storage battery contains a solution of H_2SO_4 38% by weight. At this concentration, vant Hoff factor is 2.50. At what temperature will the battery contents freeze ?

Ans : 243.92 K

45) Calculate the boiling point of a solution containing 0.61 g of benzoic acid in 50 g of carbon disulphide assuming 84% dimeization of the acid. The boiling point and Kb of CS_2 are 46.2ºC and 2.3 K Kg mole^{-1}.

Ans : 46.33 ºC

46) The degree of dissociation of $Ca(NO_3)_2$ in a dilute aqueous solution containing 7 g of salt per 100 g of water at 100ºC is 70%. Calculate the vapour pressure of solution.

Ans : 746.26 mm

47) 1 g of mono basic acid in 100 g of water lowers the freezing point by 0.168º. If 0.2 g of same acid requires 15.1 mL of N/10 alkali for complete neutralization, calculate degree of dissociation of acid K'_f for H_2O is 1.86 K mole^{-1} kg.

Ans : 19.6%

48) The freezing point of a solution containing 0.2 g of acetic acid in 20.0 g benzene is lowered by 0.45ºC. Calculate the degree of association of acetic acid in benzene. Assume acetic acid dimerizes in benzene K_f for benzene = 5.12 K mole^{-1} kg.

Ans : α = 0.945 or 94.5%

49) 2 g of benzoic acid dissolved in 25 g if C_6H_6 shows a depression in freezing point equal to 1.62K. Molal depression constant of C_6H_6 is 4.9 K mole^{-1} kg. What is the percentage association of acid if it forms double molecule in solution.

Ans : α = 0.992 or 99.2%

50) Phenol associates in benzene to a certain extent to form a dimer. A solution containing 20×10^{-3} kg of phenol in 1.0 kg of benzene has its f.pt. depressed by 0.69 K. Calculate the fraction of phenol dimerzed. K'_f for C_6H_6 = 5.12º mole^{-1} kg.

Ans : α = 0.734, 73.4%

51) A solution containing 28 g phosphorus in 315 g CS_2 (b.pt. 46.3ºC) boils at 47.98ºC. K'_b for CS_2 is 2.34 K mole^{-1} kg. Calculate m. wt. of phosphorus and deduce its molecular formula. Assume its complete association.

Ans : P_4

52) A 0.025 M solution of monobasic acid had a freezing point of –0.06ºC. Calculate K_α for the acid. K_f H_2O = 1.86º molality $^{-1}$. Assume molality equal to molarity.

Ans : 2.96×10^{-3}

53) Calculate the molal lowering of vapour pressure for H_2O at 100ºC.

Ans : 13.43 mm

54) 100 g of sucrose solution in water is cooled to –0.5ºC. What weight of ice would be separated out at this temperature, if solution started to freeze at –0.38ºC ? K'_f for H_2O = 1.86 K mole^{-1} kg.

Ans : 21.62 g

55) At 40ºC the vapour pressure, in torr, of methyl alcohol-ethyl alcohol solutions is represented by P = 119x + 135; Where x is the mole fraction of methyl alcohol. What are the vapour pressure of the pure components at this temperature ?

Ans : 254 torr, 135 torr

56) Ethylene bromide, $C_2H_4Br_2$, and 1,2 -dibromopropane, $C_3H_6Br_2$, form a series of ideal solutions over the whole range of composition. At 85ºC the vapour pressure of these two pure liquids are 173 and 127 torr, respectively. **(a)** If 10.0 g of ethylene bromide is dissolved in 80.0 g of 1,2-dibromopropane, calculate the partial pressure of each component and the total pressure of the solution at 85ºC. **(b)** Calculate the mole fraction of ethylene bromide in the vapour in equilibrium with the above solution. **(c)** What would be the mole fraction of ethylene bromide in a solution at 85ºC equilibrated with a 50:50 mole mixture in the vapour

Ans : (a) 132 torr (b) 0.155 (c) 0.423

57) 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 ?

Ans : 0.25

58) The vapour pressure of pure water at 26ºC is 25.21 torr. What is the vapour pressure of a solution which contains 20.0 g glucose, $C_6H_{12}O_6$, in 70 g water ?

Ans : 24.5 torr

59) The vapour pressure of pure water at 25ºC is 23.76 torr. The vapour pressure of a solution containing 5.40 g of a nonvolatile substance in 90.0 g water is 23.32 torr. Compute the molecular weight of the solute.

Ans : 55.8 g/mole

60) At 30ºC, pure benzene (molecular weight 78.1 g/mol) has a vapour pressure of 121.8 torr. Dissolving 15.0 g of a nonvolatile solute in 250 g of benzene produced a solution having a vapour pressure of 120.2 torr. Determine the approximate molecular weight of the solute.

Ans : 350

61) The vapour pressure of water at 28ºC is 28.35 torr. Compute the vapour pressure at 28ºC of a solution containing 68 g of cane sugar, $C_{12}H_{22}O_{11}$, in 1000 g of water.

Ans : 28.25 torr

62) Calculate the mole fraction of toluene in the vapour phase which is in equilibrium with a solution of benzene and toluene having a mole fraction of toluene 0.500. The vapour pressure of pure benzene is 119 torr, that of toluene is 37.0 torr at the same temperature.

Ans : 0.237

63) What is the composition of the vapour which is in equilibrium at 30ºC with a benzene-toluene solution with a mole fraction of benzene of 0.400 ? with a mole fraction of benzene of 0.6000

P_b^o = 119 torr and P_t^o = 37.0 torr

Ans : $X_b = 0.829$, $X_t = 0.171$

64) At 50ºC tha vapour pressure of pure CS_2 is 854 torr. A solution of 2.0 g of sulfur in 100 g of CS_2 has a vapour pressure 848.9 torr. Determine the formula of the sulfur molecule.

Ans : 8

65) Calculate the vapour pressure lowering of a 0.100 m aqueous solution of nonelectrolyte at 75ºC.

Ans : 0.533 torr

66) Calculate the composition of the vapour in equilibrium with an ideal solution of ethylbenzene (P^o_e= 10.0 torr) and methylbenzene (P^o_m= 37.0 torr) in which the mole fraction of ethylbenzene in the liquid is 0.35. Calculate the total vapour pressure of the solution.

Ans : 28 torr

67) The vapour pressure of pure benzene, C_6H_6, at 50ºC is 268 torr. How many mole of nonvoltile solute per mole of benzene is required to prepare a solution of benzene having a vapour pressure of 167.0 torr at 50ºC ?

Ans: 0.605 mole solute/mole benzene

68) At 25ºC, the vapour pressure of methyl alcohol, CH_3OH is 96.0 torr. What is the mole fraction of CH_3OH in a solution in which the (partial) vapour pressure of CH_3OH is 23.0 torr at 25ºC ?

Ans : 0.240

69) At 25ºC, the vapour pressure of pure benzene is 100 torr, while that of pure ethyl alcohol is 44 torr. Assuming ideal behavior, calculate the vapour pressure at 25ºC of a solution which contains 10.0 g of each substance.

Ans : 65 torr

70) Estimate the lowering of the vapour pressure due to the solute in a 1.0 m aqueous solution at 100ºC.

Ans : 14 torr

71) When 10.6 g of nonvolatile substance is dissolved in 740 g of ether, its boiling point is raised 0.284ºC. What is the molecular weight of the substance ? Molar boiling point constant for ether is 2.11ºC kg/mole.

Ans : 106 g/mole

72) The freezing point of a sample of naphthalene was found to be 80.6ºC. When 0.512 g of a substance is dissolved in 7.03 g maphthalene, the solution has a freezing point of 75.2ºC. What is the molecular weight of the solute ? The molal freezing point constant of naphthalene is 6.80ºC kg/mole.

Ans : 92 g/mole

73) The freezing point of a solution containing 2.40 g of a compound in 60.0 g of benzene is 0.10ºC lower than that of pure benzene. What is the molecular weight of the compound ? (K_f is 5.12ºC/m for benzene.)

Ans : 2050 g/mole

74) An aqueous solution containing 288 g of a nonvolatile compound having the stoichiometric composition $C_nH_{2n}O_n$ in 90.0 g of water boils at 101.24ºC at 1.00 atm pressure. What is the molecular formula of the compound ?

Ans : $C_{44}H_{88}O_{44}$

75) Calculate **(a)** the freezing point of a solution of 0.0100 mole of glucose dissolved in 100 g of water, and **(b)** the freezing point of a 0.100 m solution of naphthalene in benzene.

Ans : (a) 0.186ºC (b) 0.512ºC

76) A solution containing 3.50 g of solute X in 50.0 g of water has a volume of 52.5 mL and a freezing point of –0.86ºC. **(a)** Calculate the molality, mole freaction, and molarity of X. **(b)** Calculate the molecular weight of X.

Ans : (a) 0.46 m (b) 152 g/mole

77) When 36.0 g of a solute having the empirical formula CH_2O is dissolved in 1.20 kg of water, the solution freezing at –0.93ºC. What is the molecular formula of the solute ?

Ans : $C_2H_4O_2$

78) Calculate the freezing point of 0.200 m solutions of fructose, $C_6H_{12}O_6$. **(a)** in water **(b)** in acetic acid

Ans : (a) 0.372ºC (b) 0.78ºC

79) A solution of 10.0 g of a nonionic solute in 100 g of benzene freezs at 4.2ºC. Calculate the molecular weight of the solute.

Ans : 400 g/mole

80) A solution containing 6.35 g of a nonelectolyte dissolved in 500 g of water freezes at –0.465ºC. Determine the molecular weight of the solute.

Ans : 64.0 g/mole

81) A solution containing 3.24 g of a nonvolatile nonelectrolyte and 200 g of water boils at 100.130ºC at 1 atm. What is the molecular weight of the solute ?

Ans : 64.0 g/mole

82) Calculate the freezing point and the boiling point at at 1 atm of a solution containing 30.0 g cane sugar (molecular weight 342 g/mol) and 150 g water.

Ans : –1.09ºC, 100.300ºC

83) A solution was made up by dissolving 3.75 g of a pure hydrocarbon in 95.0 g of acetone. The boiling point of pure acetone was observed to be 55.95ºC, and of the solution, 56.50ºC. If the molal boiling point constant of acetone is 1.71 ºC kg/mole, what is the approximate molecular weight of the hydrocarbon ?

Ans : 123 g/mole

84) 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 99.725ºC.

Ans : 100.079ºC

85) A certain solution of benzoic acid in benzene has a freezing point of 3.1ºC and a normal boiling point of 82.6ºC. Explain these observations, and suggest structures for the solute particles at the two temperatures.

Ans : Do yourself

86) The osmotic pressure of blood is 7.65 atm at 37ºC. How much glucose should be used per L for an intravenous injection that is to have the same osmotic pressure as blood ?

Ans : 54.2 g

87) A aqueous solution of urea had a freezing point of –0.52ºC. Predict the osmotic pressure of the same solution at 37ºC. Assume that the molar concentration and the molality are numerically equal.

Ans : 7.1 atm

88) The osmotic pressure of a solution of a synthetic polyisobutylene in benzene was determined at 25ºC. A sample containing 0.20 g of solute/100 cm^3 of solution developed a rise of 2.4 mm at osmotic equilibrium. The density of the solution was 0.88 g/cm^3. What is the molecular weight of the polyyisobutylene ?

Ans : 2.4×10^5 g/mole

89) What would be the osmotic pressure at 17 ºC of an aqueous solution containing 1.75 g of sucrose ($C_{12}H_{22}O_{11}$) per 150 cm^3 solution ?

Ans : 0.81 atm

90) Calculate the osmotic pressure of a 0.100 M solution of a nonelectrolyte at 0ºC.

Ans : 2.24 atm

91) What is the molecular weight, MA, of a solute, A, if the osmotic pressure of a solution containing 10.0 g/L is 10.0 torr at 27ºC ?

Ans : 18700 g/mole

92) A 250-mL water solution containing 48.0 g of sucrose, $C_{12}H_{22}O_{11}$, at 300 K is separated from pure water by means of a semipermeable membrane. What pressure must be applied above the solution in order to just prevent osmosis ?

Ans : 13.8 atm

93) Calculate the osmotic pressure of an aqueous solution which contains 4.00 g of glucose, $C_6H_{12}O_6$, in 250 mL of solution at 25ºC.

Ans : 2.17 atm

94) 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 4ºC 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.

Ans : 5.4×10^5 g/mole

95) The solubility of N_2 in water is 2.2×10^{-4} g in 100 g of H_2O at 20ºC when the pressure of nitrogen over the solution is 1.2 atm. Calculate the solubility at that temperature when the nitrogen pressure is 10 atm.

Ans : 1.8 mg

96) Of the following 1.10 m aqueous solution, which one will exhibit the largest freezing point depression ?

Ans : (a) KCl (b) $C_6H_{12}O_6$ (c) K_2SO_4 (d) $Al_2(SO_4)_3$ (e) NaCl

97) Arrange the following aqueous solution in order of increasing freezing points (that is, lowest first): (a) 0.10 m C_2H_5OH (b) 0.10 m $Ba_3(PO_4)_2$ (c) 0.10 m Na_2SO_4 (d) 0.10 m KCl (e) 0.10 m Li_3PO_4.

Ans : b < e < c < d < a

98) Chloroacetic acid, a monoprotic acid has a K_a of 1.36 × 10–3. Compute the freezing point of a 0.10 M solution of this acid. Assume that the stoichiometeic molar concentration and molality are the same in this case.

Ans : –0.21ºC

99) A 0.025 M solution of monobasic acid had a freezing point of –0.060ºC. What are K_a and PK_a for the acid ?

Ans : $K_a = 3 \times 10^{-3}$, $PK_a = 2.5$

100) A 0.100 M solution of an acid (density = 1.010 g/cm^3) is 4.5% ionized. Compute the freezing point of the solution. The molecular weight of the acid is 300.

Ans : –0.199ºC

101) How many grams of H_2O must be used to dissolved 50.0 grams of sucrose to prepare a 1.25m solution of sucrose, $C_{12}H_{22}O_{11}$?

Ans : 117 g H_2O

102) What are the mole fractions of CH_3OH and H_2O in the solution containing 128 g CH_3OH and 108 g H_2O.

Ans : $X_{CH_3OH} = 0.400$, $X_{H_2O} = 0.600$

103) Sucrose is a nonvolatile, nonionizing solute in water. Determine the vapour pressure lowering, at 25ºC, of the 1.25 m sucrose solution in Question No.101. Assume that the solution behaves ideally. The vapour of pure water at 25ºC is 23.8 torr.

Ans : 0.52 torr

104) At 40ºC, the vapour pressure of pure n-heptane is 92.0 torr and the vapour pressure of pure n-octane is 31.0 torr. Consider a solution that contains 1.00 mole of n-heptane and 4.00 moles of n-octane. Calculate the vapour pressure of each component and the total vapour pressure above the solution.

Ans : 18.4 torr

105) Calculate the mole fractions of n-heptane and n-octane in the vapour that is in equilibrium with the solution in Question No.104.

Ans : $X_{\text{n-heptane}} = 0.426$, $X_{\text{n-octane}} = 0.574$

106) What is the normal boiling point of the 1.25 m sucrose solution of Question No.101.

Ans : 100.640ºC

107) When 15.0 grams of ethyl alcohol, C_2H_5OH, is dissolved in 750 grams of formic acid, the freezing point of the solution is 7.20ºC. The freezing point of pure formic acid is 8.40ºC. Evaluated K_f for formic acid.

Ans : 2.76ºC/m

108) What is the freezing point of the 1.25 m sucrose solution of Question No.101.

Ans : –2.32ºC

109) A 1.20-gram sample of an unknown covalent compound is dissolved in 50.0 grams of benzene. The solution freezes at 4.92ºC. Determine the molecular weight of the compound.

Ans : 2.2×10^2 amu

110) Either camphor ($C_{10}H_{16}O$, molecular weight = 152.24 g/mol) or naphthalene ($C_{10}H_8$, molecular weight 128.19 g/mol) can be used to make mothballs. A 5.0-gram sample of mothballs was dissolved in 100.0 grams of ethyl alcohol, and the resulting solution had a boiling point of 78.90ºC. Determine whether the mothballs were made of camphor or naphthalene. Pure ethyl alcohol has a boiling point of 78.41ºC, and K_b = 1.22ºC/m for this solvent.

Ans : Molucular weight of solute after calculation is around 125. Hence solute is nepthalene

111) Lactic acid, C_2H_4 (OH)(COOH), is found in sour milk. It is also formed in muscles during intense physical activity and is responsible for the pain felt during strenuous exercise. It is a weak monoprotic acid and therefore a weak electolyte. The freezing point of a 0.0100 m aqueous solution of lactic acid is –0.0206ºC. Calculate **(a)** the i value and **(b)** the percent ionization in the solution.

Ans : (a) 0.11 (b) 11%

112) What osmotic pressure would the 1.25 m sucrose solution of Question No. 101 exhibit at 25ºC? The density of this solution is 1.34 g/mL.

Ans : 28.6 atm

113) Pepsin is an enzyme present in the human digestive tract. An enzyme is a protein that acts as a biological catalyst. Pepsin catalyzes the metabolic cleavage of amino acid chains (called peptide chains) in other proteins. A solution of a 0.500-gram sample of purified pepsin in 30.0 mL of benzene solution exhibits an osmotic pressure of 8.92 torr at 27ºC. Estimate the molecular weight of pepsin.

Ans : 3.50×10^4 g/mole

114) The solubility of K_2ZrF_6 at 100ºC in 100 g of H_2O is 25 g. Express this concentration in terms of **(a)** molality and **(b)** mole fraction.

Ans : (a) 0.88 m K_2ZrF_6 (b) 0.016

115) A solution that is 24.0% fructose, $C_6H_{12}O_6$, in water has a density of 1.10 g/mL at 20ºC. **(a)** What is the molality of fructose in this solution ? **(b)** At a higher temperature, the density would be lower. Would the molality be less than, greater than, or the same as the molality at 20ºC ?

Ans : (a) 1.75 m $C_6H_{12}O_6$ (b) The same

116) The density of an aqueous solution containing 10.00 g K_2SO_4 in 100.00 g solution is 1.0825 g/mL. Calculate the concentration of this solution in molarity, molality, percent of K_2SO_4, and mole fraction of solvent.

Ans : 0.6210 M K_2SO_4, 0.6374 m K_2SO_4, 10.00% K_2SO_4, 0.9886

117) Calculate **(a)** the lowering of vapour pressure and **(b)** the vapour pressure of a solution prepared by dissolving 50.0 g of naphthalene, $C_{10}H_8$, (a nonvolatile nonelectrolyte), in 150.0g of benzene, C_6H_6, at 20ºC. Assume that the solution is ideal. The vapour pressure of pure benzene is 74.6 torr at 20ºC.

Ans : (a) 12.6 torr (b) 62.0 torr

118) What mass of a nonvolatile solute having a molecular weight of 325 g/mol would be required to decrease the vapour pressure of 1.00 kg of water by 1.00 torr at 100ºC ?

Ans : 23.9 g solute

119) At – 100ºC the vapour pressure of pure ethane, CH_3CH_3, is 394 torr and that of pure propane, $CH_3CH_2CH_3$. is 22 torr. What is the vapour pressure over a solution containing equal molar amounts of these substances ? What is the composition of the vapour ?

Ans : P_{total} = 208 torr in the vapour , X_{ethane} = 0.947, $X_{propane}$ = 0.053

120) You have separate 0.10 M aqueous solutions of the following salts: $LiNO_3$, $Ca(NO_3)_2$,and $Al(NO_3)_3$. In which one would you expect the solute to be the most completely dissociated ? Which solution would you expect to conduct electricity most strongly ?

Ans :

121) What is the value of the van't Hoff factor, i, for the following strong electrolytes at infinite dilution? **(a)** Na_2SO_4, **(b)** KOH, **(c)** $Al_2(SO_4)_3$, **(d)** $Ba(OH)_2$.

Ans : (a) 3 (b) 2 (c) 5 (d) 5

122) Four beakers contain 0.010 m aqueous solution of CH_3OH, NaOH, $CaCL_2$, and CH_3COOH, respectively. Which of these solutions has the lowest freezing point ?

Ans :

123) One gram each of NaCl, NaBr, and NaI was dissolved in 100.0 g water. What is the vapour pressure above the solution at 100ºC ? Assume complete dissociation of the three salts.

Ans : 751 torr

124) A 0.100 m acetic acid solution in water freezes at –0.1884ºC. Calculate the precentage ionization of CH_3COOH in this solution.

Ans : 1%

125) CsCl dissolves in water according to

$$CsCl \longrightarrow Cs^+ + Cl^-$$

A 0.121 m solution of CsCl freezing at –0.403ºC. Calculate i and the apparent precentage dissociation of CsCl in this solution.

Ans : i = 1.79, 79% ionization

126) **(a)** Solution of benzoic acid, C_6H_5COOH, in nonpolar solvents such as benzene, C_6H_6, yield i values that approach ½ in freezing point depression experiments. How can you account for this? **(b)** What is the apparent molecular weight of benzoic acid that would be determined by measuring the freezing point depression of a solution of benzene ?

Ans : (a) Do yourself (b) 244 g/mole