

AP Chemistry - Solutions

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Name: Key Date: _____ Period: _____

1. An aqueous solution of ethanol, C_2H_5OH , that is 12.0% ethanol by weight, has a density of 0.981g/mL at 20.0°C. The molecular mass of C_2H_5OH is 46.0g/mol. What is the molality of ethanol in this solution?

In 100.0 mL of solution: mass = 100.0 mL (0.981 g/mL) = 98.1 g
mass C_2H_5OH = 98.1 g (0.120) = 11.8 grams mass H_2O = 98.1 g - 11.8 g = 86.3 g
mole C_2H_5OH = 11.8 g / 46.0 g/mol = 0.2565 mol $m = 0.2565 \text{ mol} / 0.0863 \text{ kg} = \boxed{2.97 \text{ m}}$

2. What is the mole fraction of water in the water-ethanol solution given in question 1 above?

mole H_2O = 86.3 g / 18.016 g/mol = 4.79 mol H_2O

$\frac{4.79 \text{ mol } H_2O}{(4.79 \text{ mol } H_2O + 0.2565 \text{ mol } C_2H_5OH)} = 0.94917 = \boxed{.949 (94.9\%)}$

3. What is a colligative property? Name the four colligative properties studied in this chapter.

A colligative property is one that only depends on the number of solute particles, not their identity. This chapter discusses freezing point depression, vapor pressure lowering, boiling point elevation and osmotic pressure.

4. Which one of the following does NOT affect the solubility of a gas in solvents?
a. identity of the gas b. identity of the solvent c. pressure of the gas
d. temperature e. atmospheric pressure

Via Henry's Law, it is not dependent upon atmospheric pressure.

5. An ideal solution is formed from a mixture of the nonvolatile solute, urea ($CO(NH_2)_2$), and methanol (CH_3OH). The vapor pressure of pure methanol at 20.0°C is 89.0 mmHg

- a. Calculate the mole fraction of urea that is obtained from mixing 6.0g of urea with 32.0g of methanol.

$X_u = \frac{n_u}{n_u + n_m} = \frac{(6.0)}{(6.0) + (32.0)} = \boxed{0.091}$

- b. Calculate the vapor pressure of the methanol solution made in part a.

$P_{soln} = X_{solvent} P_{solvent}^{\circ} = (1.00 - 0.091)(89 \text{ mm Hg}) = \boxed{81 \text{ mm Hg}}$

- c. Calculate the change in vapor pressure for the methanol solution in part a compared to pure methanol.

$\Delta P = P_{solvent} - P_{soln} = 89 - 81 = \boxed{8 \text{ mm Hg}}$

6. Benzene, C_6H_6 , and toluene, $C_6H_5CH_3$, form an ideal solution. At 35.0°C, the vapor pressure of benzene is 160.torr, while that of toluene is 50.0torr. If 3.20 moles of benzene and 4.80 moles of toluene are placed in a closed container at 35.0°C and allowed to come to equilibrium

- a. what is the mole fraction of benzene in the liquid state?

$X_b = \frac{n_b}{n_b + n_t} = \frac{3.20}{(3.20 + 4.80)} = \boxed{0.40}$

- b. what is the mole fraction of benzene in the vapor phase?

$P_T = X_b P_b^{\circ} + X_t P_t^{\circ} = 0.40(160) + (0.60)(50) = 64 + 30 = 94 \text{ torr}$
 $X_b = \frac{P_b}{P_T} = \frac{64}{94} = \boxed{0.68}$

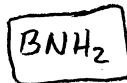
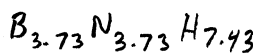
3.2964g

7. A compound is found to contain 40.3% B, 52.2%N and 7.5%H. A ~~3.2964g~~ sample of this compound is dissolved in 50.00g of benzene producing a solution with a freezing point of 1.3°C. K_f for benzene is 5.12°C/molal and it has a pure freezing point of 5.48°C

a. Determine the empirical formula of the compound from the percent composition.

$$B = 40.3g / 10.8g/mol = 3.73 \quad H = 7.5g / 1.008g/mol = 7.43$$

$$N = 52.2g / 14.0g/mol = 3.73$$



Empirical mass = 26.8

b. What is the molality of the benzene solution?

$$m = \frac{\Delta T}{K_f} = \frac{5.48 - 1.3}{5.12} = 0.82m$$

c. Determine the experimental molecular weight and molecular formula of the compound.

$$\frac{3.2964g \text{ Sample}}{0.05000kg \text{ Solvent}} = 65.928g/kg$$

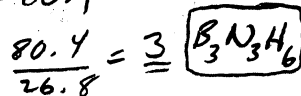
$$\text{Molar mass} = \frac{\text{mass ratio}}{\text{molality}} = \frac{g \text{ solute}/kg \text{ solvent}}{mol \text{ solute}/kg \text{ solvent}}$$

$$= 65.928 / 0.82m = 80.4$$

8. Determine the approximate van't Hoff factor, i , for a 0.001molar $Al(NO_3)_3$ solution.

Should be approximately 4 production of 4 ions

0.001M \approx 100% dissociation



9. For which of the following aqueous solutions would one expect to have the largest van't Hoff, i , factor?

- a. 0.100m $C_6H_{12}O_6$ (glucose)
- b. 0.100m NaCl
- c. 0.010m NaCl
- d. 0.100m K_2SO_4
- e. 0.010m K_2SO_4

Each K_2SO_4 dissociation produces 3 ions. The fact that it is low concentration implies \sim 100% dissociation

10. Calculate the molar mass of a small protein if a 0.20gram sample dissolved in 100.mL of water has an osmotic pressure of 9.8mmHg at 25.0°C.

$$\pi V = nRT \quad \pi V = \frac{mRT}{M} \quad R = .0821 \text{ Latm/mol K}$$

$$M = \frac{mRT}{\pi V} = \frac{(0.20g)(.0821)(298.15K)}{(9.8/760)(.100L)} \quad M = 3796.6 \text{ g/mol}$$

$$= [3.8 \times 10^3 \text{ g/mol}]$$

11. Both freezing point depression and osmotic pressure can be used to calculate the molar mass of a substance. Briefly describe which method would be better for determining the value of high vs. low molar mass substances.

Osmotic pressure can be measured for very dilute solutions whereas BP elevation & FP depression can only be measured for relatively concentrated solutions. The consequence is that osmotic pressure is better for large molar mass molecules.