

**AP Chemistry Problem Set Chapter 11**

Name \_\_\_\_\_

**Multiple Choice.** Please indicate your multiple choice answers below.

1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_ 4. \_\_\_\_\_ 5. \_\_\_\_\_

6. \_\_\_\_\_ 7. \_\_\_\_\_ 8. \_\_\_\_\_ 9. \_\_\_\_\_ 10. \_\_\_\_\_

- The molality of the glucose in a 1.0-molar glucose solution can be obtained by using which of the following?  
(A) Volume of the solution (B) Temperature of the solution (C) Solubility of glucose in water  
(D) Degree of dissociation of glucose (E) Density of the solution
- At 20.°C, the vapor pressure of toluene is 22 millimeters of mercury and that of benzene is 75 millimeters of mercury. An ideal solution, equimolar in toluene and benzene, is prepared. At 20.°C, what is the mole fraction of benzene in the vapor in equilibrium with this solution?  
(A) 0.23 (B) 0.29 (C) 0.50 (D) 0.77 (E) 0.83
- What is the mole fraction of ethanol, C<sub>2</sub>H<sub>5</sub>OH, in an aqueous solution in which the ethanol concentration is 4.6 molal?  
(A) 0.0046 (B) 0.076 (C) 0.083 (D) 0.20 (E) 0.72
- Which of the following aqueous solutions has the highest boiling point?  
(A) 0.10 M potassium sulfate, K<sub>2</sub>SO<sub>4</sub> (B) 0.10 M hydrochloric acid, HCl  
(C) 0.10 M ammonium nitrate, NH<sub>4</sub>NO<sub>3</sub> (D) 0.10 M magnesium sulfate, MgSO<sub>4</sub>  
(E) 0.20 M sucrose, C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>
- The weight of H<sub>2</sub>SO<sub>4</sub> (molecular weight 98.1) in 50.0 milliliters of a 6.00-molar solution is  
(A) 3.10 grams (B) 12.0 grams (C) 29.4 grams (D) 294 grams (E) 300. grams
- Which of the following does NOT behave as an electrolyte when it is dissolved in water?  
(A) CH<sub>3</sub>OH (B) K<sub>2</sub>CO<sub>3</sub> (C) NH<sub>4</sub>Br (D) HI (E) Sodium acetate, CH<sub>3</sub>COONa
- A solution of toluene (molecular weight 92.1) in benzene (molecular weight 78.1) is prepared. The mole fraction of toluene in the solution is 0.100. What is the molality of the solution?  
(A) 0.100 *m* (B) 0.703 *m* (C) 0.921 *m* (D) 1.28 *m* (E) 1.42 *m*
- Which of the following solutions has the lowest freezing point?  
(A) 0.20 *m* C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, glucose (B) 0.20 *m* NH<sub>4</sub>Br (C) 0.20 *m* ZnSO<sub>4</sub>  
(D) 0.20 *m* KMnO<sub>4</sub> (E) 0.20 *m* MgCl<sub>2</sub>
- Which of the following pairs of liquids forms the solution that is most ideal (most closely follows Raoult's law)?  
(A) C<sub>8</sub>H<sub>18</sub>(l) and H<sub>2</sub>O(l) (B) CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>OH(l) and H<sub>2</sub>O(l) (C) H<sub>2</sub>SO<sub>4</sub>(l) and H<sub>2</sub>O(l)  
(D) CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>OH(l) and C<sub>8</sub>H<sub>18</sub>(l) (E) C<sub>6</sub>H<sub>14</sub>(l) and C<sub>8</sub>H<sub>18</sub>(l)
- Ethyl alcohol, C<sub>2</sub>H<sub>5</sub>OH, and water become noticeably warmer when mixed. This is due to:  
(A) the decrease in volume when they are mixed  
(B) smaller attractive forces in the mixture than in the pure liquids  
(C) the hydrogen bonding of the two liquids  
(D) the change in vapor pressure observed  
(E) stronger attractive forces in the mixture than in the pure liquid

**Essays:**

1.(a) A bottle of wine contains 12.5% ethanol by volume. The density of ethanol ( $C_2H_5OH$ ) is  $0.789\text{ g/cm}^3$ . Calculate the concentration of ethanol in wine in terms of molality, and mass percent.

(b) An aqueous antifreeze solution is 40.0% ethylene glycol ( $C_2H_6O_2$ ) by mass. The density of the solution is  $1.05\text{ g/cm}^3$ . Calculate the molality, molarity and mole fraction of the ethylene glycol.

2. (a) A solution is prepared by mixing  $0.0300\text{ mol } CH_2Cl_2$  and  $0.0500\text{ mol } CH_2Br_2$  at  $25^\circ C$ . Assuming the system is ideal, calculate the composition of the vapor (in terms of mole fractions) at  $25^\circ C$ . At  $25^\circ C$ , the vapor pressures of pure  $CH_2Cl_2$  and  $CH_2Br_2$  are 133 and 11.4 torr, respectively.

(b) Benzene and toluene form an ideal solution. Consider a solution of benzene and toluene prepared at  $25^\circ C$ . Assuming the mole fractions of benzene and toluene in the vapor phase are equal, calculate the composition of the solution. At  $25^\circ C$  the vapor pressures of benzene and toluene are 95 and 28 torr, respectively.

3. (a) Anthraquinone contains only carbon, hydrogen and oxygen and has an empirical formula of  $C_7H_4O$ . The freezing point of camphor is lowered by  $22.3^\circ C$  when 1.32 g anthraquinone is dissolved in 11.4 g camphor. Determine the molecular formula of anthraquinone.

(b) An aqueous solution of 10.00 g of catalase, an enzyme found in the liver, has a volume of 1.00 L at  $27^\circ C$ . The solution's osmotic pressure at  $27^\circ C$  is found to be 0.745 torr. Calculate the molar mass of the catalase.

4. Calculate the freezing point and boiling point of each of the following solutions using the observed van't Hoff factors from table 11.6 in your text book (and in your chapter outline).

(a)  $0.050\text{ m } MgCl_2$

(b)  $0.050\text{ m } FeCl_3$

(c)  $0.050\text{ m } NaCl$

5. Explain the following on the behavior of atoms and/or ions.

(a) Cooking with water is faster in a pressure cooker than in an open pan.

(b) Salt is used on icy roads.

(c) Melted sea ice from the Arctic Ocean produces fresh water.

(d)  $CO_2(s)$  (dry ice) does not have a normal boiling point under normal atmospheric conditions, even though  $CO_2$  is a liquid in fire extinguishers.

(e) Adding a solute to a solvent extends the liquid phase over a larger temperature range.

AP Chemistry Problem Set Chapter 11

Name \_\_\_\_\_

**Multiple Choice.** Please indicate your multiple choice answers below.

1. **E-54%**    2. **D-39%**    3. **B-24%**    4. **A-27%**    5. **C-84%**

6. **A-46%**    7. **E-16%**    8. **E-31%**    9. **E-33%**    10. **E-75%**

- The molality of the glucose in a 1.0-molar glucose solution can be obtained by using which of the following?  
 (A) Volume of the solution    (B) Temperature of the solution    (C) Solubility of glucose in water  
 (D) Degree of dissociation of glucose    (E) **Density of the solution**
- At 20.°C, the vapor pressure of toluene is 22 millimeters of mercury and that of benzene is 75 millimeters of mercury. An ideal solution, equimolar in toluene and benzene, is prepared. At 20.°C, what is the mole fraction of benzene in the vapor in equilibrium with this solution?  
 (A) 0.23    (B) 0.29    (C) 0.50    (D) **0.77**    (E) 0.83
- What is the mole fraction of ethanol, C<sub>2</sub>H<sub>5</sub>OH, in an aqueous solution in which the ethanol concentration is 4.6 molal?  
 (A) 0.0046    (B) **0.076**    (C) 0.083    (D) 0.20    (E) 0.72
- Which of the following aqueous solutions has the highest boiling point?  
 (A) **0.10 M potassium sulfate, K<sub>2</sub>SO<sub>4</sub>**    (B) 0.10 M hydrochloric acid, HCl  
 (C) 0.10 M ammonium nitrate, NH<sub>4</sub>NO<sub>3</sub>    (D) 0.10 M magnesium sulfate, MgSO<sub>4</sub>  
 (E) 0.20 M sucrose, C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>
- The weight of H<sub>2</sub>SO<sub>4</sub> (molecular weight 98.1) in 50.0 milliliters of a 6.00-molar solution is  
 (A) 3.10 grams    (B) 12.0 grams    (C) **29.4 grams**    (D) 294 grams    (E) 300. grams
- Which of the following does NOT behave as an electrolyte when it is dissolved in water?  
 (A) **CH<sub>3</sub>OH**    (B) K<sub>2</sub>CO<sub>3</sub>    (C) NH<sub>4</sub>Br    (D) HI    (E) Sodium acetate, CH<sub>3</sub>COONa
- A solution of toluene (molecular weight 92.1) in benzene (molecular weight 78.1) is prepared. The mole fraction of toluene in the solution is 0.100. What is the molality of the solution?  
 (A) 0.100 *m*    (B) 0.703 *m*    (C) 0.921 *m*    (D) 1.28 *m*    (E) **1.42 *m***
- Which of the following solutions has the lowest freezing point?  
 (A) 0.20 *m* C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, glucose    (B) 0.20 *m* NH<sub>4</sub>Br    (C) 0.20 *m* ZnSO<sub>4</sub>  
 (D) 0.20 *m* KMnO<sub>4</sub>    (E) **0.20 *m* MgCl<sub>2</sub>**
- Which of the following pairs of liquids forms the solution that is most ideal (most closely follows Raoult's law)?  
 (A) C<sub>8</sub>H<sub>18</sub>(l) and H<sub>2</sub>O(l)    (B) CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>OH(l) and H<sub>2</sub>O(l)    (C) H<sub>2</sub>SO<sub>4</sub>(l) and H<sub>2</sub>O(l)  
 (D) CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>OH(l) and C<sub>8</sub>H<sub>18</sub>(l)    (E) **C<sub>6</sub>H<sub>14</sub>(l) and C<sub>8</sub>H<sub>18</sub>(l)**
- Ethyl alcohol, C<sub>2</sub>H<sub>5</sub>OH, and water become noticeably warmer when mixed. This is due to:  
 (A) the decrease in volume when they are mixed  
 (B) smaller attractive forces in the mixture than in the pure liquids  
 (C) the hydrogen bonding of the two liquids  
 (D) the change in vapor pressure observed  
 (E) **stronger attractive forces in the mixture than in the pure liquid**

**Essays:**

1.(a) A bottle of wine contains 12.5% ethanol by volume. The density of ethanol ( $C_2H_5OH$ ) is  $0.789\text{ g/cm}^3$ . Calculate the concentration of ethanol in wine in terms of molality, and mass percent.

**Mass Percent: 10.1%, Molality: 2.45 mol/kg**

(b) An aqueous antifreeze solution is 40.0% ethylene glycol ( $C_2H_6O_2$ ) by mass. The density of the solution is  $1.05\text{ g/cm}^3$ . Calculate the molality, molarity and mole fraction of the ethylene glycol.

**Molality: 10.7 mol/kg, Molarity: 6.77 mol/L, Mole Fraction: 0.162**

2. (a) A solution is prepared by mixing 0.0300 mol  $CH_2Cl_2$  and 0.0500 mol  $CH_2Br_2$  at  $25^\circ C$ . Assuming the system is ideal, calculate the composition of the vapor (in terms of mole fractions) at  $25^\circ C$ . At  $25^\circ C$ , the vapor pressures of pure  $CH_2Cl_2$  and  $CH_2Br_2$  are 133 and 11.4 torr, respectively.

**$X_{CH_2Cl_2}$ : 0.875,  $X_{CH_2Br_2}$ : 0.125**

(b) Benzene and toluene form an ideal solution. Consider a solution of benzene and toluene prepared at  $25^\circ C$ . Assuming the mole fractions of benzene and toluene in the vapor phase are equal, calculate the composition of the solution. At  $25^\circ C$  the vapor pressures of benzene and toluene are 95 and 28 torr, respectively.

**$X_{tol}$ : 0.77,  $X_{ben}$ : 0.23**

3. (a) Anthraquinone contains only carbon, hydrogen and oxygen and has an empirical formula of  $C_7H_4O$ . The freezing point of camphor is lowered by  $22.3^\circ C$  when 1.32 g anthraquinone is dissolved in 11.4 g camphor. Determine the molecular formula of anthraquinone.

**$C_{14}H_8O_2$**

(b) An aqueous solution of 10.00 g of catalase, an enzyme found in the liver, has a volume of 1.00 L at  $27^\circ C$ . The solution's osmotic pressure at  $27^\circ C$  is found to be 0.745 torr. Calculate the molar mass of the catalase.

**$2.51 \times 10^5\text{ g/mol}$**

4. Calculate the freezing point and boiling point of each of the following solutions using the observed van't Hoff factors from table 11.6 in your text book (and in your chapter outline).

(a) 0.050 m  $MgCl_2$  – **Boiling Pt.:  $100.069^\circ C$ , Freezing Pt:  $-0.25^\circ C$**

(b) 0.050 m  $FeCl_3$  – **Boiling Pt.:  $100.087^\circ C$ , Freezing Pt:  $-0.32^\circ C$**

(c) 0.020 m  $NaCl$  – **Boiling Pt.:  $100.002^\circ C$ , Freezing Pt:  $-0.071^\circ C$**

5. Explain the following on the behavior of atoms and/or ions.

(a) Cooking with water is faster in a pressure cooker than in an open pan. **Water boils when its vapor pressure equals the atmospheric pressure. In a pressure cooker the atmospheric pressure is higher, so water's boiling point is higher. At higher temperatures, food cooks faster.**

(b) Salt is used on icy roads. **Salt dissolves in water forming a solution with a melting point lower than that of pure water.**

(c) Melted sea ice from the Arctic Ocean produces fresh water. **When water freezes from a solution, it freezes as pure water, leaving behind a more concentrated salt solution. Therefore, the melt of frozen sea ice is pure water.**

(d)  $CO_2(s)$  (dry ice) does not have a normal boiling point under normal atmospheric conditions, even though  $CO_2$  is a liquid in fire extinguishers. **The triple point of carbon dioxide is above 1 atm and room temperature. At room temperature dry ice sublimates instead of boils. In a fire extinguisher, pressure is  $> 1\text{ atm}$  and liquid  $CO_2$  can exist.**

(e) Adding a solute to a solvent extends the liquid phase over a larger temperature range. **Adding a solute to a solvent increases the boiling point and lowers the freezing point of the solvent.**