Name: _____ *Date:* _____

Colligative Properties

Homework Unit 10 - Topic 5 (IB)

Colligative Properties are properties of solution that ***depend only on how much solute*** *i*s dissolved **NOT** on what type of solute is dissolved.

Some of these properties are:

- FREEZING POINT DEPRESSION
- BOILING POINT ELEVATION

When NaCl, an ionic compound, is dissolved in water it forms two particles, a Na^+ cation and a Cl^- anion, each surrounded by water.

$$NaCl_{(s)} + H_2O \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$$

When sugar, a *polar molecule*, is dissolved in water it remains as only one particle, a molecule surrounded by water.

$$C_6H_{12}O_{6(s)} + H_2O \rightarrow C_6H_{12}O_{6(aq)}$$

1. Draw a diagram for each of these compounds dissolved in water.

   Na^+ Cl^- $C_6H_{12}O_6$

   (a) When $CaCl_2$ is dissolved in water, how many particles are formed? _____

   (b) When $AlBr_3$ is dissolved in water, how many particles are formed? _____

   (c) When $Na_2(SO_4)$ is dissolved in water, how many particles are formed? _____

   (d) When CO_2 is dissolved in water, how many particles are formed? _____

2. On an equal mole basis, which of the above (a – d) is most effective in lowering the freezing point or raising the boiling point of water? Explain. _____
   _____
   _____

3. Which of the following solutions will lower the freezing point the most? Explain why in the space provided.
   (1) 3.0 M NaCl
   (2) 3.0 M $CaCl_2$
   (3) 1.0 M NaCl
   (4) 1.0 M $CaCl_2$
   (5) pure water

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Solve the following boiling point elevation problems and the freezing point depression problems as shown in the sample problems below. (NOTE: At standard pressure, 1 mol of dissolved particles will elevate the boiling point of 1000 g of water by 0.52˚C and will depress the freezing point of 1000 g of water by 1.86˚C.)

Sample Problem

Find the boiling point of a solution containing 1,000 g of water and 2 mol of dissolved MgF_2.

Step 1: Determine the number of moles of solute particles

$2MgF_2(s) \rightarrow 2Mg^{2+}(aq) + 4F^-(aq)$ *mol* =6

Step 2: Multiply the boiling point elevation per mole by the number of moles of solute to find the boiling point elevation

$BPE = 0.52^{\circ C}/mol \times$ 6 mol = 3.12

Step 3: Add the boiling point elevation to 100°C

BP = 100°C + 3.12°C = 10 3.12°C

Sample Problem

Find the freezing point of a solution containing 1,000 g of water and 30 g of dissolved antifreeze ($C_2H_4O_2$).

Step 1: Determine the number of moles of solute particles

C = 12 × 2 = 24
H = 1 × 4 = 4
O = 16 × 2 = 32
60

$mol = \frac{g}{GFM} = \frac{30g}{60 g/mol} = 0.5mol$

Step 2: Multiply the freezing point depression per mole by the number of moles of solute to find the freezing point depression

$FPD = 1.86^{\circ C}/mol \times 0.5\ mol = 0.93°C$

Step 3: Subtract the freezing point depression from 0°C

FP = 0°C – 0.93°C = – 0.93°C

4. One mole of dissolved particles elevates the boiling point of 1000 g of water by 0.52˚C. At standard pressure, what will the boiling point of a solution be if it contains 1000 g of water and:

   (a) _____ 1 mol of antifreeze ($C_2H_4O_2$)

   (b) _____ 2 mol of $CaCl_{2(aq)}$

   (c) _____ 1 mol of $KNO_{3(aq)}$

   (d) _____ 40 g of $NaOH_{(aq)}$

   (e) _____ 1 mol ethanol (C_2H_5OH)

5. One mole of dissolved particles depresses the freezing point of 1000 g of water by 1.86˚C. At standard pressure, what will the freezing point of a solution be if it contains 1000 g of water and:

   (a) _____ 1 mol of glucose ($C_6H_{12}O_6$)

   (b) _____ 1 mol of $BaCl_{2(aq)}$

   (c) _____ 2 mol of salt (NaCl)

   (d) _____ 180 gram of $KHCO_{3(aq)}$

   (e) _____ 2 mol of $CuSO_{4(aq)}$