

Name: _____

Date: _____

Colligative Properties

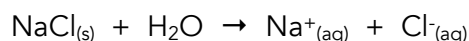
Homework Unit 10 - Topic 5 (IB)

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

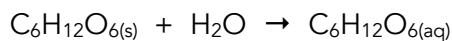
Some of these properties are:

- 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.



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



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

Na⁺

Cl⁻

C₆H₁₂O₆

- (a) When CaCl₂ is dissolved in water, how many particles are formed? _____
- (b) When AlBr₃ is dissolved in water, how many particles are formed? _____
- (c) When Na₂(SO₄) is dissolved in water, how many particles are formed? _____
- (d) When CO₂ 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 CaCl₂
 - (3) 1.0 M NaCl
 - (4) 1.0 M CaCl₂
 - (5) pure water

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
 $2\text{MgF}_2(s) \rightarrow 2\text{Mg}^{2+}(aq) + 4\text{F}^{-}(aq) \quad \text{mol} = 6$

Step 2: Multiply the boiling point elevation per mole by the number of moles of solute to find the boiling point elevation
 $\text{BPE} = 0.52^{\circ}\text{C}/\text{mol} \times 6 \text{ mol} = 3.12$

Step 3: Add the boiling point elevation to 100°C
 $\text{BP} = 100^{\circ}\text{C} + 3.12^{\circ}\text{C} = 103.12^{\circ}\text{C}$

Sample Problem

Find the freezing point of a solution containing 1,000 g of water and 30 g of dissolved antifreeze ($\text{C}_2\text{H}_4\text{O}_2$).

Step 1: Determine the number of moles of solute particles
 $\text{C} = 12 \times 2 = 24$
 $\text{H} = 1 \times 4 = 4$
 $\text{O} = 16 \times 2 = \frac{32}{60}$
 $\text{mol} = \frac{\text{g}}{\text{GFM}} = \frac{30\text{g}}{60\text{g}/\text{mol}} = 0.5\text{mol}$

Step 2: Multiply the freezing point depression per mole by the number of moles of solute to find the freezing point depression
 $\text{FPD} = 1.86^{\circ}\text{C}/\text{mol} \times 0.5 \text{ mol} = 0.93^{\circ}\text{C}$

Step 3: Subtract the freezing point depression from 0°C
 $\text{FP} = 0^{\circ}\text{C} - 0.93^{\circ}\text{C} = -0.93^{\circ}\text{C}$

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:
- _____ 1 mol of antifreeze ($\text{C}_2\text{H}_4\text{O}_2$)
 - _____ 2 mol of $\text{CaCl}_{2(aq)}$
 - _____ 1 mol of $\text{KNO}_{3(aq)}$
 - _____ 40 g of $\text{NaOH}_{(aq)}$
 - _____ 1 mol ethanol ($\text{C}_2\text{H}_5\text{OH}$)
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:
- _____ 1 mol of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)
 - _____ 1 mol of $\text{BaCl}_{2(aq)}$
 - _____ 2 mol of salt (NaCl)
 - _____ 180 gram of $\text{KHCO}_{3(aq)}$
 - _____ 2 mol of $\text{CuSO}_{4(aq)}$