# Colligative Properties

## Molality

**Molality (m)**: the number of moles of solute per kilogram of solvent

Units: m  *ex: 3.0 m is "3 molal"*

$$\text{molality (m)} = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

**Molality Example:**

*What is the molality of a solution of 47.3 grams of potassium iodide dissolved in 500.0 g of water?*

## Colligative Properties

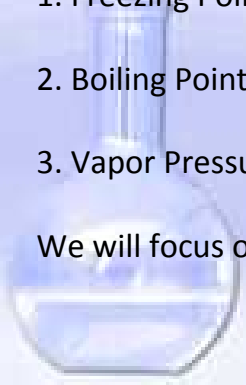
***Colligative Property:*** a property that depends only on the **number** of solute particles, and not the type of particle.

Examples of some colligative properties:
1. Freezing Point Depression

2. Boiling Point Elevation

3. Vapor Pressure Lowering

We will focus on freezing point and boiling point.



## Freezing Point Depression

*What happens when something freezes (for example, water)?*

- Decrease in energy slows molecules/atoms down
- Intermolecular forces have more effect (atoms have less energy to fight them)
- Frozen water (ice) molecules are in an orderly pattern.

*What happens when you add a solute?* Adding Solute

The addition of another substance (a solute) disrupts and prevents water molecules from forming the pattern.

## Freezing Point Depression

***Freezing Point Depression:*** adding a substance to a pure solvent *lowers* the freezing point

To calculate the change in freezing point:

Dissociation factor: How many particles the solute will break into in solution.

$$\Delta T_f = m \cdot d.f. \cdot k_f$$

Change in freezing temp.

molality of solution

constant

**Dissociation Factor**

*Covalent compounds:* will not dissociate → *d.f. = 1*

*Ionic compounds:* will dissociate into ions → *d.f. = # of ions per molecule*

## Dissociation Factor Practice

What is the dissociation factor for each compound?

1. $AlPO_4$ 2
2. $N_2O_4$ 1
3. $LiCl$ 2
4. $CaI_2$ 3
5. $PCl_5$ 1
6. $Pb(OH)_4$ 5
7. $XeF_4$ 1
8. $Cu_2CO_3$ 3

## Freezing Point Depression Example

What is the freezing point of a 2.0 m solution of NaCl in water?

$k_f$ = 1.86 $^oC/m$ for water

## Boiling Point Elevation

*Pure solvent*

*Solution containing nonvolatile solute*

Solute particles also get in the way of a solvent's ability to boil thereby increasing the boiling temperature.

## Boiling Point Elevation

***Boiling Point Elevation:*** adding a substance to a pure solvent increases the boiling point

To calculate the change in boiling point:

$$\Delta T_b = m \bullet k_b \bullet d.f.$$

## Boiling Point Elevation Example

What is the boiling point of a solution containing 100.0 g $MgCl_2$ dissolved in 250.0 g of water?

$k_b$ = 0.52 $^oC/m$ for water

## Summary

Freezing point depression

**$\Delta T_f = m*k_f*d.f.$** $k_f$ = 1.86 $^oC/m$ for water

Boiling point elevation

**$\Delta T_b = m*k_b*d.f.$** $k_b$ = 0.52 $^oC/m$ for water