TYPES OF SOLUTIONS

- A ***solution*** is a ***homogeneous*** mixture of two substances: a ***solute*** and a ***solvent***.
- ***Solute***: substance being dissolved; present in ***lesser*** amount.
- ***Solvent***: substance doing the dissolving; present in ***larger*** amount.
- ***Solutes*** and ***solvents*** may be of any form of matter: ***solid, liquid or gas***.

Some Examples of Solutions

Type	Example	Solute	Solvent
Gas in gas	Air	Oxygen (gas)	Nitrogen (gas)
Gas in liquid	Soda water	CO_2 (gas)	Water (liquid)
Liquid in liquid	Vinegar	Acetic acid (liquid)	Water (liquid)
Solid in liquid	Seawater	Salt (solid)	Water (liquid)
Liquid in solid	Dental amalgam	Mercury (liquid)	Silver (solid)
Solid in solid	Brass	Zinc (solid)	Copper (solid)

- Solutions form between solute and solvent molecules because of similarities between them. (***Like dissolves Like***)
- ***Ionic*** solids dissolve in ***water*** because the ***charged ions (polar)*** are attracted to the ***polar*** water molecules.
- ***Non-polar*** molecules such as oil and grease dissolve in ***non-polar solvents*** such as kerosene.

CONCENTRATION UNITS

- The concentration of a solution is the amount of solute dissolved in a given amount of solvent.

$$\text{Concentration} = \frac{\text{amount of solute}}{\text{amount of solution}}$$

- Several quantitative expressions of concentration are used in chemistry.

MASS PERCENT

- **Mass percent** (or weight percent) of a solution is the **mass of solute** divided by the **mass of solution**.

$$\text{mass \%} = \frac{\text{mass of solute}}{\text{mass of solution}} \text{x100}$$

$$\text{mass of solution} = \text{mass of solute} + \text{mass of solvent}$$

Example 1:
What is the mass % of a NaOH solution that is made by dissolving 8.00 g of NaOH in 50.0 g of water?

Example 2:
How many grams of solute is present in 125 g of a 3.00% salt solution?

CONCENTRATION UNITS

MOLARITY

- Molarity is defined as the moles of solute divided by liters of solution.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{Liter of solution}}$$

Example 1:
What is the molarity of a solution made by dissolving 20.0 g of KCl in water to make 150. mL of solution?

Example 2:
How many grams of KOH are in 600. mL of 0.450 M KOH solution?

CONCENTRATION UNITS

MOLALITY

- Molality is defined as the moles of solute divided by kilograms of solvent.

$$\text{Molality} = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

Example 1:
What is the molality of a solution made by dissolving 2.70 g of CH_3OH in 25.0 g of water?

Example 2:
What is the molality of a solution made by dissolving 100. g of $C_2H_6O_2$ in 200. g of water?

COLLIGATIVE PROPERTIES

- Physical properties of solutions that depend on the ***concentration***, but not the ***type*** of solute particles are called ***colligative*** properties.

- Examples of such properties are:

  Lowering of freezing point
  Elevation of boiling point
  Lowering of osmotic pressure

Freezing Point Depression

- Addition of a nonvolatile solute to a solvent lowers its freezing point.

- This freezing point depression is proportional to the amount of solute in a solution.

$$\Delta T_f = m\,K_f$$

ΔT_f = freezing point depression
K_f = freezing point depression constant
m = molality of solution

Example 1:
A solution of antifreeze contains 135 g of ethylene glycol ($C_2H_6O_2$) per 500. g of water. What is the freezing point of this solution? (K_f=1.86 ºC/m)

Example 2:
A solution is prepared by dissolving 215 g of methanol (CH_3OH) in 800. g of water. What is the freezing point of this solution? (K_f=1.86 ºC/m)

COLLIGATIVE PROPERTIES

Boiling Point Elevation

- Addition of a nonvolatile solute to a solvent increases its boiling point.
- This boiling point elevation is proportional to the amount of solute in a solution.

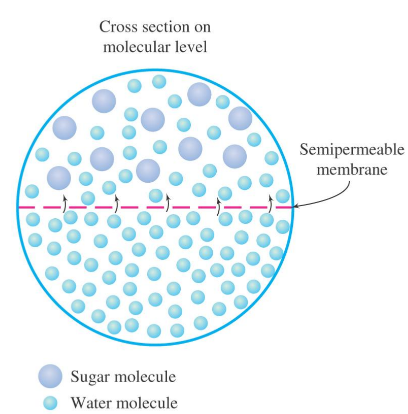
$$\Delta T_b = m\, K_b$$

ΔT_b = boiling point elevation
K_b = boiling point elevation constant
m = molality of solution

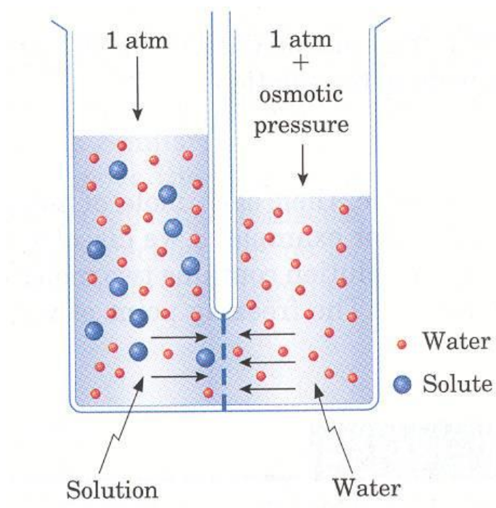
Example 1:
What is the boiling point of the antifreeze solution in the previous problem?
K_2 = 0.512 °C/m

OSMOSIS

- The **movement of water into and out** of the cells of plants as well as our bodies is an important biological process. This process is called **osmosis**.
- During **osmosis**, the solvent (water) moves through a **semipermeable membrane** (cell walls) from a solution that has a **lower concentration** of solute, to a solution that has a **higher concentration** of solute.
- This movement happens in a direction that **attempts to equalize** the concentrations of both sides.



OSMOTIC PRESSURE



- As a result of this movement, the level of the solution rises until it is balanced by the force of gravity. The pressure that prevents the flow of solution backwards is called **osmotic pressure**.

- The **osmotic pressure** depends on the number of **solute particles** in the solution.

- Osmotic pressure is a colligative property.

- Pure water has no osmotic pressure. The **greater that number of solute particles** in a solution, the **higher its osmotic pressure**.

- In the body, solutions that have the **same osmolarity** as cells and therefore **cause no osmotic pressure** are called **isotonic** solutions.

- Solutions with **osmolarity and osmotic pressure lower** than the cells are called **hypotonic** solutions.

- Solution with **osmolarity and osmotic pressure greater** than cells are called **hypertonic** solutions.

Example:
Determine the tonicity of each of the following solutions. Cells have an ion concentration of 0.30 M.

0.15 M NaCl

0.15 M $MgCl_2$

0.20 M glucose

COLLIGATIVE PROPERITES OF IONIC SOLUTIONS

- When evaluating colligative properties of ionic solutions, the total concentration of the ions must be considered.
- The number of ions produced from each formula unit is designated ***(i)***.

$NaCl \rightarrow Na^{+} + Cl^{-}$ $\quad i = 2$

$MgCl_2 \rightarrow Mg^{2+} + 2\,Cl^{-}$ $\quad i = 3$

- The colligative properties of ionic solutions can be calculated with the following modifications:

$$\Delta T_b = i\ m\ K_b$$

$$\Delta T_f = i\ m\ K_f$$

Examples:

1. Calculate the freezing point of 0.010 m solution of aluminum sulfate, $Al_2(SO_4)_3$. (K_f for water = 1.86 m/°C)

   $Al_2(SO_4)_3 \rightarrow$

   $\Delta T_f =$

   $T_f =$

2. Which of the following solutions will have the lowest freezing point?

   0.15 m NaCl

   0.25 m $C_6H_{12}O_6$

   0.10 m $Fe(NO_3)_3$