Chemistry 6A F2007

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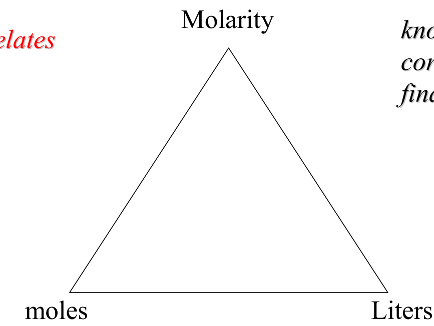
Wednesday

11/14/07

Moles/Liters and Molarity:

Molarity relates mols and volume (L)



knowing 2 corners, you can find the 3rd

If you know moles & L, you know Molarity (M)

if you know Molarity and volume, you know moles!

Molarity × Volume = moles

$$\frac{\text{mols}}{\text{L}} \times \text{L} = \text{moles}$$

if you know mols and molarity, you know volume!

$$\text{moles} \times \frac{1}{\text{M}} = \text{Volume}$$

$$\text{mol} \times \frac{\text{L}}{\text{mol}} = \text{L}$$

Dilution of Solutions:

When more solvent is added to a solution, the number of moles of solute do not change, but the total volume does.

decrease the molarity ↓

$$M = \frac{\text{moles solute}}{\text{L of solution}}$$

↑ *increase V*

What is the concentration of 250.0mL of a solution that is initially 0.450M after 50.0 mL of water is added?

Since the mols of solute do not change upon dilution:

mols initial = mols final = mols solute

$$\text{The new molarity} = \frac{\text{mols solute}}{\text{new volume of solution}}$$

mols solute = original molarity × original volume

What is the concentration of 250.0mL of a solution that is initially 0.450M after 50.0 mL of water is added?

$$\text{The new molarity} = \frac{\text{original molarity} \times \text{original volume}}{\text{new volume of solution}}$$

$$M = \frac{0.450\text{mols/L} \times 250.0\text{mL} \times \frac{L}{10^3\,ml}}{300.0\text{mL} \times \frac{L}{10^3\,ml}} = 0.375\text{ M}$$

Check this out…

$$M = \frac{0.450\text{mols/L} \times 250.0\text{mL} \times \frac{L}{10^3\,ml}}{300.0\text{mL} \times \frac{L}{10^3\,ml}} = 0.375\text{ M}$$

The conversion factors cancel out!

So one can write:

$$\text{new M} = \frac{\text{old M} \times \text{old V}}{\text{new V}}$$

One can further write:

$$\text{new M} = \frac{\text{old M} \times \text{old V}}{\text{new V}} \quad \text{or} \quad M_2 = \frac{M_1 \times V_1}{V_2}$$

Rearranging:

$$M_1 \times V_1 = M_2 \times V_2$$

10.0 mL of a 0.470 M solution is added to a 250.0 mL volumetric flask than diluted to the calibration mark with water. What is the new concentration of the solution?

$$M_1 \times V_1 = M_2 \times V_2$$

$$= \underline{\quad \times \quad}$$

$$M_2(\text{new}) = \frac{0.470\text{M} \times 10.0\text{mL}}{250.0\text{mL}} = 0.0188\ \text{M}$$

Section 7.7: *Solution Properties*

Water on it's own does not conduct electricity well *(the circuit is not completed)*

Solutions with ions do conduct electricity well *(the circuit is completed)*

Species in Solution, *Electrolytes*:

Strong electrolytes: Characterized by ***ions only*** (cations & anions) in solution (water).

Weak electrolytes: Characterized by ***ions*** (cations & anions) & ***molecules*** in solution.

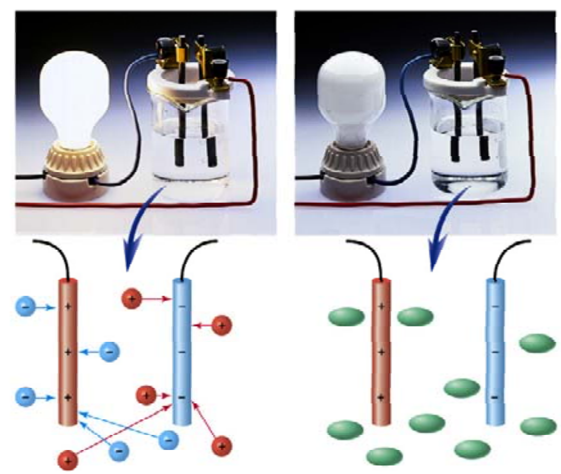
Non-electrolytes: Characterized by ***molecules*** in solution.

Strong electrolytes → Conduct electricity well

Weak electrolytes → Conduct electricity poorly

Non-electrolytes → Do not conduct electricity

Strong electrolytes



(a) (b)

Non-electrolytes

Ions complete the circuit

Molecules cannot

Weak electrolytes conduct poorly.

dim bulb

Weak electrolytes exist mainly as molecules (*which do not conduct*) in solution.

The small concentration of ions allows only a small current to flow.

Strong electrolyte solutions:

Solute (i.e. the substance dissolved) is present as ions.

examples: NaCl(aq), HCl(aq) or NaOH(aq)

Weak electrolyte solutions:

Solute is incompletely ionized.

examples: acetic acid, $HC_2H_3O_2$(aq) or ammonia water, NH_3 (aq)

Non-electrolyte solutions: Solute does not ionize.

example: ethanol, C_2H_5OH (aq); methanol, CH_3OH (aq) or sucrose, $C_{12}H_{22}O_{11}$ (aq)

COLLIGATIVE PROPERTIES OF SOLUTIONS

Colligative solution properties are properties that depend directly on the concentration of solute particles in the solution.

Experiments demonstrate that the ***vapor pressure*** of water (solvent) above a solution is lower than the vapor pressure of pure water at a given temperature.

When a solute is added to a solvent, the ***boiling point*** increase and the ***freezing point*** decreases.

Also, when a pure solvent is separated from a solution by a semi-permeable membrane, solvent molecules flow across the membrane towards the solvent side.

This phenomenon is know as ***osmosis***.

Boiling Point Elevation:

The *boiling point* of a solution is always higher than the boiling point of the pure solvent of the solution.

$$t_b\text{(solution)} > t_b\text{(solvent)}$$

The difference in boiling point between pure solvent and solution depends on the concentration of solute particles, and is calculated using the following equation:

$$\Delta t_b = nK_bM$$

$\Delta t_b = t_b$(solution) – t_b(solvent)

K_b = bp constant *(depends on the substance)*

M = the molarity of the solution

n = total number of particles in solution

n = 1 for molecular compounds n = 2 for NaCl (Na^+ and Cl^-)

Freezing Point Depression: Similarly:

The *Freezing point* of a solution is always lower than the freezing point of the pure solvent of the solution.

$$t_f(\text{solvent}) < t_f(\text{solution})$$

The difference in freezing point between pure solvent and solution depends on the concentration of solute particles, and is calculated using the following equation:

$$\Delta t_f = nK_fM$$

$\Delta t_f = t_f(\text{solution}) - t_f(\text{solvent})$

K_f = fp constant *(depends on the substance)*

M = the molarity of the solution

n = total number of particles in solution

n = 1 for molecular compounds

n = 2 for NaCl (Na^+ and Cl^-)

Calculate the freezing point of a solution made up by adding and completely dissolving 4.52g sodium phosphate to 100.0 mL of water.

$$\Delta t_f = nK_fM$$

$$K_f = -1.86\frac{^\circ C}{M}$$

step 1: Calculate the molarity of the solution

step 2: Recognize that n = 4

$$Na_3PO_4(aq) \rightarrow 3Na^+(aq) + PO_4^{3-}(aq)$$

$$n = 3 + 1 = 4$$

step 3: enter the values into the equaton

Calculate the freezing point of a solution made up by adding and completely dissolving 4.52g sodium phosphate to 100.0 mL of water.

$\Delta t_f = nK_fM$ n = 4 $K_f = -1.86\frac{^\circ C}{M}$

$$\Delta t_f = 4 \times \left(-1.86\frac{^\circ C \cdot \cancel{L}}{\cancel{mol}}\right) \times 4.52\cancel{g}\ Na_3PO_4 \times \frac{1\cancel{mol}Na_3PO_4}{163.94\cancel{g}} \times \frac{1}{100.0\cancel{mL}} \times \frac{10^3\cancel{mL}}{\cancel{1L}}$$

$$\Delta t_f = -2.05\ ^\circ C$$

$$t_f = 0.00\ ^\circ C + \Delta t_f = 0.00\ ^\circ C - 2.05\ ^\circ C = -2.05\ ^\circ C$$

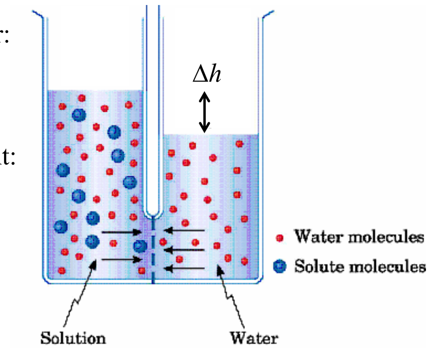
By spreading salt on the roadway, the freezing point of water is lowered, thus preventing ice formation or causing already solid ice to melt!

OSMOTIC PRESSURE OF SOLUTIONS

When solutions having different concentrations of solute are separated by a semi-permeable membrane, the solvent tends to flow across the membrane from a less concentrated solution towards a more concentrated solution in a process called ***osmosis***.

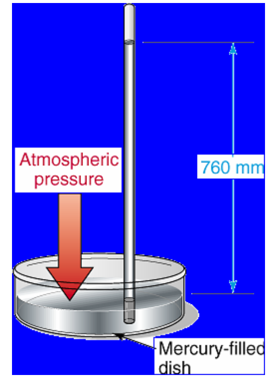
Solution opposite the water: The height of the more concentrated solution to rises!

water on each side, same height:



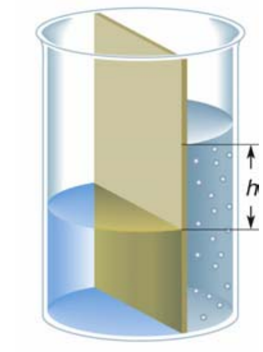
The solvent molecules (water) want to dilute the solution by moving across the membrane.

Recall that pressure is related to the height of a column of liquid:



Analogously, the height increase due to osmosis is like a pressure:

$$\pi = nMRT$$



π = osmotic pressure (torr)

M = mols/L

T = Kelvins

$$R = 64.2\,\frac{L \cdot torr}{mol \cdot K}$$