What happens in solution

When ionic complexes dissolve the cations and anions dissociate. The balanced equation is written as follows:

$$NaCl(s) \xrightarrow{H_2O} Na^{+}(aq) + Cl^{-}(aq)$$

(Often the solvent is written over the reaction arrow)

Notice that we are now indicating the state of the chemical; s = solid, l = liquid, g = gas, aq = aqueous (dissolved in water), and soln = dissolved in some solvent (soln is uncommon).

When covalently bonded compounds dissolve several things can happen.

If the molecule is a weak acid, or a weak base it might ionize. Otherwise, the molecular will simply dissolve.

For a weak acid like acetic acid (CH_3CO_2H) the reaction could be described as follows:

$$2\ C\ H_3CO_2H\ (l) \longrightarrow (2\text{-}x)\ CH_3CO_2H\ (aq) + (x)\ CH_3CO_2^{-}\ (aq) + (x)\ H^{+}(aq)$$

notice that all the acid does not ionize. That is the factor that make acetic acid a weak acid and a weak electrolyte.

in addition to writing the reaction as described above we can write an equation which describes the reaction in solution. The H_3CCO_2H which is dissolved ionizes to form $H_3CCO_2^-$ and H^+, but is that the end of it? Does the reaction just stop all together? No, the forward reaction continues, but the products can combine to form more starting material. This kind of reaction is an equilibrium reaction. The amount of reactants and the amount of products stop reach a certain level and the reaction appears to stop, but the reaction actually continues to occur the rate of the forward reaction is equal to the rate of the reverse reaction so the amount of

$$CH_3CO_2H\ (aq) \rightleftharpoons CH_3CO_2^{-}(aq) + H^{+}(aq)$$

products and reactants does not change. The equilibrium reaction is normally written as follows:

$$HCl\ (g) \xrightarrow{H_2O} H^{+}(aq) + Cl^{-}(aq)$$

A strong acid will ionize completely when dissolved in water.

The extent to which an acid ionizes when added to water is one basis for deciding whether an acid is a strong acid or a weak acid.

$$C_{12}H_{22}O_{11}\ (s) \xrightarrow{H_2O} C_{12}H_{22}O_{11}\ (aq)$$

A molecular solid (sucrose, or common sugar) which dissolves in water is described as follows:

Solutions and Molarity

The amount of material in a solution has to be expressed in terms of concentration. You can see how confusing it would be if solutions were discussed in terms of moles.

A B

If flask A was labeled 1 mole sugar because 1 mole of sugar was placed in it after some of the solution was removed there would be no way of knowing how much sugar was left.

So, it would be better if the jar was labeled 360 g of sugar in 2 L water. Then we would be able to tell how much sugar was left after some of the solution was removed.

Solutions are described in terms of amount of solute dissolved in amount of solution or in terms of amount of solute dissolved in amount of solvent.

For convenience a standard unit has been chosen. The unit is called Molarity. Molarity is abbreviated (M) and it is defined as follows:

$$M = \frac{\text{moles solute}}{\text{liters of solution}} \text{ or } \text{mol/L}$$

Which brings up several types of molarity problems.

First one: Determine the concentration of a solution.

What is the concentration (molarity) of a solution made by dissolving 0.20 mol ammonium nitrate (NH_4NO_3), which is a fertilizer, in enough water to make 500.0 mL of solution.

$$M = \frac{\text{moles solute}}{\text{liters of solvent}} = \frac{0.2 \text{ mol}}{500 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 0.40 \text{ M } NH_4NO_3 \text{ soln}$$

Second kind: Determine the number of moles in a certain volume of a solution of known concentration.

How many moles of albumin are in 3.00×10^2 mL of a 0.015 M soln?

Remember where to start— 3.00×10^2 mL:

$$3.00 \times 10^2 \text{ mL albumin soln} \times$$

Remember to go to L:

$$3.00 \times 10^2 \text{ mL albumin soln} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times$$

You want to go from L to mol so L on bottom and mol on top:

$$3.00 \times 10^2 \text{ mL albumin soln} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{\text{mol}}{\text{L}} = \qquad \text{mol}$$

Do we know something that relates mole to L? Yes. M= 0.015 mol/L

$$3.00 \times 10^2 \text{ mL albumin soln} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.015 \text{ mol}}{1 \text{ L}} = 0.0045 \text{ mol}$$

Third type: making a solution.

How many grams of isopropanol are needed to make 250 mL of a 2.5 M aqueous $CH_3CH(OH)CH_3$ (isopropanol) solution.

You need to now how much isopropanol to mix with the water. So, you need to detemine the number of moles of isopropanol that you need, which will allow you to calculate the number of grams of isopropanol are needed.

Start with 250 mL because that is how much you want to make, and convert to L because that is what molarity uses.

$$250 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times$$

So how many moles?

Use the molarity to go from L to mol.

$$250 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{2.5 \text{ mol}}{1 \text{ L}} \times$$

So, how many grams are needed?

Use molar mass to go from mol to g.

$$250 \text{ mL soln} \times \frac{1 \text{ L soln}}{1000 \text{ mL soln}} \times \frac{2.5 \text{ mol isop}}{1 \text{ L soln}} \times \frac{60.09 \text{ g isopropanol}}{1 \text{ mol isopropanol}} = 37.55 \text{ g}$$

or 38 g isopropanol

Since isopropanol is a liquid you would convert that number to mL and measure 48 mL isopropanol. Does that mean you need to add 202 mL H_2O? **NO**. You must use a 250 mL volumetric flask and dilute to the line. You will be adding more than 202 mL water.

Dilutions

(which are really the 1st kind of problem; that is, determine concentration of a solution)

Almost everyone remembers that M1V1 = M2V2. But it might help to just go through moles.

10 mL of a 0.2 M NaCl solution are diluted to 100 mL. What is the concentration of the final solution?

Using M1V1 = M2V2

$$10 \text{ mL} \times 0.2 \text{ M} = 100 \text{ mL} \times X \text{ M}$$

solving for X

$$X = 0.02 \text{ M}$$

Or use moles....that is, how many moles are in the 100 mL solution? The answer is that those moles came from the 10 mL solution, so...

$$10 \text{ mL soln} \times \frac{0.2 \text{ mol NaCl}}{1000 \text{ mL soln}} = 0.002 \text{ mol NaCl}$$

Those 0.0020 moles NaCl are now dissolved in 100 mL of solution.

$$\frac{0.002 \text{ mol NaCl}}{100 \text{ ml soln}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 0.020 \text{ M aqueous NaCl solution.}$$