Introduction

You might not realize it yet, but you already know half of this material. Since the beginning of the course, we've been writing and balancing chemical equations involving reactions of molecular and ionic species.

Molecular equations

You're used to writing chemical equations that look like this:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$
$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

The first equation deals with molecular species, so it's only logical to write the species as molecules. The second species deals entirely with ionic species. These are written in the above equations using the **formula unit** of each ionic compound - in other words, they're written as if they too are molecules. This type of chemical equation is called a **molecular equation**.

Ionic equations - complete and net

Let's look again at our example equation - the one involving ionic compounds.

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

Now let's think about how we'd do the actual experiment:

Take beakers containing $AgNO_3$ and NaCl solution. Pour both solutions together into the same container.

Illustrations 1 and 2 show cartoon versions of the beakers before they are mixed together. Since both $AgNO_3$ and NaCl are both **soluble ionic compounds** (and strong electrolytes), they exist in solution as **free ions**. [Remember the ionic theory of solutions!] In other words,

The beaker of $AgNO_3$ solution really contains a mixture of Ag^+ and NO_3^- in solution.
The beaker of NaCl solution really contains a mixture of Na^+ and Cl^- in solution.

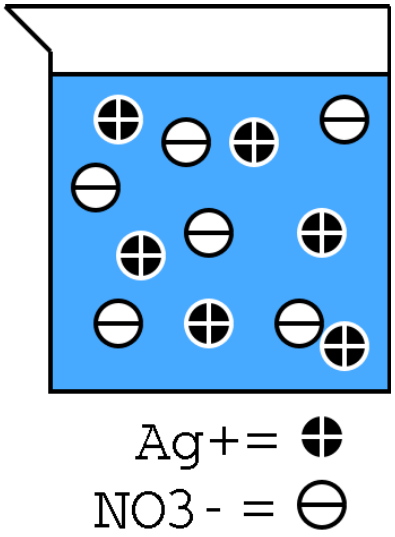

Illustration 1 - $AgNO_3$ solution

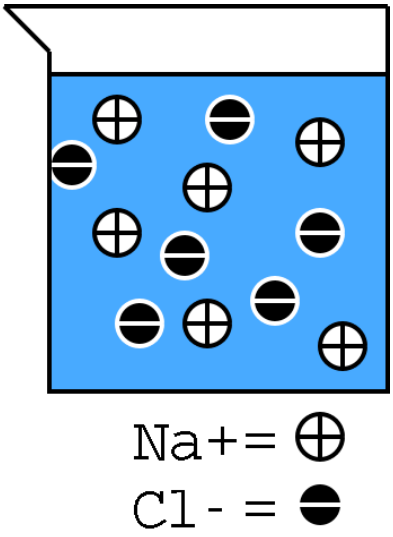

Illustration 2 - NaCl solution

When the contents of the beakers are mixed, you briefly have a beaker containing all four ions in solution. When silver ions hit chloride ions, they stick together and fall out of solution as the insoluble compound silver chloride. The reaction is shown in cartoon form in Illustration 3.

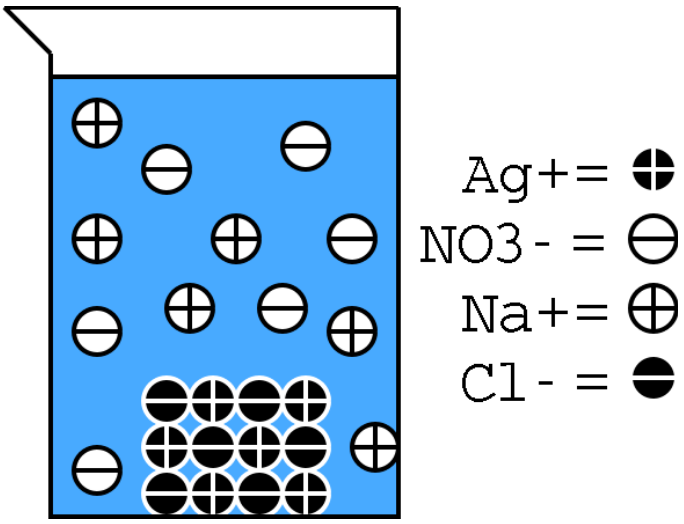

Illustration 3 - $AgNO_3$ and NaCl solutions mixed together

You could write the equation of the chemical reaction this way.

$$Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + Cl^-(aq) \rightarrow AgCl(s) + Na^+(aq) + NO_3^-(aq)$$

This form of the chemical equation is called the **complete ionic equation**.

In complete ionic equations...

1. Weak electrolytes like $HC_2H_3O_2$ are represented by their molecular formulas, since they exist in solution mainly as molecules.
2. Insoluble ionic compounds like AgCl are represented by their formula unit, since they are present in solid form and not as free dissolved ions.
3. Soluble ionic compounds like NaCl are shown as separate ions.

Two species in the complete ionic equation appear on both the left and right hand side of the equation in **exactly the same form**: $Na^+(aq)$ and $NO_3^-(aq)$. In the illustrations, these ions are free in solution both before **and** after the reaction. These species are called **spectator ions** because they don't participate in the reaction at all! They're just along for the ride. We can write the equation again, leaving out the spectator ions.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

This much shorter form is called the **net ionic equation**. The net ionic equation shows the meat of the reaction. Only species that actually change chemically are shown.

Why?

At this point, you may be asking yourself why there are three different ways to write what is presumably the exact same chemical reaction. The answer is convenience. Sometimes, it's more convenient to write an equation in one form as opposed to another. For example,

- You might choose to write an equation in **molecular form** when you're talking about an **exchange reaction**.
- You might write a **complete ionic equation** to show more accurately what is going on in a reaction vessel and how each substance exists in solution.
- You might use a **net ionic equation** to refer to a whole class of reactions with similar chemistry. [$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ applies to any salts which can form silver and chloride ions in solution]

Summary

In this note pack, you have learned how to write molecular, complete ionic, and net ionic equations. We illustrated the process by using a sample chemical reaction - the reaction between silver nitrate solution and sodium chloride solution to form the insoluble salt silver chloride.