Combination Reactions

Skills to Develop

- Describe the various types of combination reactions using chemical equations

Combination reactions describe a reaction like this:

$$A + B \rightarrow C \tag{1}$$

in which two or more reactants become one product (are combined). The problem with this term is that it doesn't give you much chemical insight because there are many different types of reactions that follow this pattern. So we'll break it into groups that reflect what's actually happening a little better.

Combination of Elements to Make Ionic Substances

In this category, an elemental metal and an elemental non-metal react to make an ionic substance that is neutral and has each ion in its correct charge state or valence. For instance,

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s) \tag{2}$$

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s) \tag{3}$$

$$2Al(s) + 3O_2(g) \rightarrow Al_2O_3(s) \tag{4}$$

If the metal is a transition metal, it will be much harder to predict the correct charge on the metal ion in the ionic compound. You can check the element info in the nomenclature section or the links from the periodic table section. As you practice, you'll start to get a sense for what common charges are, but even then it is often good to check, because it might not be what you expect! For example, what's the charge on iron in Fe_3O_4 (magnetite)?

Under what circumstances do these reactions happen? Often, an elemental metal and non-metal "want" to make an ionic compound, because this is a more stable state (think about a heavy ball on a table: it can easily roll to the ground, where it has less potential energy, so the table isn't a stable state; if the heavy ball is in a small hole in the ground, it can't easily move, and if it did, it would have more potential energy, so the hole is a stable, low energy state). However, that doesn't necessarily mean the reaction will just happen on its own. That depends on how easily the reaction can happen (think about a place you want to go, but don't go because traveling there is very inconvenient).

A ball being held above a ledge has more potential energy so it is in a less stable state than if it were at the bottom of the ledge.

For instance, the alkali metals and the halogens react pretty easily, so they will often react even without a "push." Oxygen is very reactive, which is why things burn, but you have to light them on fire to get them started. This is good, because otherwise we would burn in air at room temperature! Many of these elemental combination reactions might need a high temperature to get started, even if they want to happen. It won't be hard to remember that alkalis, alkaline earth metals and halogens react easily, because this is why they are very hard to find in elemental form! Oxygen and nitrogen are very abundant in elemental form because it is hard for them to react even if they want to. Nitrogen in particular reacts only with lithium metal and a few complicated compounds at room temperature, although it will react with many other elements at high temperatures. Most metals aren't found in elemental form in nature (except for ones that don't want to react, like gold), but if you find them in elemental form in your house, then probably they don't react easily.

Combination of Elemental Non-metals into Covalent Compounds

These reactions involve elemental forms of elements like H, C, N, O, Cl, S, P, etc. It will often be hard to predict the product because these elements can often combine in different ratios (this is where the law of multiple proportions comes from!). You can always expect that H will have a valence of 1, and O will usually have a valence of 2. Many of these reactions will happen quickly if you get them started with a little heat, especially if oxygen or a halogen is involved. Otherwise, they might happen very slowly or not at all except under special circumstances that we will talk more about later. Some examples:

$$C(s) + O_2(g) \rightarrow CO_2(g)\ (fast,\ once\ lit) \tag{5}$$

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)\ (usually\ very\ slow) \tag{6}$$

Basic Anhydrides

Basic anhydrides are compounds that turn into a base (a hydroxide salt) when you add water. They are metal oxides. Here's an example:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) \tag{7}$$

If the metal is an alkali or alkaline earth, the reaction probably happens quickly and produces a lot of heat. If the metal is a transition metal, the reaction might not happen so easily or at all.

Acid Anhydrides

Acid anhydrides are compounds that turn into an acid when you add water. They are non-metal oxides. These are a little more complicated than basic anhydrides, so don't worry too much about them right now. Here's an example:

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq) \tag{8}$$

Other Combination Reactions

There are many other circumstances in which a combination reaction could happen. The types listed here are the simple ones that are good to know in the beginning.

Outside Link

- Reacting alkali metals with chlorine (3 min)

Contributors and Attributions

- Emily V Eames (City College of San Francisco)
