**Predicting Reaction Products**

A Helpful Guide

People sometimes have trouble predicting reaction products. Fortunately, if you break these problems into small pieces, they’re not so bad. Let’s have a look!

How to predict reaction products correctly:

**1) Determine what type of reaction is taking place and write the products. Here’s how:**

* **Synthesis: element + element →**
  + The product is typically an ionic compound. If not, it’s something simple like water, CO2, or NH3.
  + A + B → C
* **Decomposition: compound →**
  + Assume this compound is broken into its constituent elements.
  + C → A + B
* **Single displacement: element + ionic compound →**
  + The product is an ionic compound made by the element switching place with the cation of the ionic compound.
  + A + BC → B + AC
* **Double displacement: ionic compound + ionic compound →**
  + The products are two new ionic compounds made by the cations switching places.
  + AB + CD → CB + AD
* **Acid-base: H[something] + [something]OH →**
  + The products are water and an ionic compound.
  + HA + BOH → H2O + BA
* **Combustion: [something with some combination of C, H, O] + O2 →**
  + The products are CO2 and H2O

**2) Determine if the reaction actually occurs. Depending on what compounds are reacting with each other, there may or may not be a chemical reaction that occurs.**

* Always assume synthesis, decomposition, acid-base, and combustion reactions occur.
* Single displacement reactions only take place if the element by itself on the left side of the equation is higher on the activity series than the element on the right side.
* Double displacement reactions only occur if both reagents AND one of the products are soluble in water. Additionally, none of the compounds anywhere in the equation can be partially soluble, unstable, decomposing, or anything else that’s weird.

**3) Determine if the formulas of the products are valid**

* When you predict the formulas of the products of the reaction, you’ll be writing a bunch of chemical formulas. These formulas must be correct – if they’re not, then your answer won’t be completely right.
* Common things that you should check for:
  + If you’ve written an ionic formula, is the formula valid? Remember to find the charges on the cation and anion, then switch them to find the subscripts in the compounds. For example, it’s not “CaF”, but “CaF2” because calcium has a charge of +2 and fluorine has a charge of -1.
  + If you’ve written the formula of an element, did you remember that some elements are diatomic (the big 7 and the weirdo), that phosphorus is P4, and that sulfur is S8?

**4) Balance the equation**

**Now for an example**: **NaOH + CaF2 →**

**Step 1:** It’s a double displacement reaction because two ionic compounds are reacting with one another. NaOH is a base, but since there’s no acid in the reaction, it’s not an acid-base reaction. Using the rules for a double displacement reaction, we can write that

NaOH + CaI2 → CaOH + NaI

**Step 2:**  Does the reaction occur? It’s a double displacement reaction, so it might not – it only takes place if both reagents and only one product is soluble in water. Looking at the solubility sheet, we find that NaOH is soluble, CaI2, and NaI are all soluble, while Ca(OH)2 is not. As a result, this reaction does take place.

**Step 3:** Are the formulas correct? The ones I gave you (NaOH) and (CaI2) are valid – I gave them to you, but CaOH and NaI might not be. Looking at the periodic table, we see that calcium has a +2 charge and we know OH has a -1 charge, so the formula of calcium hydroxide is actually Ca(OH)2. In NaI, Na has a +1 charge and I has a -1 charge, so everything is fine.

**Step 4:** Balance your equation. In this case, it’s **2 NaOH + CaI2 → Ca(OH)2 + 2 NaI**