

## Experiment 8: Chemical Moles: Converting Baking Soda to Table Salt

### What is the purpose of this lab?

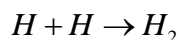
We want to develop a model that shows in a simple way the relationship between the amounts of reactants used in a chemical reaction, and the amounts of products formed.

### Why is this important?

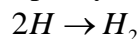
A good model is predictive, and allows us to confidently make statements about future behavior. (Not to mention to confidently split infinitives.) This type of model is important because it allows us to make quantitative predictions about the production of CO<sub>2</sub> from the burning of carbon containing fuels, or the amount of ozone destroyed in a sequence of reactions involving CFCs.

### What is the most fundamental way to understand the quantities involved in chemical reactions?

The most fundamental way is to understand that atoms and molecules are reacting with each other to produce other atoms and molecules. For a very simple example, in the reaction

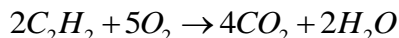


one hydrogen atom reacts with another hydrogen atom to make one hydrogen molecule. We can also write this reaction more compactly as



Notice that when written this way, it becomes clear that 2 hydrogen atoms are necessary to make one hydrogen molecule, i.e, twice as many hydrogen atoms are used as hydrogen molecules are formed.

For another example, consider the combustion of acetylene, C<sub>2</sub>H<sub>2</sub>. The equation for this reaction is:



Let's see if we can work out together what the ratios of each of the products and reactants are in this reaction.

### Is there a special name for the coefficients preceding the chemical formulas?

Yes, they're called stoichiometric coefficients. This is a terrible name that just reeks of jargon. To avoid confusion, just think of stoichiometric as simply meaning "how many".

### How do you determine what these coefficients are?

The procedure is called balancing the equation. It's based on two ideas. The first is called Conservation of Matter. The second is the idea that we need to deal with whole numbers of atoms and molecules, since they are discrete entities.

### **What is the Conservation of Matter?**

Conservation of matter says that matter can't be created or destroyed. In chemical reactions, there is also a requirement that elements can't be changed to other elements.

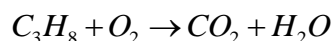
### **How do we use this when we balance the equation?**

We make sure that we have the same number of atoms of each element in our reactants as we do in our products.

For example in the hydrogen reaction, we have two H atoms on the reactant side, and two on the product side. (Note that it's atoms we're conserving, not molecules – molecules can change into other molecules and so are not conserved).

In our other example we have 4 C atoms, 4 H atoms, and 10 O atoms both on the reactant side of the equation and on the product side of the equation.

Let's do another example together, this time combustion of propane, the gas in most cigarette lighters. I'll give you the reactants and products and we can balance the reaction together.



### **So why can't we just use number of atoms and molecules to understand the relationship between the quantities of reactants and products?**

The problem is one of measurement. Any claim that we make with regard to these amounts is useless unless we can prove that it's right, and proof requires measurement.

### **Why can't we directly measure the number of atoms and molecules?**

They're too small. In order to count them we need to see them, but atoms and molecules are 100,000 times too small for our eyes to see.

### **So how do we tell how much reactants and how much products we have?**

We weigh them.

### **So we can weigh small numbers of atoms and molecules?**

Nope. They're weigh too light. (Note the clever pun, or play on words)

### **So what do we do?**

We define a number of atoms or molecules that's convenient to weigh. The usual unit is a mole. A mole is  $6.02 \times 10^{23}$  of whatever object we're counting, atoms, molecules, or even lemmings.

The number of objects in a mole is called Avogadro's number (not avocado's number,  $6.023 \times 10^{23}$  avocados, called a guacamole; or abogado's number which is \$300/hour).

So just remember that a mole is a fixed number of objects, like a dozen, a pair, a gross or a baker's dozen.

This means that when we look at a balanced equation, we can either interpret it as the number of atoms and molecules consumed and produced, or the number of MOLES of atoms and molecules consumed and produced.

### **How does this help?**

It turns out that a mole of an element or a compound has the same mass in grams that one atom or molecule has in atomic mass units (AMUs).

### **How can we figure out the mass of elements or compounds in AMUs?**

For elements this is really easy. Just look at the periodic table. The mass of the element in AMUs is right under the atomic symbol.

For compounds it's almost as easy. You just find the masses in AMU for all the elements in the compound and then add them up.

We call these masses molar masses.

### **How do you figure out how many moles you have if you know the mass of a compound?**

You take the measured mass and divide by the molar mass.

### **How do you figure out the mass of a compound if you know the number of moles?**

You take the number of moles and multiply by the molar mass.

### **If you know the mass of a reactant, how do you figure out the mass of the reactant that will be produced?**

There are four steps:

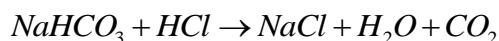
1. Balance the reaction.

2. Calculate the number of moles of your reactant by dividing the mass of the reactant by the molar mass of the reactant.
3. Use the stoichiometric factors to figure out how many moles of product there will be.
4. Calculate the mass of the product by multiplying moles of product by molar mass.

### What reaction are we actually studying today?

The conversion of  $\text{NaHCO}_3$  to  $\text{NaCl}$ .

### What's the reaction?



### Can we have a recap?

Sure.

### Well? How about it then?

Oh. OK.

1. Balanced equations show the ratios between atoms and molecules of reactants and products, or between moles of reactants and products.
2. The ratio of atoms or molecules of reactants to atoms or molecules of products is the same as the ratio of moles of reactants to moles of products.
3. To determine mass ratios of reactants to products, first convert mass of reactant to moles of reactant, then convert to moles of product, then to mass of product.
4. Use molar masses to convert from moles to masses or from masses to moles.

### Do you have any experimental tips for us today?

Experimental tips? Who, me? Umm, actually, yes, I do.

1. Don't use test tubes, use 30 mL beakers.
2. Don't use bunsen burners, use hot plates. Set the hot plates to a setting of 3.
3. Do not use any boiling chips in this experiment.
4. Measure 0.30 to 0.70 grams of  $\text{NaHCO}_3$ .
5. **Don't stop adding HCL when the solid is dissolved. Keep going until the liquid doesn't fizz when you add HCL.**
6. Add the HCl to all three samples before you evaporate the liquid from any of them. Then do the evaporations of all three at the same time.
7. Evaporations should be done in the hood.
8. Evaporation is completely done when there are crystals on the bottom of the beaker AND all liquid has evaporated from the sides of the beaker.

9. Don't boil away your liquid TOO quickly. Once it starts boiling turn the heat on so the sample is boiling steadily but not violently. If the sample boils too fast, then you can lose product, and in addition, heating too much can cause some of your solid product to blow away.
10. The beakers will be hot, so remember to use the right tool to remove them from the hotplate.
11. Don't weigh your NaCl product until the beakers are at room temperature.
12. Post your average ratio on the board when you get it.

**Lab Report:**

Data sheet on page 55 and questions on page 54.

**Honor:**

All material in this lab can be worked on with your lab partner.

**Lab notebook:**

Prelab, procedure, observations, records of measurements, conclusion, initialed pages and witnessed. Proper correction method.