

Models, Mass and Stoichiometry

©David A. Katz. All rights reserved.
Permission for educational use as long as the original copyright is included.

As a college chemistry teacher, I must begin by stating that I'm opposed to "dry labs" where students get bored and turned off to chemistry by writing chemical formulas, building models, calculating moles and masses, and writing chemical equations without any hands-on activities. Generally, I try to do many of these activities in the classroom, rather than the laboratory. I accomplish much of these through a series of activities, both in the classroom and, to some extent, in the lab.

Basic Models of Molecules

Textbooks normally present molecular structures along with rules for writing Lewis structures. For a student with little or no previous chemistry, this is, in my opinion, a totally confusing and useless activity. I prefer to start with the VSEPR approach to molecular shapes. I explain the VSEPR shapes as part of a hands-on activity in the classroom using modeling clay and toothpicks. (Note: There are variations on this using candies and toothpicks, but, after all the handling of that candy, would you eat it?)

Why modeling clay? Mainly because there are no pre-set holes in the "atoms". (Remember, many students cannot think in 3 dimensions and, even though they had math and geometry courses, have not applied a lot of that material to the physical world.) Students must manipulate "bonds and atoms" and physically put them in the proper orientations.

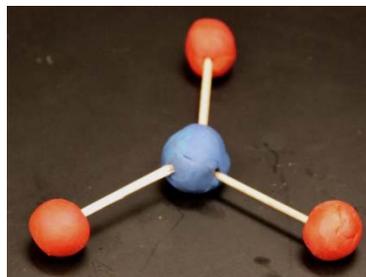
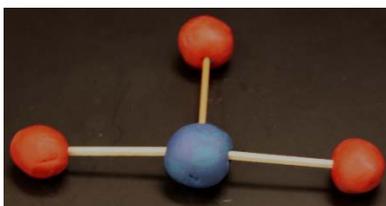
Form the class into small groups. Supply each group with a small bag containing modeling clay and toothpicks. Optional: Give out protractors for students to measure angles.

A **Group IIA** element can form 2 bonds to the central atom. Essential to any model, the bonds must be arranged at the maximum distance apart. Ask the students to build a simple model. (The students usually get this correct.)



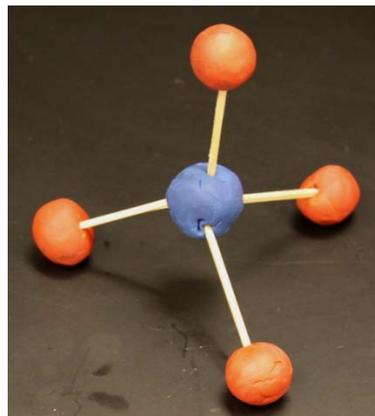
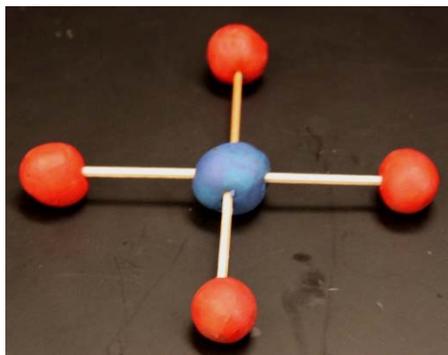
Survey the class. Correct any incorrect models. Give some examples of compounds.

A **Group IIIA** (Group 13) element can form 3 bonds to the central atom. Ask the students to build a simple model. (These are the 2 most common results.)



Survey the class. Correct any incorrect models. Give some examples of compounds.

A **Group IVA** (Group 14) element can form 4 bonds to the central atom. Ask the students to build a simple model. (These are the 2 most common results.)



Survey the class. Correct any incorrect models. Emphasize the tetrahedral arrangement with a 109° angle. Give some examples of compounds. Reminder: It is important that the students have to physically place the “bonds” and “atoms” in a 3-dimensional arrangement.

You can continue this with a **Group VA** (Group 15) element and a **Group VIA** (Group 16) element, or you can do that later or in another class. Don't forget to survey the class, correct any incorrect models, emphasize shapes and angles, and give some examples of compounds.

Molecular models

Once students have some ideas of molecular shapes, they are ready to draw Lewis structures and build models using molecular model sets. Build some of the compounds you used as examples in the previous activity. Choose representative molecules from each periodic group and stress the similarity between compounds formed within a group such as CH_4 and SiH_4 or NH_3 and PH_3 .

The recommended models are the Flinn Scientific Molecular Model Sets. Either the inorganic or organic student individual sets (AP6242 or AP6252) or the larger Inorganic-Organic Teacher or Organic Teacher model sets (AP5455 or AP5454). Similar model sets are made by Molymod. Note: Do not substitute for these two brands as I have not tested them. These models are injection molded and the masses are essential identical for the same “atoms” and “bonds”.

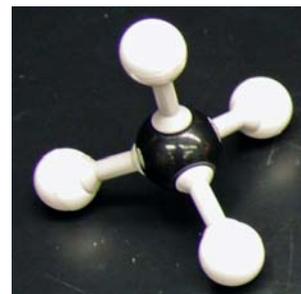
Some sample models are:



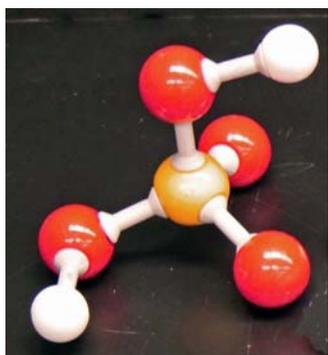
carbon dioxide



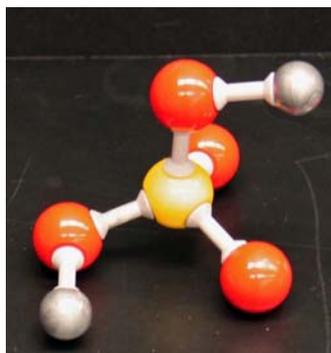
water



methane



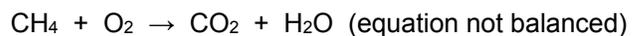
sulfuric acid



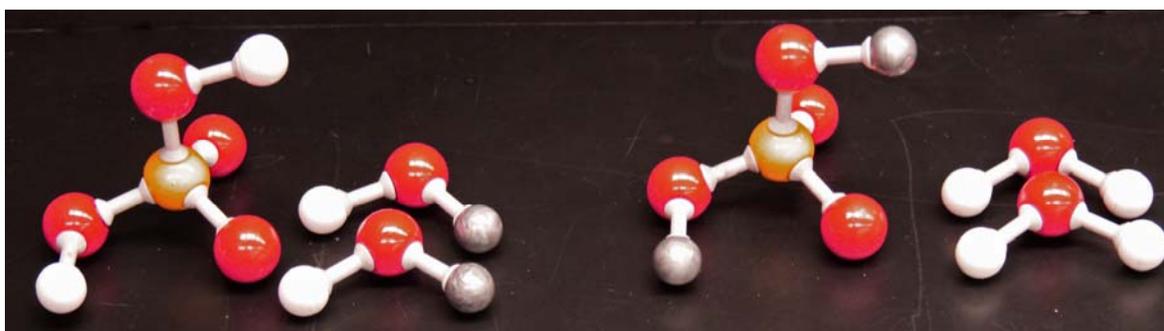
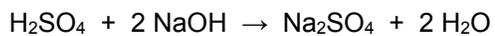
sodium sulfate

After successful model building for individual molecules, construct models for chemical reactions. Note: It is essential that all the “atoms” and the “bonds” be exactly the same.

These are the reactants and products for the combustion of methane:



This is the reaction between sulfuric acid and sodium hydroxide:



Balancing Reactions and Stoichiometry

Using a double pan balance, weigh the reactants and products. This demonstrates that the total mass of the reactants must equal the total mass of the products.

The combustion of methane:

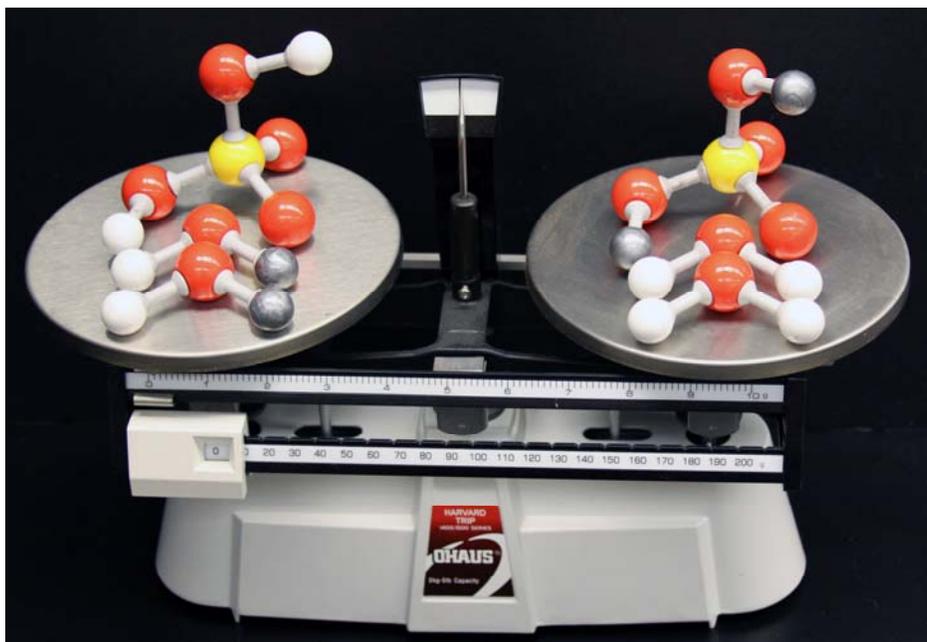


This is the comparison of the masses of the reactants and products, unbalanced.



This is the comparison of the masses of reactants and products for the balanced reaction.

The neutralization of sulfuric acid with sodium hydroxide:



For any reactions the class constructs models for, the masses will be the same on both sides only if the equations are balanced. The appropriate masses can be calculated and additional reactions assigned to the class.