Alternative Activity 1.2

Description

In this activity the students will use physical models of molecules to explore the origins of reaction stoichiometry.

Objective

The objective is to help students understand that reaction stoichiometry is a consequence of the fact that the individual atoms involved in a reaction do not change, only the bonding between them changes.

Preparation

1. You will need a supply of some type of molecular model. One low-cost possibility is to use styrofoam balls painted two different colors to represent atoms and toothpicks to represent bonds.
2. Decide how students will perform the activity (individually or in groups) and then bring enough models to class so that each person/group can ultimately be given two N_2 models and one O_2 model.
3. Bring the slides for this activity to class.

Lesson Plan

1. Show the slide for the activity. Ask the class if anyone knows why and where this reaction is important. Lead the discussion so that the students realize or learn that this reaction takes place inside automobile engines and that the NO_2 that is produced causes smog. If it does not come up during the discussion, point out that there are two possible reasons why we have air to breathe: either the rate of this reaction is very slow at ambient temperatures or thermodynamics limits the conversion so that very little NO_2 is formed. If anyone asks which it is, tell them that in a few units they'll know how to do a thermodynamic analysis and they can figure it out themselves.
2. Point out that there are actually several different nitrogen oxides with different stoichiometries, and explain that this is the reason why emissions often refer to NO_x and not any one particular product.
3. Tell them that in this activity, they are going to use this particular reaction to learn about the origins of reaction stoichiometry.
4. Give each person/group one N_2 molecule and one O_2 molecule and ask them to make them react and produce NO_2.
5. Have them show their products, ask someone to go to the board and write down the reaction that they made happen. Bring the discussion around to the point that there was an extra N atom left over at the end, and therefore the reaction that they made occur was $N_2 + O_2 \rightarrow N + NO_2$ and not the reaction on the slide. Discuss that the left over atom can't just be ignored because if these were real molecules, it wouldn't just disappear. Also note that the left over atom can't be changed into another element; all a reaction does is re-arrange bonding, it doesn't change the identity of the atoms.
6. Ask them whether they could make the reaction occur as written if you gave them one additional N_2 and one additional O_2. If anyone thinks they can, let them try. If they do, again have them write the reaction on the board as $2\ N_2 + 2\ O_2 \rightarrow N_2 + 2\ NO_2$. Have them cancel out one N_2 from each side and come up with the correct stoichiometry.

7. Alternatively, if no one thinks they can make the reaction go as written, ask them what they would need to do so, and when they state they only need an N_2 molecule, give it to them and let them make the reaction occur.
8. Conclude the activity by pointing out that you could never make the reaction go as written if you started with an equal number of N_2 and O_2 molecules, but that you'd always need 2 O_2 molecules for every one N_2 molecule.

Variations

The activity can also be used to illustrate that more than one set of stoichiometric coefficients is possible but that they always are multiples of each other.

When the students are making the first reaction occur, you can let them combine forces if they like; no matter what they do, they won't have a stoichiometric starting composition, so they won't be able to make the reaction occur.

When introducing the reaction, ask them how it's possible for us to breathe oxygen? Shouldn't all the oxygen and nitrogen react to form NO_2? Lead the discussion to realize that first they'd need a thermodynamic analysis to see how far the reaction can go at atmospheric conditions and then they'd need to know the kinetics to see how long it would take.

Tips and Suggestions

A student may "hide" their left-over N atom; by pointing out that real atoms won't hide, this can be worked into the discussion at point 5