Putting Chemicals Together

NC Standards
PS.8.1.4 & PS.8.1.5

Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

In this 50-minute activity, students combine two liquid reactants and measure the amount of gas produced. Their goal is to find a combination of reactants that produces the greatest volume of gas. The activity allows students to experience early experimenters' empirical approach to determining a chemical formula and the use of chemical equations to describe a reaction. It also provides a basis for understanding one of the keystones in the development of the atomic theory.

Correlations to NC Science Standards

PS.8.1.4 Construct an explanation to classify changes in matter as physical changes (including changes in size, shape, and state) or chemical changes that are the result of a chemical reaction (including changes in energy, color, formation of a gas or precipitate).

PS.8.1.5 Use models to illustrate how atoms are rearranged during a chemical reaction so that balanced chemical equations support the Law of Conservation of Mass (in both open and closed systems).

Learning Targets

Students will demonstrate knowledge and understanding of the following ideas and content:

- Chemical compounds are composed of proportional amounts of substances.

Students demonstrate this knowledge and understanding by determining, through experimentation, the proportion of reactants that produce the largest volume of a gas. They explain this result as evidence that matter combines chemically in specific proportions. After this, they can explain that one logical explanation has each kind of matter composed of tiny particles, each of which possesses the property of combining with other particles in specific proportions.

Brief Science Background

Early experimenters in chemistry used empirical evidence to develop the atomic theory that explained the interactions of matter in chemical reactions. Early on, scientists like Proust deduced that compounds are formed in exact proportions that do not change (his law of definite proportions). This concept gave support to Dalton's theory that matter is made of atoms of different elements that combine in definite proportions. This early experimentation provided evidence for the atomic theory that would be developed later.

Part 1 — Putting Chemicals Together

Materials

Materials for the whole class

- 2 half-gallon bottles of 1.66% sodium bicarbonate solution
- acetic acid solution (vinegar)
- universal indicator solution
- silicone lubricant

Materials for groups of 2 students

- 1 reaction bottle (4 oz clear plastic)
- 1 rubber stopper with a hole
- 1 syringe, 60 mL
- 1 syringe, 20 mL
- a 9 oz cup half filled with acetic acid solution (vinegar) that is colored with universal indicator (see step 3 under Preparation below)
- a 9 oz cup half filled with sodium bicarbonate solution that is colored with universal indicator (see step 4 under Preparation below)

Materials for each student

- safety glasses (supplied by teacher)
- science notebooks (supplied by teacher)

Preparation

Allow for 45 min.

1. Prepare two half-gallon bottles of 1.66% sodium bicarbonate solution. Place 33.5 g of sodium bicarbonate in each of two half-gallon containers, then fill both containers with water to the half-gallon line. This needs to be accurate. To compare results, both bottles of sodium bicarbonate solution should be very close to the same concentration. Be sure to shake thoroughly before use.
2. Remove plungers from the large syringes and lightly spray silicone lubricant on the rubber part of the plungers. The plungers must be lubricated to accurately measure the amount of gas produced.
3. Half-fill 9-oz cups with acetic acid solution (one cup per pair of students) and add 5 drops of universal indicator to make it light red. Each pair of students will use this as a stock solution for the investigation
4. Half-fill a 9-oz cup with 1.66% sodium bicarbonate (1 cup per pair of students) and add 5 drops of universal indicator to make it blue/green. Each pair of students will use this as a second stock solution for the investigation.

Procedure

1. Tell students that they will try to make the most gas they can by mixing the red and the blue solutions. Their job is to discover the right amount of red to mix with the right amount of blue to do that. Tell them that you will demonstrate the apparatus that they will use for this. As you demonstrate, **do not tell students how much of each reagent you are using.**
2. Use the 20mL syringe to measure out 10 mL of the blue sodium bicarbonate solution and squirt it into the reaction bottle. Place the rubber stopper firmly into the reaction bottle.

Procedure Cont.

3. Draw 10 mL of red acetic acid solution into the 60 mL syringe. Explain that the total amount of chemicals they can use must be 20 mL.
4. Taking care not to touch the plunger, fit the 60 mL syringe containing the measured amount of acetic acid into the rubber stopper and push the rubber stopper firmly into the mouth of the reaction bottle without pushing down on the syringe plunger. Check to be sure that the stopper is pushed firmly into the mouth of the reaction bottle. Push the plunger all the way down and leave it down. All of the red solution will go into the bottle.
5. Swirl the bottle until all bubbling stops. As the reaction proceeds, the moves up. When the plunger no longer rises, press it down and let it spring back up twice. That number is the volume of gas produced in mL.
6. Tell students that they will do what you just did multiple times, and gather data each time. When teams finish, they should have enough data to help them determine the proportion of red and blue solutions that produces the most gas.
7. Tell students to start and remind students of these rules (if it helps, project SD 1 for the whole class to see):
   - ***For each test, the amount of red and blue must add up to 20 mL. No more. No less.***
   - Use the small (20 mL) syringe *only* for blue solution
   - Use the large (60 mL) syringe *only* for red solution
   - Always put the blue solution in the bottle first, then seal the bottle and add the red solution.
   - The large 60 mL syringe always measures the volume of gas produced.
   - For each trial, record three things:
     - the volume in mL (ex. 12 mL) of red solution used for that trial
     - the volume in mL of blue solution used for that trial
     - the volume in mL of gas the trial produced

Content Connection

8. Ask, "How would you describe the changes that occurred in this model?" **This question is intended to get students to recognize physical and chemical changes and that this is a model for a chemical reaction.**
9. Ask, “What do our results tell us about the proportions of red and blue reactants? How could we express that without a lot of words?” Allow students to write what they think in their notebooks and use whatever shorthand they develop to express their ideas. Depending on what the students generate, a discussion of how to write chemical equations using simple terms can help. Teams should come close to 15mL blue to 5mL red, which you can simplify to something like: 3 B + 1 R = Most Gas.
10. Say, “The proportion of red and blue liquids that makes the most gas always

seems to be the same. What reasons might you give for this?" **This question is intended to get students to think about this. Answers at this time do not need to be correct.**

Formative Asessment/ Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions *before* an assessment and to provide opportunities for discussion, re-teaching, and for students to justify an-swers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask them to write responses in notebooks.

Some industrious students are working to create a perfect liquid glue recipe. They mix 1 gram of Gl (a white powder) with 1 gram of Ue (a green powder) in 100 mL of water and shake the mixture well. The product is a very sticky blue liquid super glue with some of the original white powder at the bottom of the mixing jar. When they pour off the glue and dry and weigh the white powder they find that it weighs .5 grams. Which of the student suggestions below might improve the recipe? Support your idea with evidence.

a. Add more water to make more glue and dissolve the white powder better.

b. Increase the amount of white powder.

c. Decrease the amount of white powder by half.

d. Shake the mixture for a longer time.

e. Increase the amount of green powder.

Answer Key

Either c. or e. would work. Some white powder was left because the green and white powders do not combine in a 1:1 proportion by weight, but more like twice as much green as white powder.

SD 1

- For each test, the amount of red and blue must add up to 20 mL. No more. No less.

- Use the small (20 mL) syringe *only* for blue solution.

- Use the large (60 mL) syringe *only* for red solution.

- Always put the blue solution in the bottle first, then seal the bottle and add the red solution.

- The large 60 mL syringe always measures the volume of gas produced.

- For each trial, record three things:
  - the volume in mL (ex. 12 mL) of red solution used for that trial
  - the volume in mL of blue solution used for that trial
  - the volume in mL of gas the trial produced.