Types of Chemical Reactions Lab Experiment

The purpose of this lab[1] is to become more familiar with each of the 5 basic categories of chemical reactions: synthesis, decomposition, single replacement, double replacement, and combustion. This lab addresses the Next Generation Science Standard: ***HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.***

Background

1. **Synthesis/Combination reactions**
   Two or more reactants combine to make 1 new product.
   Examples: $C(s) + O_2(g) \rightarrow CO_2(g)$
   $H_2O(l) + SO_3(g) \rightarrow H_2SO_4(aq)$

2. **Decomposition reactions**
   A single reactant breaks down to form 2 or more products.
   Examples: $H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$
   $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

3. **Single-replacement reactions**
   A single element replaces a similar element of an adjacent reactant compound.
   Examples: $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

4. **Double-replacement reactions**
   Two ionic compounds exchange ions, producing 2 new ionic compounds.
   Examples: $NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$
   $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

5. **Combustion reactions**
   A single element or compound combines with oxygen gas releasing energy. This rapid oxidation is called burning.
   Examples: $C(s) + O_2(g) \rightarrow CO_2(g) + \text{energy}$
   $2Mg(s) + O_2(g) \rightarrow 2MgO(s) + \text{energy}$
   $2C_4H_{10}(g) + 13O_2 \rightarrow 8CO2(g) + 10H_2O(g) + \text{energy}$

Materials

Glassware: 250 mL beaker, 250 mL Erlenmeyer flask, 600 mL flask, 4 test tubes, evaporating dish
Miscellaneous equipment: Test Tube Rack, Wooden splint, matches, laboratory thermometer, steel wool, zinc-coated nail, rubber band
Chemicals: Distilled Vinegar ($HC_2H_3O_2$), 3% Hydrogen Peroxide (H_2O_2), 95% Ethanol (EtOH), Baking Soda ($NaHCO_3$), 0.5 M $CuSO_4$, Active Yeast

Procedure

Synthesis

1. Measure room temperature and record: ____°C.
2. Soak a steel wool pad in 30 mL of vinegar in a 250-mL beaker.
3. Remove pad and squeeze the excess vinegar back into the beaker. The vinegar strips away the coating on the steel filaments, which are 96 to 98% iron.

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[1] This lab is adapted from one developed by Mike Isley. Accessed on 2/6/18: https://www.carolina.com/teacher-resources/Interactive/classifying-chemical-reactions/tr10679.tr

4. Wrap the pad around the thermometer bulb, secure it with a rubber band, and observe the temperature over 5 min.
5. Record the final temperature of the steel wool: _____°C. Was there a temperature change?
6. Describe any changes to the steel wool. _____.
7. Write a balanced equation for this reaction. Include heat as a reactant or product.

Decomposition activity

1. Pour the yeast from the test tube into the 250 mL Erlenmeyer flask containing the 20 mL of hydrogen peroxide (H_2O_2). The yeast contains the enzyme catalase that decomposes hydrogen peroxide. What gas or gases could be produced?
2. Review the table below for confirming 3 common gases.
3. Insert a flaming splint into the flask held at a 45° angle. Is the test positive for hydrogen (see Fig. 1)?
4. Insert a glowing splint into the flask. Is the test positive for oxygen (see Fig. 1)?

Oxygen Gas	Insert a glowing splint into the container. If it bursts back into flame, the test is positive.
Hydrogen Gas	Insert a flaming splint into the container held at a 45° angle. If there is a small explosion or barking sound, the test is positive.
Carbon Dioxide Gas	Insert a flaming splint into the container. If the flame is extinguished, the test is positive.

Figure 1 Standard tests for 3 common gases.

5. Write a balanced equation for this decomposition reaction.

Single-replacement activity

1. Hold the test tube containing 0.5 M $CuSO_4$ solution at a 45° angle and insert the zinc-coated nail.
2. Place the test tube in the test tube rack. What happens?
   A galvanized nail (coated with Zn), undergoes a reaction:
3. Describe what you see: _____.
4. Complete and balance the equation: $Zn(s) + CuSO_4(aq) \rightarrow$ _____(aq) + _____(s)

Double-replacement activity

1. Pour the baking soda (sodium hydrogen carbonate, $NaHCO_3$) from the test tube into the 600 mL beaker containing 30 mL of vinegar (acetic acid, $HC_2H_3O_2$).
2. Describe what happens.
3. Complete and balance the equation for this reaction: $NaHCO_3 + HC_2H_3O_2 \rightarrow$ _____(aq) + _____(aq)
4. One of the products, carbonic acid (H_2CO_3), immediately decomposes into water and a gas. Complete and balance this equation, and identify the gas with a flaming or glowing splint:
   $H_2CO_3 \rightarrow H_2O +$ _____(g)

Combustion activity

1. Pour the 1 mL of ethanol from the stoppered test tube into the evaporating dish.
2. With a flaming splint, carefully ignite the ethanol in the dish. (This reaction occurs in your car's engine if you use gasoline that contains ethanol.) Do not touch the dish until 5 min after the flame extinguishes.
3. Complete and balance the equation for this reaction:
   $C_2H_5OH(l) + O_2(g) \rightarrow$ _____(g) + _____(g) + energy
4. The combustion reaction for a Bunsen burner uses methane (CH_4) or propane (C_3H_8). Complete and balance these 2 reactions:
   $CH_4(g) + O_2(g) \rightarrow$ _____(g) + _____(g) + energy
   $C_3H_8(g) + O_2(g) \rightarrow$ _____(g) + _____(g) + energy