5B Types of Chemical Reactions

There are many varieties of chemical reactions, some of them difficult to classify. However, the majority of chemical reactions fit into one of four main categories:

a. Synthesis (Combination): $A + B \rightarrow AB$
(Two substances combine to form a new substance.)

b. Decomposition: $AB \rightarrow A + B$
(The opposite of synthesis; one substance decomposes or breaks apart to form two new substances.)

c. Single Replacement: $AB + X \rightarrow A + XB$
(A single change of partners results.)

d. Double Replacement: $AB + XY \rightarrow AY + XB$
(Similar to single replacement, but a double exchange of partners occurs.)

In this experiment, you will first observe examples of each of the four types of chemical reactions. Next, you will write chemical equations that support your observations. Finally, you will classify each reaction as synthesis, decomposition, single replacement, or double replacement.

OBJECTIVES

1. to observe a variety of chemical reactions
2. to interpret and explain observations with balanced chemical equations
3. to classify each reaction as one of the four main types

CAUTION

Most of these solutions are poisonous, corrosive, or irritants. Wash any spills and splashes immediately with plenty of water. Notify your instructor.

SUPPLIES

Equipment

lab burner
6 test tubes (13 mm × 100 mm)
  one test tube will be flame heated
test-tube clamp
dropping pipet
wood splints
crucible tongs
steel wool
safety goggles
lab apron

Chemical Reagents

copper wire (bare)
iron nail
0.5*M* copper(II) sulfate solution
solid copper(II) sulfate pentahydrate
water
0.5*M* calcium chloride solution
0.5*M* sodium carbonate solution
mossy zinc
2*M* hydrochloric acid solution
hydrogen peroxide solution (6%)
manganese(IV) oxide

PROCEDURE

1. Put on your lab apron and safety goggles.
2. Make observations before, during, and after each reaction. Record your observations in your copy of Table 1 in your notebook.

Reaction 1

3. Adjust a burner flame to high heat.
4. Using crucible tongs, hold a 6 cm length of bare copper wire in the hottest part of the flame for a few minutes.

Reaction 2

5. Clean an iron nail with a piece of steel wool so the surface of the nail is shiny.
6. Place the nail in a test tube and add copper(II) sulfate solution so that one half of the nail is covered.
7. After approximately 15 min, remove the nail and note any changes in both the nail and the solution. (You should move onto Reactions 3 and 4 while you are waiting.)

CAUTION

Copper(II) sulfate is poisonous. Wash any spills and splashes immediately with plenty of water.

Reaction 3

8. Put some solid copper(II) sulfate pentahydrate in a test tube so that it is one third full. Note: Ensure that this test tube is heat resistant.
9. Using a test tube clamp, hold the test tube and contents at an angle away from yourself and your classmates. Heat the test tube, moving it back and forth gently over a burner flame.
10. Continue heating until no further change is observed. (Save the contents for Reaction 4.)

Reaction 4

11. Allow the test tube and contents from Reaction 3 to cool.
12. Use a dropping pipet to add 2 or 3 drops of water to the test tube.

Reaction 5

13. Fill a test tube one quarter full with calcium chloride solution. Fill a second test tube one quarter full with sodium carbonate solution.
14. Pour the calcium chloride solution into the test tube containing sodium carbonate solution.

Reaction 6

15. Place a piece of mossy zinc in a test tube.
16. Add hydrochloric acid solution to the test tube until the mossy zinc is completely covered.

CAUTION

Hydrochloric acid is corrosive to skin, eyes, and clothing. Wash any spills and splashes immediately with plenty of water.

Reaction 7

17. Half fill a test tube with hydrogen peroxide solution.

18. Add a small amount of manganese(IV) oxide. (Note: Manganese(IV) oxide acts as a catalyst in this reaction.)

19. Test the gas evolved by placing a glowing (not burning) splint into the mouth of the test tube.

20. Before leaving the laboratory, wash your hands thoroughly with soap and water.

REAGENT DISPOSAL

Place all liquid and solid waste into the designated waste containers.

POST LAB CONSIDERATIONS

To predict the products of a reaction, it is helpful to examine the chemical formulas of the reactants. Therefore, your first task is to determine which chemicals reacted in each case, then to write chemical formulas for these reactants.

Next, using a combination of logic and observations, predict the products for each reaction. Finally, balance each equation so that the number of atoms is conserved.

Classifying the reactions requires you to match each equation with one of the four types that were described in the introduction.

EXPERIMENTAL RESULTS

When making up the data table, leave spaces between each reaction.

Table 1

	Observations		
Reaction	Before	During	After
1			
2			
3			
4	COMPLETE IN YOUR NOTEBOOK	COMPLETE IN YOUR NOTEBOOK	COMPLETE IN YOUR NOTEBOOK
5			
6			
7			

ANALYSIS OF RESULTS

1. In Reaction 1, with which substance in the air did the copper react?
2. In Reaction 2, changes occurred in both the nail and the solution. What do the changes in the solution indicate?
3. What evidence did you see that the chemical changes took place in Reactions 3 and 4?
4. In Reaction 5, one of the products is sodium chloride (table salt), which, as you know, is highly soluble in water. What, therefore, would be the product that would account for the precipitate which formed?
5. How could you test the gas released in Reaction 6 to confirm its identity?
6. a. What does the glowing splint test suggest about the identity of the gas evolved in Reaction 7?
   b. The formula for hydrogen peroxide is H_2O_2. Two products are formed in Reaction 7, one of them is a common gas that you know from Analysis 6a and the other is a common liquid. What is the most likely identity of this common liquid?

FOLLOW-UP QUESTIONS

1. In some industrial processes, solutions have impurities removed by single replacement reactions. In electrolytic zinc processes, for instance, impurities of cadmium in the form of $CdSO_4$ are removed from the electrolyte by the addition of zinc dust. Write a balanced equation for this reaction.
2. Write the balanced equation for the electrolysis of water. What type of reaction is this?

CONCLUSION

For each of the seven reactions in this experiment, write a balanced equation and classify it as a synthesis, decomposition, single replacement, or double replacement reaction.