5 Chemical Reactions

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- **Classify, by observation, several different types of chemical reactions.**
- **Write balanced molecular equations and balanced net ionic equations for these different types of chemical reactions.**

DISCUSSION

In this experiment, you will observe four different types of chemical reactions. These are (1) combination, (2) decomposition, (3) displacement, and (4) metathesis.

A *combination reaction* occurs when two substances (either elements or compounds) combine to form a single product:

$$A + B \rightarrow AB$$

In this experiment, you will see the formation of a solid when two gases combine.

A *decomposition reaction* is the opposite of a combination reaction. A single substance decomposes into two or more simpler substances:

$$AB \rightarrow A + B$$

You will observe that heat causes some compounds to decompose.

A *displacement reaction* occurs when an element reacts with a compound and displaces one of the elements in the compound. That is, the original element becomes part of a new compound with the displaced element as a byproduct:

$$A + XY \rightarrow AY + X$$

As an example of displacement, you will react a active metal with an acid and see which element is displaced.

A *metathesis reaction* is an exchange of "partners" between two compounds:

$$AB + XY \rightarrow AY + XB$$

You will observe the formation of a precipitate when solutions of two ionic compounds are mixed.

In each of these reactions, indicate the state of each reactant or product by the appropriate subscript. Use the subscript *(g)* for gases, *(s)* for solids and precipitates, and *(aq)* for *aqueous* or water solutions. For example, the reaction of calcium metal with sulfuric acid to form calcium sulfate and hydrogen gas would be indicated by the equation

$$Ca(s) + H_2S0_4(aq) \rightarrow CaSO_4(aq) + H_2(g)$$

PROCEDURE

A. Combination Reactions: The Formation of Ammonium Chloride

1. At one station in the fume hood, find a bottle of 12 *M* HCl*(aq)* and a bottle of 15 *M* NH_3 *(aq)*. Remove their stoppers. Move the two bottles next to each other, and record your observations. Replace the stoppers.

2. The HCl and NH_3 that vaporize from the solutions are both gases, and ammonium chloride product is a solid. Write a balanced chemical equation for this reaction.

B. Combination Reactions: The Formation of Magnesium Oxide

3. At another station in the fume hood, find a strip of magnesium, a bunsen burner, and a pair of welder's goggles. Describe the appearance of the magnesium, then put on the goggles.

4. Light the burner, and pick up the magnesium with forceps. Ignite the strip of magnesium in the burner flame. Describe the reaction. **CAUTION**, *do not look directly at reacting magnesium except through the goggles.*

5. Describe the product, magnesium oxide.

6. Write a balanced chemical equation for the reaction.

C. Decomposition Reactions: Baking Soda

When baking soda or sodium bicarbonate, $NaHCO_3$, is heated, it decomposes with the release of carbon dioxide gas and water vapor. The third decomposition product is a solid which is either sodium carbonate, Na_2CO_3, or sodium oxide, Na_2O. Chemical equations can be written for both of these possible reactions even though only one of them actually occurs.

7. Write the balanced decomposition reaction of baking soda with sodium carbonate as a product.

8. Write the balanced decomposition equation of baking soda with sodium oxide as a product.

9. To determine which of the two is the actual reaction, first obtain a crucible and cover. Make sure they are clean. Position them on a clay triangle which is supported on a ring clamp. Heat the crucible and cover with a bunsen burner, carefully for a few seconds and then strongly for about 2 minutes. Allow the crucible and cover to cool for 5 minutes. Record their mass to the nearest milligram.

10. Add about half a gram of baking soda, and record the new mass.

11. Determine the mass of the baking soda.

12. Heat the covered crucible and its contents strongly for about five minutes. Let them cool for another five minutes. Measure and record their mass.

13. Determine the mass of the decomposition product.

14. Calculate the number of moles of $NaHCO_3$ that decomposed. (Assume the entire mass decomposed.)

15. From the appropriate chemical equation, calculate the expected mass of product assuming it is Na_2CO_3.

16. From the other equation, calculate the expected mass assuming the product is Na_2O.

17. Compare these two theoretical numbers with the measured mass of the product. Decide whether the product is actually Na_2CO_3 or Na_2O.

Another method to tell the difference between Na_2O and Na_2CO_3 is to add a little 6 M HCl. Sodium oxide will dissolve quietly, while sodium carbonate will dissolve with bubbling.

D. Displacement Reactions: An Active Metal with a Strong Acid

18. Place one or two small pieces of zinc in a 150 *mm* test tube. Add about 5 *mL* of 6 *M* HCl. Observe the reaction for any effervesence. If a gas is formed by zinc's displacing an element in hydrochloric acid, then the gas can only be H_2 or Cl_2. Capture some of the gas by placing an empty test tube at the mouth of the first test tube so that the gas will flow into the empty test tube. See if the gas has the characteristic yellow-green color of chlorine. Record your observations.

19. Test to see if the gas is hydrogen by placing a match or burning splint into the second test tube. Do it quickly before the gas is lost. You will get a pop if the gas is hydrogen. Which gas is it, H_2 or Cl_2?

20. If the gas is hydrogen, the zinc displaced hydrogen from the compound HCl, and the zinc formed a compound with chlorine. (Zinc forms an ion with 2+ charge.) On the other hand, if the gas is chlorine, then zinc formed a compound with hydrogen. Write a balanced equation for the reaction that fits your observations.

21. Write the net ionic equation for this reaction.

E. Metathesis Reactions:
The Formation of a Precipitate

22. Place 1 *mL* of 0.1 *M* sodium carbonate in a 100 *mm* (small) test tube, and add 1 *mL* of 0.1 *M* copper(II) nitrate. Record your observations.

23. Both of the reactant solutions are of ionic compounds, and any new compound must be a combination of the original ions. Given that nitrate ions do not form precipitates, identify the insoluble product. Write a balanced equation for the reaction, and indicate the state of each reactant and product.

24. Write the net ionic equation for this metathesis reaction.

5 Chemical Reactions

Name _____
Partner _____
Section _____Locker ____
Instructor _____

Enter the data or answer the questions *according to the corresponding step in the procedure*

A. Combination Reactions: The Formation of Ammonium Chloride

1. What did you observe when you moved the two bottles together? What was the product?	
2. Write a balanced equation for the reaction. (Include *(g)* after each gas and *(s)* after each solid.)	

B. Combination Reactions: The Formation of Magnesium Oxide

3. Describe the appearance of the magnesium.	
4. Tell what the reaction was like.	
5. Describe the residue.	
6. Write a balanced equation for the reaction. Indicate the states of the reactants and products with the proper subscript.	

C. Decomposition Reactions: Baking Soda

7. Balanced reaction with sodium carbonate as a product.	
8. Balanced reaction with sodium oxide as a product.	

9. Mass of the crucible and cover	
10. Mass of the crucible, cover, and baking soda	
11. Mass of the baking soda	
12. Mass of the crucible, cover, and decomposition product	
13. Mass of the decomposition product	
14. Moles of baking soda that decomposed	
15. Expected mass of product, assuming it is Na_2CO_3	
16. Expected mass of product, assuming it is Na_2O	
17. Formula for actual product (Na_2CO_3 or Na_2O)	

D. Displacement Reactions: An Active Metal with a Strong Acid

18. Did gas form when the HCl was added? What color was the gas?	
19. Explain what happened when you tested for hydrogen. Was the gas hydrogen or chlorine?	
20. Write a balanced equation for the reaction. Indicate the states of the reactants and products with the proper subscript.	
21. Net ionic equation.	

E. Metathesis Reactions: The Formation of a Precipitate

22. What evidence did you observe that indicated that a reaction occurred when you mixed the two solutions.	
23. Write a balanced equation for the reaction. Indicate the states of the reactants and products with the proper subscript.	
24. Net ionic equation.	

APPLICATION OF PRINCIPLES

Classify each of the following reactions as (1) combination, (2) decomposition, (3) displacement, or (4) metathesis. Place the appropriate number in the blank at the left of the equation. Balance each equation.

_____ $NaOH + Pb(NO_3)_2 \rightarrow Pb(OH)_2 + NaNO_3$

_____ $CaCO_3 \rightarrow CaO + CO_2$

_____ $Al + HCl \rightarrow AlCl_3 + H_2$

_____ $MgBr_2 + Cl_2 \rightarrow MgCl_2 + Br_2$

_____ $N_2 + H_2 \rightarrow NH_3$

_____ $Zn + AgNO_3 \rightarrow Zn(NO_3)_2 + Ag$

_____ $HgO \rightarrow Hg + O_2$

_____ $K_2CO_3 + FeCl_3 \rightarrow Fe_2(CO_3)_3 + KCl$

2. Write balanced equations for each of the following reactions. Classify the type of reaction as you did above.

_____ Magnesium reacts with sulfuric acid to produce hydrogen and magnesium sulfate.

_____ A solution of barium chloride is mixed with a solution of sodium sulfate. Barium sulfate is formed as a precipitate, and a soluble substance is produced as a byproduct.

_____ Chlorine gas reacts with aluminum metal to form aluminum chloride.

_____ A piece of magnesium metal is placed in a solution of copper(II) nitrate. A reaction takes place, and copper metal is formed on the surface of the magnesium. Magnesium nitrate is also formed.