

## Chemical Reactions and Equations

### EXPERIMENTAL TASK

Carry out a number of chemical reactions, predict the products of each reaction based on the reaction's class, and then write a balanced equation for the reaction.

### Objectives

**After completing this experiment, the student will be able to:**

1. Observe the properties of reactants before and after mixing, and use these observations to determine whether a reaction has taken place or not.
2. Predict the products of a chemical reaction, based on the reactants and the class of the reaction.
3. Write the balanced equation for a given chemical reaction.

### Additional Reading

- General, Organic and Biological Chemistry, by Timberlake, sections 6.1 – 6.5
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### Background

*Chemical reactions* are processes in which one or more substances change into new substances—that is a chemical reaction is the same thing as a *chemical change*. A particular substance is identified by the properties that are specific to that substance, and when these properties are observed to change during a process, that process must involve the production of new substances, and therefore the process is a chemical reaction.

What kinds of observations constitute evidence that a chemical reaction has occurred? Color changes, production of a solid from liquids or gases, production of gases from liquids or solids, and transfer of heat (especially if a flame is produced) may all be used as clues that a chemical reaction is taking place. These observations are not **proof** of a chemical reaction, however. It is important to gather as much information as possible before coming to a conclusion as to whether a chemical reaction has actually taken place. For instance, if a solid is produced from a liquid, the process involved might be as simple as the liquid freezing, which is a physical change. So, in order to rule out freezing of the liquid, it is necessary to look for other clues: Is the liquid being cooled in some way? Is the color of the solid different from that of the liquid? Etc.

The amazing variety of chemical reactions can be quite interesting as well as quite confusing. One way that chemists make this variety less confusing is to look for patterns in the wide array of reactions, and classify reactions according to these patterns. The most basic of these classification schemes are presented in General, Organic and Biological Chemistry, by Timberlake, in sections 6.4 and 6.5.

In this experiment you will combine substances in various ways and look for evidence of chemical reactions. Where reactions occur, you will predict the products based on the classes of the reactions, and then write balanced chemical reaction equations for them.

***The final result for each reaction will be:***

***A) proof the reaction occurred (the “before and after” observations)***

***B) the balanced chemical equation for the reaction***

### Pre-lab Questions

1. For each description given here: i) determine if a reaction occurs or not; ii) predict the products of the reaction, if one does occur; and iii) write the balanced equation for the reaction.
  - A. **Single replacement** An aqueous solution of nickel(II) nitrate (green, clear) is added to a strip of magnesium (shiny, silver metal) in a beaker. The solution becomes light green and the metal strip becomes black and dull.
  - B. **Combination** Aluminum metal (shiny, grayish-silver solid) is heated in oxygen gas (clear, colorless) to give a white powder.

- C. **Single replacement** An aqueous solution of copper(II) nitrate (blue, clear) is added to a coil of silver wire (shiny, silver metal) in a beaker. The solution remains clear and blue and the metal wire remains shiny and silver.
- D. **Double replacement** An aqueous solution of cobalt(II) nitrate (pink, clear) is mixed with an aqueous solution of sodium carbonate (clear, colorless) in a beaker. The mixture becomes cloudy and pink.
2. For each reaction that actually occurs in question 1. above, determine whether the reaction is an oxidation-reduction reaction or not.

### **BEFORE STARTING THE EXPERIMENT**

The amounts of solutions used in this experiment are fairly small, and it is a good idea to work with the other groups at your bench in obtaining enough of each solution for all of your groups to use. Most of the solutions and other reagents used in this experiment are used more than once, so make sure you go through the entire procedure to find all places a given reagent is used and get just enough of that reagent to last the groups your bench for the entire experiment.

### **Safety**

Always keep in mind the rules presented in both the "MCC Laboratory Safety Rules" and the Laboratory Handbook for General Chemistry. It is your responsibility to make sure that you follow all safety rules at all times, and to graciously help everybody else in the laboratory (including the instructor) to do the same. You will be heating crucibles using Bunsen burners, so you should review Bunsen burner safety—see page 37 of the Laboratory Handbook for General Chemistry, 2<sup>nd</sup> edition, by Griswold, et al.

### **Hazardous Materials**

**6 M hydrochloric acid** is a strong irritant and toxic—you must wear gloves while handling it, and immediately wash it off of exposed skin if spilled.

**Bromine water (saturated aqueous bromine)** is a strong irritant and toxic—you must wear gloves while handling it, and immediately wash it off of exposed skin if spilled.

**Aqueous silver nitrate** is a strong irritant and toxic, and will stain your skin—you must wear gloves while handling it, and immediately wash it off of exposed skin if spilled.

**All other solutions** are irritants—wash off exposed skin in the case of spills.

ALL WASTES MUST BE DISCARDED IN THE APPROPRIATE WASTE CONTAINERS, AS DIRECTED BY THE INSTRUCTOR. MAKE SURE **ALL SOLIDS** ARE SEPARATED FROM LIQUIDS BEFORE DISPOSAL.

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### EXPERIMENT PROCEDURE

Optional Instructor demos If time allows, and the materials and equipment are available, your instructor will carry out the following demonstrations. You **MUST** record the procedure and observations in your own notebook.

- Hydrolysis of water—Electrical current is passed through water in order to decompose it.
- Dichromate volcano—When heated by a flame, ammonium dichromate decomposes to give nitrogen gas, solid chromium(III) oxide and water vapor.
- Aluminum + bromine—When pieces of aluminum foil are mixed with pure liquid bromine, the two elements combine to form a simple ionic compound.

### Part A: Combination Reactions

**The first two element combinations (magnesium + oxygen and iron + oxygen) will be carried out by heating the metal element in a crucible and allowing the oxygen in the air to enter the crucible as it is being heated.**

1. Magnesium and oxygen: Begin by obtaining a ringstand and ring, a Bunsen burner, a clay triangle, and a crucible and cover. Attach the ring to the ringstand. Obtain a Bunsen burner and connect the hose of the burner to the gas outlet on the bench. Place the burner on the base of the ringstand, and adjust the ring so that it is about 3 – 4 cm above the top of the burner. Place a clay triangle (from your lab drawer) on the ring.

Obtain a 1 – 2 cm strip of magnesium from the reagent cart, and use a small piece of sand paper to clean it so that it is silvery and shiny. Place the magnesium in the crucible, place the cover on the crucible, and then place the crucible in the clay triangle so that the bottom of the crucible is centered over the burner. Adjust the ring so that the bottom of the crucible is about 2 – 3 cm above the top of the burner.

Move the burner out from under the crucible, light the burner, and then replace it under the crucible. Adjust the flame to give an inner bright blue cone that has its tip just touching the bottom of the

crucible. Heat the crucible this way for about 5 minutes, then turn off the burner by closing the gas valve on the gas outlet. Remove the crucible cover using crucible tongs. Record your observations.

2. Iron and oxygen: Repeat the above process using a pinch of steel wool (iron) instead of the magnesium.

The rest of the combinations will involve test tubes and solutions. Disassemble the apparatus used for heating the crucibles, and put away the various pieces before proceeding.

3. Zinc and bromine: Obtain a small square of zinc—it should be clean and shiny, so it shouldn't need cleaning. Place about 1 – 2 mL of saturated bromine water in a small test tube and add the zinc to the test tube. Record your observations immediately, and again after about 5 minutes.

### **Part B: Single Displacement Reactions**

Set up five small test tubes in a test tube rack. Label them with substances shown below.

1. Aqueous copper(II) sulfate + zinc metal
2. Aqueous zinc sulfate + copper metal
3. Aqueous silver nitrate + copper metal
4. Aqueous hydrochloric acid + zinc metal
5. Aqueous hydrochloric acid + copper metal

Add about 1 – 2 mL of the indicated solution to each test tube (that is, add  $\text{CuSO}_4$  to test tube 1,  $\text{ZnSO}_4$  to test tube 2, etc.). Then, one test tube at a time, add a piece of the indicated metal and record your observations. If there is no apparent change at first, observe again after about 5 minutes.

**Dispose of all wastes in appropriate containers—separate metal pieces from liquids before disposing of them.**

### **Part C: Double Displacement Reactions**

Set up four small test tubes in a test tube rack. Label them with substances shown below.

1. Aqueous copper(II) sulfate + aqueous sodium nitrate
2. Aqueous sodium carbonate + aqueous calcium chloride
3. Aqueous silver nitrate + aqueous sodium chloride
4. Aqueous copper(II) sulfate + aqueous sodium chloride

Add about 1 – 2 mL of the first indicated solution to each test tube (that is, add  $\text{CuSO}_4$  to test tube 1,  $\text{Na}_2\text{CO}_3$  to test tube 2, etc.). Then, one test tube at a time, add the second solution, and record your observations.. If there is no apparent change at first, observe again after about 5 minutes.

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### **RESULTS**

Create a table showing for each trial: the substances that were combined, their appearances before mixing and the appearance of the mixture after mixing

### **DISCUSSION**

Give the balanced chemical reaction equation for each trial in which a reaction occurred, and explain both how you know a reaction occurred and how you predicted the products in each case.