LAB 2: CHEMICAL REACTIONS

Lab Overview

A chemical reaction is a chemical process that leads to the transformation of one set of chemical substances (aka starting materials, reactants, or reagents) to another (known as products). In a chemical process, starting materials change into new substances. In order for this change to occur, the chemical bonds that hold atoms together in starting materials break; subsequently, atoms that compose the starting materials separate and then rearrange themselves into new substances with new chemical bonds.

In this lab, you will carry out a number of chemical reactions and record your observations (formation of a colored solid or precipitate, disappearance of a solid, bright light given off, fumes/smoke formed, etc.…) as you carry out the reactions.

A chemical reaction is represented by a chemical reaction **equation** of the general form:

Reactants → Products

On the reactants' side, formula of starting materials (aka reagents or reactants) are given. The products' side lists all products, including main product(s) and byproduct(s). All chemical equations have reactants on the left, an arrow that is read as "yields", and products on the right. An example of a chemical equation we have seen in lecture is:

$$\mathbf{2}\ H_2 + O_2 \rightarrow \mathbf{2}\ H_2O$$

Even though the starting chemical compounds are broken up and new compounds are formed during a chemical reaction, atoms in the reactants do not disappear nor do new atoms appear to form the products. ***In chemical reactions, atoms are never created or destroyed*** because mass is always conserved in chemical reactions. The same atoms that were present in the reactants are present in the products - they are merely reorganized into different arrangements. In a complete chemical equation, the two sides of the equation must be present on the reactant and the product sides of the equation. Chemical equations must always be balanced. A balanced chemical equation has the same number and type of each atom on both sides of the equation. This is achieved by placing integer numbers, called coefficients, in front of the chemical formula (for example the red number 2 in front of hydrogen and water in the example above). As you complete the report sheet during this lab, make sure you write the **chemical names** of both the starting materials and the products for each reaction (you will be given the names of the products in the lab). You will need this information to complete your post-lab assignment on bblearn. We are going to learn how to write and balance equations later in the semester; at that time, you will reexamine today's reaction to write correctly balanced equations.

In this lab, you will also analyze the copper content of a penny (modern pennies are made of zinc metal covered with a thin copper skin). You will do this by dissolving away the zinc inside of the penny leaving just the copper shell. This works because the hydrochloric acid used to dissolve the zinc does not react with the copper.

EXPERIMENTAL PROCEDURE

A. TA Demonstration of Combination Reactions

These reactions are to be performed by your TA. Students record your observations on Part A of the report sheet.

Reaction 1. Grasp a 2–3 cm strip of magnesium with a pair of crucible tongs. Hold the magnesium in the flame of a Bunsen burner until it ignites.

Note that Mg metal is easily oxidized forming a white coating of MgO over the ribbon; id the Mg strip does not ignite, this layer must be removed. It can be scratched off or chemically removed. To remove the MgO layer by chemical means, grab the ribbon with tweezers, and carefully dip it in the 0.1 M HCl solution. Do not let the tweezers to make contact with the acid solution; they will rust. When you notice that the Mg ribbon is clean, remove it from the HCl solution, rinse with DI water, and dry with a paper towel.

CAUTION: STUDENTS SHOULD NOT LOOK DIRECTLY AT THE MAGNESIUM AS IT BURNS.

Reaction 2. Half fill a deflagrating spoon with sulfur. Heat the deflagrating spoon in the flame of the Bunsen burner until the sulfur melts, and then ignites.

CAUTION: THIS REACTION PRODUCES SULFUR DIOXIDE GAS, WHICH IS TOXIC.

B. Student-Performed Analysis of the Copper Content of a Penny

- Obtain a pre-cut piece of a post 1982 penny.
- Accurately weigh the piece on a balance, and record the mass.
- Using a grease pencil, mark your 50 mL beaker with your initials, place the penny piece into it, and place it in the fume hood designated by your TA.
- Your TA will add ~ 5 mL of concentrated hydrochloric acid to the beaker containing the penny. When the coin stops producing gas bubbles, your TA will discard the acid, rinse the penny, and return it to you.
- When the penny appears to be dry, weigh the remaining shell of copper, and report the mass on the report sheet. Also, calculate and report the mass of zinc that was lost from the penny.

C. Single Replacement Reactions

- Place about 20 drops of silver nitrate solution in a test tube, and drop a pre-cut piece of copper wire into the solution. Allow the test tube to sit undisturbed in a test tube rack for about 10 minutes. Record your observations.
- Place about 20 drops of 0.1 M hydrochloric acid into a test tube, and add a few magnesium turnings, or a 2 cm strip of magnesium. Record your observations.

- Place about 20 drops of deionized water in a large test tube, and add a small piece of calcium metal. Place the test tube in a test tube rack, or hold it with a test tube holder, as the test tube will become hot. Record your observations.

D. Precipitation (Double Replacement) Reactions

For reactions 1, 2, and 3.

- Add 10 drops of silver nitrate, copper(II) nitrate, and aluminum nitrate into wells 1, 2, and 3 of your spot plate. A spot plate is a laboratory tool (see Fig 1), also called reaction plate, that has multiple wells and allows us to perform and observe reactions on a small scale.
- Add a few drops of ammonium carbonate solution to each well, stir, and record your observations.

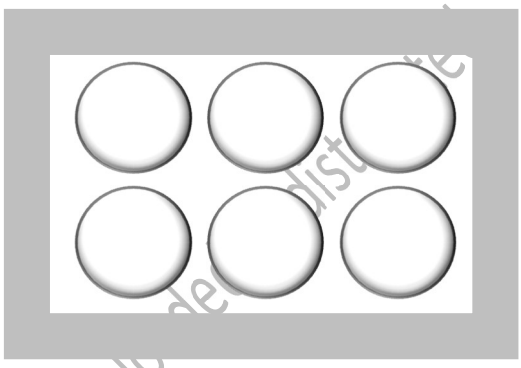

Fig. 1. Scheme of a spot/reaction plate.

For reactions 4, 5, and 6.

- Add 10 drops of silver nitrate, copper(II) nitrate, and aluminum nitrate into wells 5, 6, and 7 of your spot plate.
- Add a few drops of sodium phosphate solution to each well, stir, and record your observations.

E. Neutralization Reactions

First, empty your well plate from the double displacement reactions into the appropriate waste container and clean it so that you can use it for the neutralization reactions.

- Add 5 drops of nitric acid into well 1. Add 1 drop of phenolphthalein (this indicator will cause the solution to turn pink once it becomes basic). Add drops of dilute sodium hydroxide, with stirring, until you see a permanent color change. Record the number of drops needed.
- Add 5 drops of sulfuric acid into well 2. Add 1 drop of phenolphthalein. Add drops of dilute sodium hydroxide, with stirring, until you see a permanent color change. Record the number of drops needed.
- Add 5 drops of phosphoric acid into well 3. Add 1 drop of phenolphthalein. Add drops of dilute sodium hydroxide, with stirring, until you see a permanent color change. Record the number of drops needed.

REPORT SHEET FOR CHEMICAL REACTIONS

Please complete the report sheet below. For each reaction, make sure you write detailed observations (such as formation of a colored solid/precipitate, disappearance of a solid, bright light given off, fumes/smoke formed, etc.…). You will need this information to complete your post-lab assignment on bblearn.

OBSERVATIONS

A. Combination Reactions **Observations**

1. Burning of magnesium ($Mg + O_2$) _____

2. Burning of Sulfur ($S + O_2$) _____

B. Analysis of the Copper Content of a Penny

1. Zinc + hydrochloric acid ($Zn + HCl$) _____

(Zinc is from inside the Penny)

Mass of penny piece _____ g

Mass of copper shell left over _____ g

Mass of zinc (mass of penny minus mass of copper shell) _____ g

C. Single Replacement Reactions

1. Copper + silver nitrate ($Cu + AgNO_3$) _____

2. Magnesium + hydrochloric acid ($Mg + HCl$) _____

3. Calcium + water ($Ca + H_2O$) _____

D. Precipitation (Double Replacement) Reactions

1. Silver nitrate + ammonium carbonate ($AgNO_3 + (NH_4)_2CO_3$) _____

2. Copper(II) nitrate + ammonium carbonate ($Cu(NO_3)_2 + (NH4)_2CO_3$)_____

3. Aluminum nitrate + ammonium carbonate ($Al(NO_3)_3 + (NH_4)_2CO_3$_____

4. Silver nitrate + sodium phosphate ($AgNO_3 + Na_3PO_4$)_____

5. Copper (II) nitrate + sodium phosphate ($Cu(NO_3)_2 + Na_3PO_4$)_____

6. Aluminum nitrate + sodium phosphate ($Al(NO_3)_3 + Na_3PO_4$)_____

F. Neutralization Reactions

1. Nitric acid + sodium hydroxide ($HNO_3 + NaOH$)_____ drops

2. Sulfuric acid + sodium hydroxide ($H_2SO_4 + NaOH$)_____ drops

3. Phosphoric acid + sodium hydroxide ($H_3PO_4 + NaOH$)_____ drops

The complete reactions including both the reactants and products are given below. You will use this information in a future lab activity after you learn how to balance chemical reactions.

A. Combination reactions

1. Magnesium + oxygen yields magnesium oxide.

$Mg + O_2 \rightarrow MgO$ (unbalanced)

2. Sulfur + oxygen yields sulfur dioxide: $S + O_2 \rightarrow SO_2$

B. Analysis of the Copper Content of a Penny

1. Zinc + hydrochloric acid yields zinc chloride + hydrogen:

$Zn + HCl \rightarrow ZnCl_2 + H_2$ (unbalanced)

C. Single Replacement Reactions

1. Copper + silver nitrate yields copper(II) nitrate + silver:

$Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$ (unbalanced)

2. Magnesium + hydrochloric acid yields magnesium chloride + hydrogen

3. Calcium + water yields calcium hydroxide + hydrogen

D. Precipitation (Double Replacement) Reactions

1. Silver nitrate + ammonium carbonate yields silver carbonate + ammonium nitrate

$AgNO_3 + (NH_4)_2CO_3 \rightarrow Ag_2CO_3$ (s) + NH_4NO_3 (unbalanced)

2. Copper(II) nitrate + ammonium carbonate yields copper(II) carbonate + ammonium nitrate

3. Aluminum nitrate + ammonium carbonate yields aluminum carbonate + ammonium nitrate

4. Silver nitrate + sodium phosphate yields silver phosphate + sodium nitrate

5. Copper(II) nitrate + sodium phosphate yields copper(II) phosphate + sodium nitrate

6. Aluminum nitrate + sodium phosphate yields aluminum phosphate + sodium nitrate

E. Neutralization Reactions

1. Nitric acid + sodium hydroxide yields water + sodium nitrate:

$HNO_3 + NaOH \rightarrow H_2O + NaNO_3$

2. Sulfuric acid + sodium hydroxide yields water + sodium sulfate

3. Phosphoric acid + sodium hydroxide yields water + sodium phosphate