COPPER CYCLE

Reminder – Goggles must be worn at all times in the lab!

PRE-LAB DISCUSSION:

Five reaction types you should be able to recognize are synthesis / combination, decomposition, single displacement (replacement), double displacement (replacement) reactions and Redox reactions. Listed below are the details about each type of chemical reaction we will come across in this lab.

Reaction Classifications

1. Synthesis (or Combination) Reactions

In a synthesis or combination reaction, two or more substances combine to form one product. The general form of a combination reaction can be written as:

$$X + Y \rightarrow XY$$

An example of a combination reaction is:

$$MgO + CO_2 \rightarrow MgCO_3$$

2. Decomposition Reactions

In a decomposition reaction, a reactant separates into two or more simpler products. The general form of a decomposition reaction can be written as:

$$XY \rightarrow X + Y$$

An example of a decomposition reaction is:

$$2HgO \rightarrow 2Hg + O_2$$

3. Single Displacement (or Replacement) Reactions

In a single displacement reaction, an element replaces another element in a reacting compound. The general form of a single replacement reaction can be written as:

$$X + YZ \rightarrow Y + XZ$$

An example of a single displacement reaction is:

$$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$$

4. Double Displacement (or Replacement) Reactions

In a double displacement reaction, the cation and anion pairs that make up the reacting compounds change partners to form the products. The general form of a double displacement reaction can be written as:

$$AX + BY \rightarrow AY + BX$$

An example of a double displacement reaction is:

$$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$$

5. Oxidation-Reduction (Redox)

You will be asked to determine whether each reaction you observe in this experiment is an oxidation- reduction reaction or not. Remember that in an oxidation-reduction reaction, electrons are transferred from one element to another. Atoms in the elemental form are neutral, or have no charge, because the number of negatively charged electrons equals the number of positively charged protons. When elements react to form ionic compounds, electrons are transferred from one atom to another, the atoms become charged and the overall process is considered an oxidation-reduction reaction.

Determining whether or not the reactions in this experiment are oxidation-reduction is actually quite simple. In this cycle of reactions, copper will either be in its elemental form with no charge or it will be a cation in an ionic compound with a charge of 2+. If the charge on copper changes during the reaction, that is an indication that electrons have been transferred and the reaction is oxidation-reduction. If the charge on copper does not change during the reaction, that is an indication that no electrons have been transferred and the reaction is not oxidation-reduction.

Here are some examples to illustrate the process of determining if a reaction is oxidation-reduction or not. We will focus on the metal atoms in these illustrations.

Example #1: When HgO is heated it decomposes according to the following equation. Is this reaction an oxidation-reduction reaction?

$$2HgO \rightarrow 2Hg + O_2$$

HgO is an ionic compound and Hg has a 2+ charge in this compound. In the products Hg is in its elemental form which means it is a neutral atom and has no charge. Since the charge on Hg changed from 2+ to 0 during the reaction, electrons were transferred <u>and the reaction is oxidation- reduction.</u>

Example #2: When solutions of $BaCl_2$ and Na_2SO_4 are mixed, the following reaction occurs. Is this reaction an oxidation-reduction reaction?

$$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$$

To determine if this reaction is an oxidation-reduction reaction we can again focus on the cations. Notice that Ba has a 2+ charge as a reactant and a 2+ charge as a product. Na has a 1+ charge as a reactant and also as a product. Since the charge on these ions did not change during the reaction, no electrons were transferred <u>and the</u> <u>reaction is not oxidation-reduction</u>.

PURPOSE

Can copper be obtained after it is chemically changed? In this experiment, you will begin with a small piece of copper and perform a series of experiments that will incorporate the copper into a number of compounds before returning the original elemental copper. In this experiment you will gain experience in recognizing and classifying reaction types. You will follow the instructions to perform the reactions, record your observations as the reactions proceed, write balanced chemical equations for the reactions, classify the reactions and determine whether or not the reactions are oxidation-reduction reactions.

MATERIALS

- Small Piece of Copper
- Balance
- Bunsen burner setup and clamps / holders
- Lab Kit
- Small test tube
- Reagents
- Litmus paper
- Beakers
- Centrifuge

PRE-LAB QUESTIONS

1. Write the chemical formula for iron (II) nitrate.
2. Is the following reaction a synthesis/combination, decomposition, single displacement, or double displacement reaction?
$$6HCl + 2Al \rightarrow 3H_2 + 2AlCl_3$$
3. Is the above reaction an oxidation-reduction reaction?
4. Write the balanced chemical equation for the reaction of magnesium chloride with lithium hydroxide to form magnesium hydroxide and lithium chloride.
5. Classify the reaction type (synthesis/combination, decomposition, single displacement, or double displacement) for the reaction you wrote in #4.

Safety 

1. Wear safety goggles at all times in the laboratory.
2. No food or drink is allowed in the laboratory at any time.
3. Wash your hands thoroughly before leaving the laboratory.

PROCEDURES

Obtain a small piece of copper and determine the mass and record. Obtain a small test tube, determine the mass and record.

Copper to Copper (II) Nitrate

Copper + Nitric Acid → Copper (II) Nitrate + Nitrogen Dioxide + Water

Perform this reaction in the fume hood. Place 20-25 drops of 16 M nitric acid in a small test tube and support the test tube in a beaker in the hood. Add a small piece of copper to the test tube. Allow the copper approximately five minutes to dissolve. The brown gas produced is toxic nitrogen dioxide. When all of the copper has dissolved, fill the test tube approximately ¼ full with distilled water.

Copper (II) Nitrate to Copper (II) Hydroxide

Copper (II) Nitrate + Sodium Hydroxide →

Place the test tube in a beaker of ice water. Add 2 mL of 6 M sodium hydroxide. Stir with a glass stir rod. To test whether enough sodium hydroxide has been added to react with all of the copper, touch the stir rod on a piece of pink litmus paper. If the litmus turns blue, enough sodium hydroxide has been added. If the litmus remains pink, add more sodium hydroxide and repeat the litmus test. The blue precipitate that forms is copper (II) hydroxide.

Copper (II) Hydroxide to Copper (II) Oxide

Copper (II) Hydroxide →

Using a Bunsen burner, heat a beaker of water to boiling. Place the test tube in the boiling water and stir the copper (II) hydroxide until all of the copper (II) hydroxide turns to black copper (II) oxide.

Place the test tube in a centrifuge. Balance the centrifuge by placing a test tube with an approximately equivalent amount of water opposite your test tube in the centrifuge. Centrifuge the test tube and carefully remove the liquid with a plastic dropper. Fill the test tube ¾ full with distilled water, stir and centrifuge the test tube. Again remove the liquid with the dropper.

Copper (II) Oxide to Copper (II) Sulfate

Copper (II) Oxide + Sulfuric Acid →

Add about 3 mL 3 M sulfuric acid to the tube and stir the contents. The black copper (II) oxide will dissolve to give a blue solution of copper (II) sulfate.

Copper (II) Sulfate to Copper

Copper (II) Sulfate + Zinc →

Slowly add a small amount of granular zinc metal to the copper solution. Occasionally stir with the stir rod. Spongy red copper will deposit in the bottom of the tube. The blue coloration will disappear as the copper ions change to copper atoms.

As the copper forms, you will also observe hydrogen gas bubbles being produced as a result of the reaction between zinc and the sulfuric acid.

Zinc + Sulfuric Acid →

Determine the mass of the copper recovered in your experiment. (Hint! It may need to be dried but don't burn it!!!!)

Cleaning Up

1. Clean all items used in the lab
2. Return the glassware to its proper location.
3. Dispose of all trash in a waste basket.
4. Wash your hands thoroughly before leaving the laboratory.

POST-LAB QUESTIONS

1. Compare the amount (mass) of copper that you started with to the mass after performing all of the reactions.

2. How do account for any differences?

3. Is the following reaction a combination, decomposition, single replacement, or double replacement reaction?

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl$$

4. Is the above reaction an oxidation-reduction reaction?

5. Which of the copper cycle reactions in this lab are Redox and why?

6. Compare the appearance of the copper you started out with to the copper you ended up with. Provide possible reasons.

7. Write the balanced chemical equation for the reaction of aluminum with copper(II) chloride.

8. Classify the reaction type (combination, decomposition, single replacement, or double replacement) for the reaction you wrote in #7.