Chemistry 101
CLASSIFICATION OF CHEMICAL REACITONS
Pre-Lab Exercises

Student:____________________________
Date:______________________________
Instructor:___________________________
Section:_____________________________

1. Write the chemical formula for iron (II) nitrate.

2. Is the following reaction a combination, decomposition, single replacement, or double replacement 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 (combination, decomposition, single replacement, or double replacement) for the reaction you wrote in #4.

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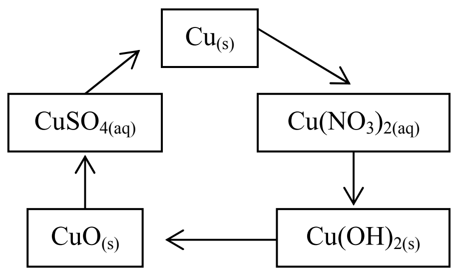
DISCUSSION

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. The series of reactions is summarized by the copper cycle shown below.



Copper Cycle

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.

Reaction Classifications

In this experiment you will gain experience in recognizing and classifying reaction types. The four reaction types you should be able to recognize are combination, decomposition, single replacement and double replacement reactions.

Combination Reactions

In a 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:

$$MgO + CO_2 \rightarrow MgCO_3$$

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:

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

Single Replacement Reactions

In a single replacement 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 replacement reaction is:

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

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

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

An example of a double replacement reaction is:

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

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 reaction is not oxidation-reduction</u>.

PROCEDURE AND REPORT

Copper to Copper (II) Nitrate

Perform this reaction in the fume hood. Place 25 drops of 8 M nitric acid (HNO_3) 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 (NO_2). When all of the copper has dissolved, fill the test tube approximately ¼ full with distilled water.

Write the balanced chemical equation:

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

Observations	Redox?

Copper (II) Nitrate to Copper (II) 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.

Write the balanced chemical equation:

Copper (II) Nitrate + Sodium Hydroxide →

Observations	Type of Reaction	Redox?

Copper (II) Hydroxide to Copper (II) Oxide

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 (CuO).

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.

Write the balanced chemical equation:

Copper (II) Hydroxide $\xrightarrow{\Delta}$

Observations	Type of Reaction	Redox?

Copper (II) Oxide to Copper (II) Sulfate

Add about 3 mL 3 M sulfuric acid (H_2SO_4) to the tube and stir the contents. The black copper (II) oxide will dissolve to give a blue solution of copper (II) sulfate.

Write the balanced chemical equation:

Copper (II) Oxide + Sulfuric Acid →

Observations	Type of Reaction	Redox?

Copper (II) Sulfate to Copper

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.

Write the balanced chemical equation:

Copper (II) Sulfate + Zinc →

Observations	Type of Reaction	Redox?

As the copper forms, you will also observe H_2 bubbles being produced as a result of the reaction between zinc and the sulfuric acid.

Write the balanced chemical equation:

Zinc + Sulfuric Acid →

Observations	Type of Reaction	Redox?