Chemistry CP

Name:

Lab: Mass Relationships in Displacement Reactions Section:

The "recipe" for a chemical reaction is the balanced chemical equation. In the simple example of $2\ H_2 + O_2 \rightarrow 2\ H_2O$, the recipe states that 2 moles of hydrogen molecules plus one mole of oxygen molecules will produce 2 moles of water molecules. Moles are the common language of chemical equations. However, there are no balances that measure amounts in moles. Balances measure amounts in grams. In the above example, we can use the molar masses (gfm) of hydrogen, oxygen, and water to change the equation to say that 4.0 g of hydrogen will combine with 32.0 g of oxygen to form 36.0 g of water.

Often in chemical reactions, the amounts of substances are known or can be easily measured with a balance. In this experiment you carry out a reaction between metallic aluminum atoms and copper(II) ions in solution to produce aluminum ions in solution and metallic copper atoms. The expression, shown without coefficients, is shown here:

$$Al\ (s) + CuCl_2(aq) \rightarrow AlCl_3\ (aq) + Cu\ (s)$$

Since the copper metal is insoluble in water, it is possible to determine the mass of copper produced by gravimetric analysis.

In a chemical reaction, theoretical yield is the term used to describe the expected or ideal amount of product based on a stoichiometric calculation. The actual yield is the experimentally determined amount of product. Percent yield tells you the percent of product obtained compared to the theoretical yield. You can calculate the theoretical yield by using the formula:

$$\%\ yield = \frac{actual\ yield\ (g)}{theoretical\ yield\ (g)} \times 100$$

Objectives

- To observe the reaction between aluminum metal and a solution of copper(II) chloride
- To calculate the number of moles of each of the starting materials present in the solutions
- To determine the limiting reactant
- To determine the theoretical amount of copper that could be produced
- To compare the theoretical amount to the actual amount of copper and calculate the percent yield

Materials

Aluminum foil
Solid copper(II) chloride
Balance
Stirring rod with rubber policeman
Distilled water
Ring stand
Wash bottle containing distilled water
funnel
2 beakers
drying oven (optional)
weighing boats or weighing paper
filter paper
ring

Safety

Safety goggles must be worn throughout the experiment. Copper(II) chloride is a skin and eye irritant.

Procedure

1. Obtain a small piece of aluminum foil. Record observations about the sample.
2. Use a balance to determine the mass of the aluminum sample and record your results to the appropriate number of significant figures.
3. Obtain a small sample of copper(II) chloride. Record observations about the sample.
4. Use a balance to determine the mass of the copper(II) sample and record your results to the appropriate number of significant figures.
5. Transfer the copper(II) chloride sample to a clean beaker. Add some distilled water to the sample and stir to dissolve.
6. Add the aluminum foil to the sample in the beaker. Stir the mixture gently and then allow it to sit undisturbed for 5-10 minutes. Record your observations.
7. Carefully weigh a piece of filter paper to the appropriate precision. Place the filter paper into a funnel, and place the funnel in a ring above a beaker.
8. Carefully remove the copper from the aluminum foil. Use a wash bottle containing distilled water to rinse the foil.
9. Decant the liquid supernatant onto the weighed filter paper. (*Decant* means to pour off the liquid layer without disturbing the underlying solid.) Use the rubber policeman and wash bottle to transfer the copper onto the filter paper.
10. Wash the copper thoroughly with water at least 2 times. Allow the sample to drain.
11. Remove the filter paper from the funnel, open up on a piece of paper towel, and allow to dry overnight. (Alternatively, you may place the sample in the drying oven.) Weigh and record the mass of the filter paper and the dry copper.

Data and Calculations

Be sure to use significant figures properly! Make sure that all required data and calculations are included in your formal lab report.

1. Mass of copper(II) chloride before reaction		Observations
2. Mass of aluminum before reaction		
3. Mass of filter paper and dry copper		
4. Mass of filter paper		
5. Mass of copper produced in reaction		
6. Moles of copper(II) chloride initially present		
7. Moles of aluminum initially present		
8. Moles of solid copper produced		

Analyze and Apply

Answer these questions in complete sentences in your lab report; show all your work for calculations (remember to include units and report your answer with the appropriate number of significant figures).

1. Write a balanced equation for this reaction. What type of reaction is this?

2. Based on the initial masses of copper(II) chloride and aluminum, identify the limiting reagent and determine the theoretical yield (in grams) of copper. You must support your answers with calculations.

3. What observations from the experiment support your identification of the limiting reagent?

4. Calculate the percent yield of solid copper in your experiment. (Remember to include the appropriate formula)

5. Was your percent yield exactly 100%? If it was less than 100%, explain where you think the lost copper went. If it was more than 100%, explain why you have more apparent product than the law of conservation of mass allows.

6. Imagine that you were required to determine the identity of the gas released in this reaction. In order to accomplish this task, you will need a sample of the gas. How will you get it? Be creative—show a picture of your method (no text)!

Remember to write an appropriate conclusion for this lab. Refer to the guidelines for writing a formal lab report.

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Prelab Assignment

1. Define the term *limiting reactant* in your own words.

2. In a maximum of three or four sentences, describe an everyday example of a limiting reagent situation.

3. For a reaction of your choice, use *picture models* to illustrate a limiting reactant situation, including initial and final conditions. Identify the limiting reactant, determine the amount of excess reagent left over, and determine the amount of product formed. Be sure to include the equation!

4. Consider the following chemical reaction: $2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ H_2O(g) + 2\ SO_2(g)$
   a) If 19.7 g of H_2S are reacted with 31.2 g of oxygen gas, what is the theoretical yield of sulfur dioxide gas?
   b) If the actual yield of sulfur dioxide is 24.3 g, calculate the percent yield.