Chemistry 3A

Introductory General Chemistry

Experiment 4a

Law of Constant Composition

Mitch Halloran

Fresno City College

Introduction

Observe

- physical properties of PURE elements: copper wire and solid sulfur

What are the symbols? What is the proposed chemical reaction?

- physical properties of compound formed from a chemical reaction of these elements

copper (Cu)

crystalline

amorphous powder

sulfur (S)

Background

Joseph Proust (1797) stated any sample of a particular compound would be made of same elements in same proportion by mass. This is the Law of Constant Composition.

This principle is connected with the Law of the Conservation of Mass and also Dalton's Atomic Theory concerning how the atoms of elements are never destroyed or created, but just rearranged in chemical reactions forming new compounds.

Limiting & Excess Reagents

- You will learn a very useful concept in chemistry, which is that of the limiting and excess reagents.
- In this experiment, the copper solid mass will be the limiting reagent, and sulfur will be the excess reagent.
- This means we want ALL the copper mass to completely react with an excess amount of sulfur

So how do we know if all the copper will react?

Experiment Planning

- Our lab manual says we should have from 2-4 g sulfur used in the reaction. Let's assume we are at 2 g sulfur: what is the maximum amount of copper mass we should have for it to completely react with the sulfur we use?
- First we to see the chemical reaction that is happening

$$2\ Cu\ (s) + S\ (s) \rightarrow Cu_2S\ (s)$$

- You should know how to write & BALANCE this reaction because you should know that copper sulfide is copper (I) sulfide. Note how mass is balanced

Experiment Planning

- The next step is to know the molar mass of the reactants and the product
  - Copper: 63.546 g/mol
  - Sulfur: 32.065 g/mol
  - Copper (I) sulfide: 2 × Cu + S = 159.16 g/mol
- Two atoms of Cu will be used for every one atom of S
- Two MOLES (mol) of Cu will be used for every one MOLE (mol) of S
- You have 2.00 g S: how many g of Cu will it change?
- $2.00\ \text{g S} \times \frac{1\ \text{mol S}}{32.065\ \text{g S}} \times \frac{2\ \text{mol Cu}}{1\ \text{mol S}} \times \frac{63.546\ \text{g Cu}}{1\ \text{mol Cu}} = 7.93\ \text{g Cu}$
- If you consider you can weigh out up to 4.00 g S, then you could consume as much as ~16 g Cu

Equipment You Will Use

crucible

Bunsen Burner

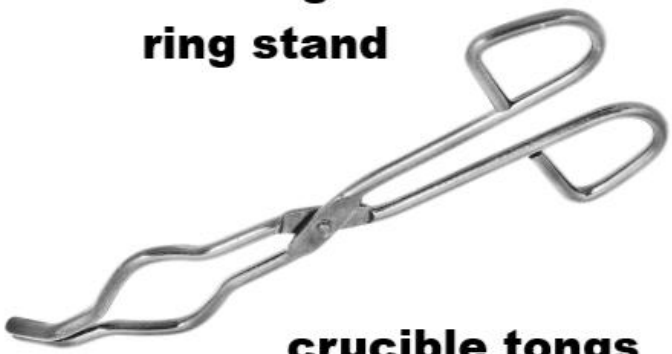
iron ring on ring stand

clay triangle

watch glass

gauzed wire mesh

steel wool



crucible tongs

Procedure

Cleaning the Crucible

1. If crucible dirty, use small steel wool piece to scrape out solids. Wipe with dry paper towel
2. Put crucible on stand and heat with blue-coned flame until slightly red hot
3. Use tongs to set crucible on wire mesh and let cool to room temperature (~5 minutes)

DO NOT SET ANY **HOT** CRUCIBLE ON COUNTERTOP OR ON PAPER OR THEY CAN BURN!

Procedure

Before Reaction

1. Determine mass of empty crucible (A)
2. Get copper wire, coil it to fit in crucible. Record the physical properties, and then the mass of the wire in crucible (B)
3. On glassine paper, use scoopula to get 2-4 g sulfur. Add to the crucible to cover the coiled wire. Record total mass in crucible (C)

Procedure

Reaction

1. Heat the contents with a blue flame of the Bunsen burner. The sulfur will melt within about a minute.
2. Use the crucible tongs to transfer the crucible to the wire mesh. The melted sulfur reacts with the copper during this time.
3. Put the crucible back on the flame: the unreacted sulfur will burn off, forming sulfur dioxide (SO_2) gas, vented in the hood. The crucible looks clean and dry except for the coil of copper sulfide.
4. Set the crucible again on the wire mesh to cool
5. Record mass of crucible with the new compound (**D**)
6. Carefully tip crucible contents on to watch glass and make observations of physical properties

Example Data Analysis

1. Suppose A=23.7584 g, B=34.3532 g, C=37.5732 g. After the reaction, D=36.7841 g
2. [B-A]=10.5948 g, [C-B]=3.2200 g, [D-A]=13.0257 g
3. Copper reacted should be same as initial copper, because copper doesn't go anywhere
4. Sulfur reacted should be [D-A]-[B-A]=13.0257 g - 10.5948 g= 2.4309 g
5. Excess sulfur = [C-B]-2.4309 g = 3.2200 g – 2.4309 g =0.7891 g

Mass ratio = copper/sulfur reacted = 10.5948 g/2.4309 g = 4.3583

Example Data Analysis

What does the mass ratio show?

For every 1 g of S, there are about 4.4 g Cu

Look at the molar masses of S and Cu.

If there are 32.065 g/mol S and 63.546 g/mol Cu, and there are 2 mol Cu and 1 mol S in Cu_2S, then what is the theoretical mass ratio of S to Cu in Cu_2S?

$$\frac{\frac{63.546\ \text{g Cu}}{\text{mol Cu}} \times 2\ \text{mol Cu}}{\frac{32.065\ \text{g S}}{\text{mol S}} \times 1\ \text{mol S}} = \frac{3.9636\ \text{g Cu}}{1\ \text{g S}}$$

4.4 g Cu/g S seems close to 4.0 g Cu/g S. How close can you get?

Clean Up

- The copper sulfide product goes into solids waste container
- WITHOUT AT ALL GETTING CRUCIBLE WET WITH ANY WATER, wipe crucible with dry paper towel
- Use soapy water to clean the watch glass
- Place all other items in appropriate locations