

Mole Ratios

Copper and Silver Nitrate

Introduction

The reaction of copper wire with silver nitrate in aqueous solution provides an interesting display of chemistry in action—silvery silver crystals begin to grow on the wire surface, and the color of copper(II) ions gradually appears in solution. What relationships govern the relative quantities of reactants and products in this chemical reaction?

Concepts

- Mole ratio
- Balanced chemical equation
- Stoichiometry
- Single replacement reactions

Background

Stoichiometry is the branch of chemistry that deals with the numerical relationships and mathematical proportions of reactants and products in a chemical reaction. One of the most important lessons of stoichiometry is that the amounts of the reactants and products in a chemical reaction are related to one another on a mole basis. Chemical reactions are normally represented by balanced chemical equations. The coefficients in a balanced chemical equation summarize the relative number of moles of each reactant and product involved in the reaction. The ratios of these coefficients represent the *mole ratios* that govern the disappearance of reactants and appearance of products. Knowing the mole ratios in a balanced chemical equation is essential to solving stoichiometry problems.

The reaction of copper metal with silver nitrate solution is a single replacement reaction, represented by the following unbalanced chemical equation.



The values of the coefficients x , y , z , and w can be determined experimentally by measuring the mass of copper wire that reacts and the mass of metallic silver that is produced in the reaction.

Experiment Overview

The purpose of this experiment is to determine the number of moles of reactants and products in the reaction of copper and silver nitrate and to calculate their mole ratios. The mole ratio relating the disappearance of copper and the formation of silver metal will be used to write the balanced chemical equation for the reaction.

Pre-Lab Questions

Copper(II) chloride (CuCl_2 ; 0.98 g) was dissolved in water, and a piece of aluminum wire (Al; 0.56 g) was placed in the solution. The blue color due to copper(II) chloride soon faded, and a red precipitate of solid copper was observed. After the blue color had disappeared completely, the leftover aluminum wire was removed from the solution and weighed. The mass of the leftover aluminum wire was 0.48 g.

1. Calculate the number of moles of copper(II) chloride and of aluminum that reacted.
2. What is the mole ratio of copper(II) chloride to aluminum metal? Express this to the nearest whole-number ratio.
3. What happened to the aluminum metal that was consumed in this reaction? Write the formula of the most probable aluminum-containing product.
4. Write a balanced chemical equation for the single replacement reaction of copper(II) chloride with aluminum.

Materials

- Acetone, 125-mL, in a 250-mL beaker*
- Copper wire, Cu, 25 cm
- Nitric acid, HNO_3 , 3 M, 3 drops
- Silver nitrate, AgNO_3 , 1.5 g
- Balance, constant (0.01-g precision)
- Beakers, 50- and 100-mL
- Erlenmeyer flask, 125-mL
- Labeling or marking pen
- Spatula
- Spring scale
- Wash bottle and distilled or deionized water
- Waxen splint

*This is an oxidizing reagent and should be stored with care in groups of students in the laboratory. Place the beaker in the fume hood with a vented burner for use of acid.

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