Flame Tests for Unknowns

Flame Tests

Introduction

The color of light emitted from each metal is unique to that metal alone. No two metals emit the exact same color. Allow students to witness the characteristic colors of four metals.

Concepts

- Flame tests
- Absorption/Emission
- Excited state

Materials

Copper(II) chloride solution, 1.0 M, 5 mL
Lithium chloride solution, 1.0 M, 5 mL
Nichrome wire
Potassium chloride solution, 1.0 M, 5 mL
Sodium chloride solution, 1.0 M, 5 mL
Water, distilled or deionized
Beaker, 200-mL
Bunsen burner
Test tubes, 13 × 100 mm, 4

Safety Precautions

Copper(II) chloride is moderately toxic; avoid contact with eyes, skin, and mucous membranes. Lithium chloride is a body tissue irritant. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review Material Safety Data Sheets for additional safety information. Wash hands thoroughly before leaving the laboratory.

Preparation

Using a pliers bend the end of the nichrome wire to form a loop approximately the size of an inoculating loop.

Procedure

Part A. Teacher demonstration (Day 1)

1. Pour approximately 5 mL of copper(II) chloride solution into a 13 × 100 mm test tube and label the test tube.
2. Repeat step 1 with lithium chloride solution, potassium chloride solution, sodium chloride solution using the three remaining test tubes.
3. Add approximately 100 mL of distilled or deionized water to a 200-mL beaker and set aside.
4. Light the Bunsen burner and adjust flame if necessary.
5. Dip the loop end of the nichrome wire into the copper(II) chloride solution.
6. Carefully place the loop end of the nichrome wire in the flame of the Bunsen burner. *Note:* Nichrome is a poor conductor of heat but still exercise caution and hold the end furthest away from the flame.
7. Instruct students to record the colors of each metal.
8. Dip and swirl the nichrome wire in the rinse water.
9. Repeat steps 5–7 with the three remaining solutions.

Part B. Student Test (Day 2)

1. Give each student (or group) two test tubes containing two unknown solutions.
2. Inform students that their unknowns will be one of the four metals demonstrated during the previous class. It is up to the students to repeat the test to determine the identity.

Publication No. 91346
061616

Tips

- The solutions used in the video are 1.0 M solutions. The exact concentration is not crucial. The most concentrated solutions Flinn Scientific offers of copper(II) chloride and potassium chloride are 0.5 M. If 1.0 M solutions are desired, they should be made from a solid. However, 0.5 M solutions will still produce the characteristic color of each metal.
- As an extension, have students look at the flames through a diffraction grating or piece of Flinn C-Spectra® to observe the line emission spectrum for each metal. Each element has a unique line emission spectrum. Students can sketch the line emission spectrum for each solution, then use them to identify unknown solutions.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Remaining amounts of the metallic salts included in this kit may be saved and reused or disposed of in the trash according to Flinn Suggested Disposal Method #26a.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter

Discussion

Absorption and Emission of Light in a Flame

When a substance is heated in a flame, the substance's electrons absorb energy from the flame. This absorbed energy allows the electrons to be promoted to excited energy levels. From these excited energy levels, the electrons naturally want to make a transition, or relax, back down to the ground state. When an electron makes a transition from a higher energy level to a lower energy level, a particle of light called a *photon* is emitted. A photon is commonly represented by a squiggly line (see Figure 1).

An electron may relax all the way back down to the ground state in a single step, emitting a photon in the process. Or, an electron may relax back down to the ground state in a series of smaller steps, emitting a photon with each step. In either case, the energy of each emitted photon is equal to the difference in energy between the excited state and the state to which the electron relaxes. The energy of the emitted photon determines the color of light observed in the flame. Because colors of light are commonly referred to in terms of their wavelength, equation 1 is used to convert the energy of the emitted photon to its wavelength.

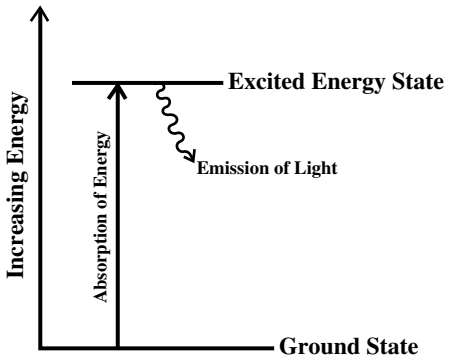

Figure 1. Absorption and Emission of Light.

$$\Delta E = \frac{hc}{\lambda} \qquad \text{Equation 1}$$

In Equation 1,

ΔE is the difference in energy between the two energy levels in Joules,
h is Plank's constant ($h = 6.626 \times 10^{-34}$ J·sec),
c is the speed of light ($c = 2.998 \times 10^{8}$ m/sec), and
λ is the wavelength of light in meters.

Wavelengths are commonly listed in units of nanometers ($1 \text{ m} = 1 \times 10^{9}$ nm), so a conversion between meters and nanometers is generally made.

The color of light observed when a substance is heated in a flame varies from substance to substance. Because each element has a different electronic configuration, the electronic transitions for a given substance are unique. Therefore, the difference in energy between energy levels, the exact energy of the emitted photon, and its corresponding wavelength and color are unique to each substance. As a result, the color observed when a substance is heated in a flame can be used as a means of identification.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Flame Tests for Unknowns* activity, presented by Jeff Bracken, is available in *Flame Tests,* part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Flame Test for Unknowns* are available from Flinn Scientific, Inc.

Catalog No.	Description
L0096	Lithium Chloride Solution, 1 M, 500 mL
C0381	Copper(II) Chloride Solution, 0.5 M, 500 mL
P0236	Potassium Chloride Solution, 0.5 M, 500 mL
S0347	Sodium Chloride Solution, 1 M, 500 mL
N0040	Nichrome, Wire, 16 gauge, 4 oz
AP1714	Flinn C-Spectra®, An Instant Spectroscope

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.