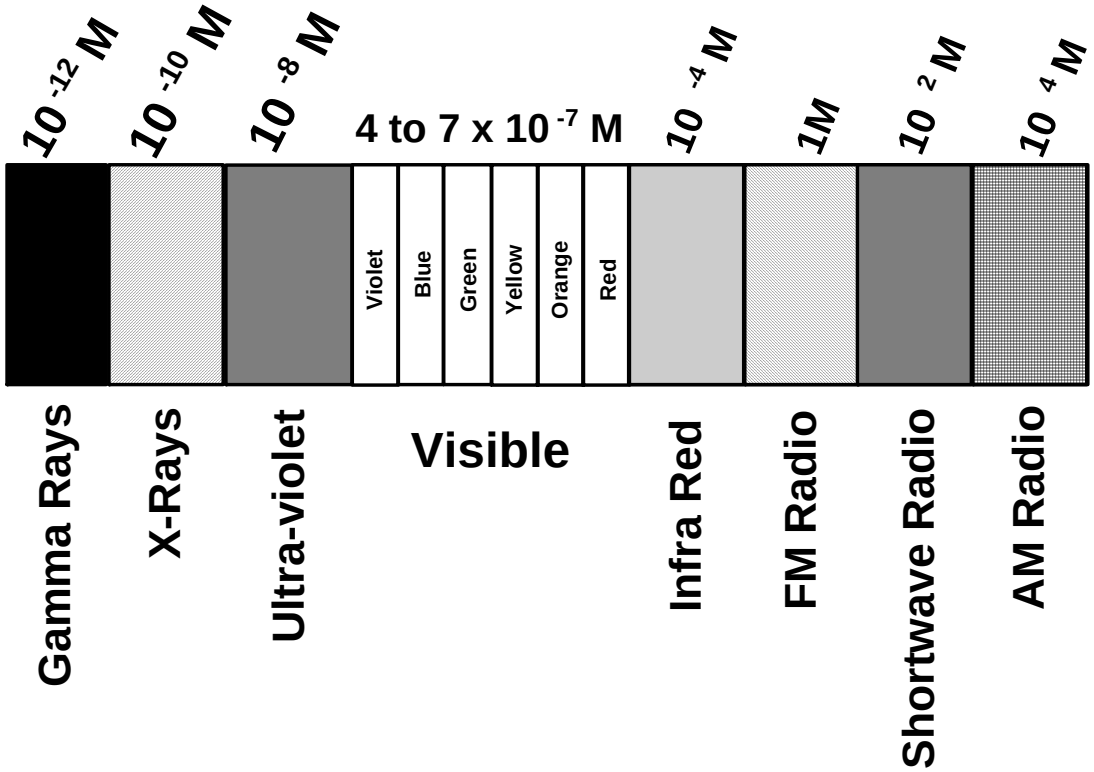
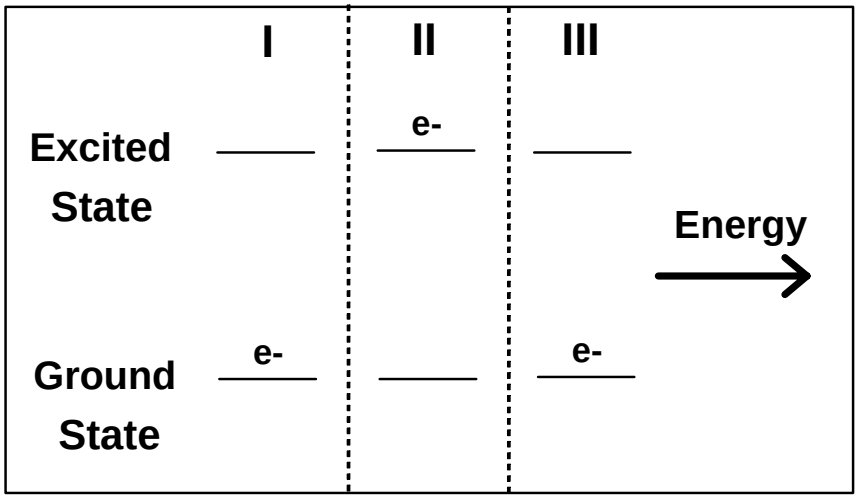
ATOMIC SPECTRA:
Energy, Light, and the Electron

Types of Electromagnetic Radiation



INTRODUCTION

Most metals are very reactive and do not naturally occur in the elemental state. Instead, they normally occur as a component of an inorganic compound. One example of a metal occurring in this state is **hematite**, an ore which contains iron and is used in the production of steel and other iron alloys. Flame tests determine the identification of metals in compounds such as hematite.



Flame tests are performed by placing a compound containing a metal ion in a flame. Once in the flame, the compound is broken down into free, gaseous atoms in a process termed **atomization**. The gaseous metal atoms absorb energy from the flame gases, promoting one of the atom's outer electrons to a higher, unstable energy state called the **excited state** (II). In order to achieve the more stable energy state, the electron eventually loses the absorbed energy and returns to its normal electronic energy level, the **ground state** (III). The energy lost by the atom is in the form of electromagnetic radiation (light) having unique wavelengths.

Every unlike metal has different electronic energy levels. Thus, for different atoms in the flame, energy transitions occurring from element to element will not be equal in magnitude. The unequal magnitudes of energy manifest themselves as different colors of light emitted by the free, gaseous atoms in the flame. This process accounts for the various colors emitted by fireworks, which contain a mixture of metal salts.

The entire process is called **flame emission** and has the following significance: No two unlike elements can emit identical wavelengths (or colors) of light in a flame. The unique colors of light emitted by metals can be effectively and easily used as an identifying test for the presence of the metal in a substance. With the proper equipment and conditions, the flame emission tests can also be used to quantitatively measure the amount of metal present in the substance.

Another method for obtaining spectra utilizes electric current in an arc lamp. The lamp, which contains a rarefied gaseous element, is used to excite the valence electrons of the gaseous element. When the electrons relax from the excited state, they will emit light in the visible region of the spectrum. We will be using **spectroscopes** to view the spectrum produced by these lamps.

TECHNIQUES

Lighting a Bunsen Burner

Consult the “Bunsen Burner” section on Page 14.

Using a wire loop

1. Use the loop labeled for that compound only.

2. DO NOT put hot wires into solutions. Be sure wires are at room temperature before using them.

3. Leave wires as clean as possible by burning off any excess chemicals in the flame.

4. Remember to view the potassium emission through a piece of cobalt glass. This will help to eliminate any interference due to the sodium impurity which may be present.

Using a Spectroscope

1. Hold the spectroscope flat with the narrow end toward you and the opposite side of the spectroscope pointing to the right. Place your eye near the small square on the narrow end of the spectroscope.

2. Point the other end of the scope in the direction of the light source you wish to analyze.

3. On the inside right of the box, you should be able to see bands of colors with numbers increasing from left to right.

4. Record what colors you see and in what order (from left to right) the colors appear.

SAFETY AND DISPOSAL

Burners will be set up in the hoods. Use proper caution around flames (watch long hair, clothing, etc.).

EXPERIMENTAL PROCEDURE

I. Flame emission

A. Observation of known compounds
Dip the labeled wire loop into the corresponding solution to obtain a film in the loop. Hold the loop in the flame and observe the color of flame. record your observations.

1. LiCl
2. $BaCl_2$
3. $CaCl_2$
4. $SrCl_2$
5. $CuCl_2$
6. NaCl
7. KCl (Optional: view through cobalt glass.)

B. Determine the identity of two unknowns by performing a flame emission test. Record the numbers of your unknowns and your test results.

II. Arc emission

A. Observe and record the colors of the gases in the arc lamps. (The lamps will be handled by the instructor or TA ONLY).
   1. Helium
   2. Hydrogen
   3. Mercury vapor
   4. Neon

B. Observe the lamp through the spectroscope provided. Record your observations.

C. Describe the differences between any two of the lamps
   1. Without the spectroscope
   2. With the spectroscope