Atomic Emission Spectra—Flame Tests

Introduction

In the simple Bohr atomic theory you have discussed in lecture, when a HYDROGEN ATOM is bombarded with sufficiently HIGH ENERGY, the electron of the hydrogen atom ABSORBS some of the energy and MOVES TO A HIGHER ORBIT (an orbit that is farther from the nucleus). At a later time, the electron DROPS BACK TO ITS ORIGINAL ORBIT and RELEASES the "extra" energy it had absorbed. In some instances, the energy released by an electron in dropping back to a lower orbit is of such a WAVELENGTH that it is visible to the eye as COLORED LIGHT.

Since the orbits in the hydrogen atom are FIXED DISTANCES apart, corresponding to DISCRETE DIFFERENCES IN ENERGY, the light emitted by hydrogen atoms when excited always occurs at EXACTLY THE SAME wavelengths (colors). The hydrogen atom emits visible light at the following wavelengths (given in nanometers, with the corresponding color listed): 410 (violet), 434(blue), 486 (green), and 656 (red). In addition to the light that is visible to the pigments of the eye, other wavelengths of radiation are also emitted by the hydrogen atom (e.g., ultraviolet, infrared). These emissions, however, also occur at characteristic wavelengths.

The idea of an excited atom emitting light applies in general, in particular with the metallic elements (found at the left and bottom of the Periodic Table of the elements). In most cases, the WAVELENGTHS (colors) of light emitted by excited atoms are so CHARACTERISTIC and SPECIFIC that they can be used to IDENTIFY the atoms. For example, when table salt ($NaCl$) is spilled into a flame, an intense bright ORANGE color results: This orange color is due to a PARTICULAR EMISSION WAVELENGTH that is CHARACTERISTIC of sodium atoms. If such an orange color is observed in the light emitted by an "unknown" excited atom, the unknown atom is almost certainly sodium. The study of the characteristic wavelengths emitted by excited atoms is called EMISSION SPECTROSCOPY.

In today's experiment, you will observe the colors emitted by certain KNOWN elements when they are excited in the Bunsen burner flame. You will then be given an UNKNOWN SAMPLE containing one of the elements previously studied, and will attempt to identify the unknown by the color of the flame produced when excited.

CHEMICALS

$NaCl$ (sodium chloride)—irritant
KCl (potassium chloride)—no health related risks
$SrCl_2$ (strontium chloride)—no health related risks
$BaCl_2$ (barium chloride)—toxic by ingestion
$CaCl_2$ (calcium chloride)—no health related risks
$CuCl_2$ (copper(II) chloride—toxic
HCl (hydrochloric acid)—toxic and corrosive

Procedure

CAUTION! HYDROCHLORIC ACID IS IRRITATING TO THE SKIN AND RESPIRATORY SYSTEM. WEAR SAFETY GLASSES AT ALL TIMES!!

Prepare a flame test wire by obtaining a 10 to15 cm length of Nichrome wire, and bending one end of the wire into a very tiny loop (not more than a millimeter or two in diameter).

Dip the loop end of the flame test wire into a few mL of 6M HCl (to remove any oxides that may be coating the wire). Do not set the wire down any place where it might be contaminated.

Light the Bunsen burner, and open the air-holes of the burner to give a hot flame. Hold the loop end of the flame test wire in the burner flame until it is red hot (this takes only l5 to 20 seconds). Cool the wire in a place where it will not be contaminated.
Obtain 1 or 2 drops of l M NaCl solution on a clean watchglass or in a plastic boat. With the wire loop, pick up a drop of NaCl solution, and place the loop into the burner flame. Observe the color produced and record on the lab report sheet. Caution: The color obtained may only persist for a few seconds before the test solution completely vaporizes.

Re-clean the flame test wire by dipping in 6 M HCl and heating in the burner flame.

Repeat the process for the other available known metal ion solutions: $CaCl_2$, KCl, $BaCl_2$, $SrCl_2$, and $CuCl_2$.

Obtain an unknown sample and record its code number or letter in your lab notebook. Repeat the flame test process and identify which metal ion is contained in the unknown solution.

Note: Since the copper(II) chloride known solution is blue-colored, ALL THE UNKNOWNS HAVE HAD BLUE FOOD COLORING ADDED.

DISPOSAL

Place all the plastic containers and the chemicals into the large beaker labeled Atomic Emissions discarded chemicals.

REMEMBER TO TURN IN THE YELLOW COPY OF YOUR LAB NOTEBOOK TO YOUR TA.

Report Sheet (30 Points)

Name ______________________________ Date _________________

Lab Instructor __________________ Lab Day _____________

Experimental Results

List the flame colors observed for each of the following substances:

$NaCl$ ____

$CaCl_2$ ____

KCl ____

$SrCl_2$ ____

$BaCl_2$ ____

$CuCl_2$ ____

UNKNOWN CODE LETTER ___________________

IDENTIFICATION OF UNKNOWN _________________________

Atomic Emission Spectra
Post Lab Questions (40 Points)

Name ___________________________ Date _______________

Lab Instructor ________________ Lab Day ____________

1. A. Describe the spectrum you would observe for the emission spectrum of elemental hydrogen gas.

   B. Describe the spectrum you would observe for the absorption spectrum of elemental hydrogen gas.

2. List all the possible transitions that can occur between n = 1 and n = 4 in a hydrogen atom. Which ones correspond to lines in the visible region of the spectrum?

3. WBCN FM broadcasts at a frequency of 104.1 megahertz. What is the wavelength and energy of the radio waves sent out by WBCN. (Note 1 megahertz = 1×10^6 Hz)

4. If the planet Mars is about 56 million kilometers from Earth, how long would it take for a radio wave sent from a space satellite circling Mars to reach Earth? Assume that radio waves (a form of electromagnetic radiation) travel at the speed of light.

5. If a laser with a wavelength of 450 nm emits total 7.25×10^{17} photons over a given time period, what is the total energy produced?

6. A fluorescent mineral absorbs "black light" from a mercury lamp. It then emits visible light with a wavelength 520 nm. The energy not converted to light is converted into heat. If the mineral has absorbed energy with a wavelength of 320 nm, how much energy (in kJ/mole) was converted to heat?

Atomic Emission Spectra
Preliminary Questions (10 Points)

Name ___________________________ Date _______________

Lab Instructor ________________ Lab Day ____________

l. Calculate the wavelength, in nanometers, for the colored line that appears in the spectrum of the hydrogen atom corresponding to an n = 4 to n = 2 electronic transition.

2. Draw a simple energy level diagram for the hydrogen atom, and illustrate with arrows the transitions that give rise to VISIBLE light emissions.