Atomic Structure and Periodicity

Objective: It is not common in nature to find the elements on the periodic table in their elemental or pure form. Instead you typically find them either with extra electrons (anions) or with some electrons missing (cations). In today's lab you will use different methods for determining the cation and anion in two unknown samples.

Background: Niels Bohr used the line spectrum of hydrogen gas to create a model of the atom. By exciting the electrons in gases, you can look through a diffraction grating to see individual lines indicating the light energy that is emitted upon the relaxation of the electrons from a higher to lower energy level. An example of this is a neon light. Bohr described this using a planetary model where an electron of hydrogen might get excited from the 1^{st} orbit to the 4^{th} orbit. Upon releasing some of this energy, the electron may relax to the 2^{nd} orbit generating a photon of light that has a wavelength of 486 nm (green). The electron is taking quantum jumps from one particular orbital to another. Likewise, metal ions can be heated and they release energy in the same way, emitting light that is of a distinctive color for that element. This technique is used in fireworks. You will be using a flame test to qualitatively determine which cation is in a solution. Qualitative analysis is the study of what ions or other molecules are present in a sample whereas quantitative analysis is the study of how many molecules/ions are in the sample. Therefore, at the end of your analysis you should be able to say what cations are in your sample, although you will not be able to say how many grams of each cation is present.

In addition to determining an unknown cation, you will also determine which anions are present in a water sample. You will test your unknown water sample for the presence of chloride (Cl^-), iodide (I^-), and sulfate (SO_4^{2-}) anions. When found in excess, these ions have been shown to be indicators of water pollution. The way in which you will do this is by testing their solubilities with different cations. The solubility has been empirically (experimentally) determined and you can find the information in Table 4.1 in your textbook (p. 111). Before jumping in and testing your unknown you should run knowns (also called controls). What is the reaction of each ion alone, without any other ions present? If you observe this first, you know what to look for in your unknown analysis.

Procedure:

Gases

Begin by looking at Hydrogen (H_2) as it is electrically excited using a diffraction grating. Page 194 of your text shows a nice spectrum of hydrogen and sodium. Compare the spectrum to at least two other gases (neon, mercury, helium, xenon, krypton, oxygen, or iodine). Not only are the colors of the lines important, but also the spacing between them. Draw the spectra in your notebook.

Cations

Dip the Q-tip into the lithium ion solution and hold the Q-tip just above the inner blue cone of the Bunsen burner flame. Observe the color emitted by the heated solution. Do not hold the Q-tip in the flame so long that you begin to burn it, but re-dip it in the metal solution if necessary. Repeat the process at the different burners around the lab using the other metal ions (sodium, calcium, strontium, barium, copper, potassium, and lead). You may also want to look at the color using the blue glass filter, which will filter out some of the impurities. Lastly, choose an unknown solution and determine which cation is present.

Anions

The grid below is incorporated to give you an idea of how your lab notebook could be arranged. Your data should ALWAYS be entered into the notebook itself, and not onto some pieces of paper lying around in the lab (i.e., this handout).

I. Solubility of the halogens and the halides

A. Test the solubility of Cl^-, Br^-, and I^- in both water and cyclohexane (C_6H_{12}) by adding a small amount (the size of a match head) of their sodium salts to separate test tubes and adding 0.5-1.0 mL of water. Repeat the test with C_6H_{12}. Mix vigorously. Record your observations. What conclusions can you draw?

B. Mix the Cl^- (in water) with the Cl^- (in C_6H_{12}). Mix the solutions vigorously for 15 seconds. Do the same for the Br^- solutions and I^- solutions. Record your observations and conclusions. Which layer is on top? How do you know?

C. Test the solubility of a few I_2 crystals in water and in C_6H_{12} in a manner similar to part I.A. Add about 1.0 mL of C_6H_{12} to the water solution of I_2 and mix vigorously. Record your observations and conclusions. Contrast I^- with I_2.

D. Obtain approximately 10 mL each of water solutions of I_2, Br_2, and Cl_2. Place 5 drops of each in separate test tubes and add about 1 mL of C_6H_{12}. Mix vigorously. Repeat the test with 10 drops of each in about 1 mL of C_6H_{12}. Record your observations.

E. Summarize your observations on the colors and solubility of the halides and halogens in a grid.

	Cl^-	Br^-	I^-	Cl_2	Br_2	I_2
in water						
in cyclohexane						

II. Interactions between <u>chlorine</u> and other halides

A. Add 5 drops of Cl_2 (in water) to 1 mL of Br^- (in water). Mix thoroughly. Add 0.5 mL of C_6H_{12} and mix vigorously. Record your observations.

B. Repeat experiment II.A substituting I^- (in water) for the Br^-. Record your observations.

III. Interactions between <u>bromine</u> and other halides
   A. Repeat experiment II.A and B using Br_2 (in water) with Cl^- (in water) and with I^- (in water). Record your observations.

IV. Interactions between <u>iodine</u> and other halides
   A. Repeat experiment II.A and B using I_2 (in water) with Cl^- (in water) and with Br^- (in water). Record your observations.

	Cl_2	Br_2	I_2
Cl^-			
Br^-			
I^-			

V. Unknown
   Devise a method for determining which of the following anions is in your unknown sample: Cl^-, Br^-, or I^-. One and only one anion is in each sample.

VI. Waste
   Pour any cyclohexane waste into the separatory funnel located in the hood.

Write Up

Complete the write up sheet posted at the web page.

Questions:

1. Are there any correlations between the reactivity of the halogens and their position on the periodic table? How about the halides?