PERIODIC PROPERTIES OF THE ELEMENTS

Adapted from General Chemistry Laboratory, Chemistry Department, University of Wisconsin-Madison

The purpose of this experiment is to explore the chemistry of a few of the elements, both in the laboratory and by computer. You will look for trends in the chemical and physical properties of the elements as a function of the position of the elements in a periodic group.

GENERAL DIRECTIONS

1. Follow the experimental procedure detailed in the laboratory write-up.
2. Record your observations in the Data Section of this handout for the reactions observed. In this experiment, some reactions occur immediately, some take longer, some never occur. (The element being investigated is always the limiting reagent, if it reacts, all of it should be consumed.)

   Note any and all reactions that may occur. Especially record similarities and differences between different elements within the same group and between elements of different groups. From your observations, try to determine the form and formula of the resulting products.
3. From your observations, complete the questions at the end of this write-up.
4. Using the computer program, *The Chemistry Navigator*, which is available on the Macintosh computers in the Chemistry/Physics Computer Center in Room 122, complete the attached Periodic Properties Computer Exercise.

EXPERIMENTAL PROCEDURE

Use distilled or deionized water in all experiments calling for water. *Record all observations on the accompanying data sheets as you do the experiment*. Write chemical equations for all reactions observed; if no reaction is observed, write n.r. in the appropriate space.

Observation of Properties

A. The Group IA Elements: Alkali Metals–Lithium and Sodium

1. Using a clean, dry watch glass, get a small piece, about 1/8 in. diameter (about 0.03 g) of metallic lithium and sodium under kerosene from your instructor. Handle these pieces with dry forceps or tongs. Remove the excess kerosene from the metal by pressing the metal against a piece of paper towel. [After you are finished with the paper towel, thoroughly wet the paper towel in the sink and then discard it in the waste bucket.]
2. Cut the piece of sodium metal with the end of a spatula and simultaneously observe what happens as the freshly cut surface is exposed to the atmosphere.
3. Drop the small piece of sodium metal into 50 mL of distilled water in a 250 mL beaker, simultaneously covering the beaker with a wire gauze. Keep the beaker at arms length. Test the resulting solution with litmus paper.
4. Carry out the same reaction with lithium metal. Record your observations.

3 **Li** 6.941
11 **Na** 22.998
19 **K** 39.0983
37 **Rb** 85.4678
55 **Cs** 132.905

The Group 1A alkali metal elements

4 **Be** 9.0122
12 **Mg** 24.305
20 **Ca** 40.078
38 **Sr** 87.62
56 **Ba** 137.327

Most of the Group 2A or alkaline earth metals

B. The Group 2A Elements: Alkaline Earth Metals–Magnesium and Calcium

1. Grasp a small piece of magnesium ribbon with crucible tongs and, while holding it at arm's length, insert it in the burner flame. Do not look directly into the flame. Record your observations and write the balanced equation for the reaction.
2. Repeat the test with a small piece of calcium. Record the observations.
3. Scratch a small piece of magnesium ribbon with a spatula. Make up a test tube of 5 mL of water and a few drops of phenolphthalein indicator. Place your magnesium in the test tube. Record your results.
4. Repeat this test with water and a small piece of calcium. (It may be necessary to break the calcium into small pieces.) Record the observations and note the difference in behavior of these elements toward water as compared to the metals of Group 1A. Write equations for the reactions.
5. Place 5 mL of 6 M HCl in each of two test tubes. Carefully drop a piece of magnesium into one test tube and a piece of calcium into the other. Place an inverted test tube over one of the test tubes to collect a sample of the gas being evolved. Immediately put the inverted test tube over an open flame. Record the observation.

5 **B** 10.81	6 **C** 12.011
13 **Al** 26.9815	14 **Si** 28.0855
31 **Ga** 69.723	32 **Ge** 72.61
49 **In** 114.82	50 **Sn** 118.710
81 **Tl** 204.383	82 **Pb** 207.2

Groups 3A and 4A of the periodic table.

C. The Group 3A Elements–Aluminum

1. Grasp a small piece of aluminum wire with crucible tongs and, while holding it at arm's length, insert it in the burner flames. Record the observations.
2. Place about 0.25 g of granular aluminum in a test tube containing water and another sample of aluminum in a 150 mL beaker containing 5 mL of 6 M HCl. Record the observations. Write a balanced equation for any reaction you may observe.

D. The Group 4A Elements–Carbon

Place about 0.25 g of powdered carbon in a test tube containing water and another sample of carbon in a test tube containing 5 mL of 6 M HCl. Tap the bottom of each tube gently with a finger. Wait 5 minutes, then tap each tube again. Record your observations.

E. The Group 7A Elements: the Halogens–Chlorine, Bromine, and Iodine

Here you will place a small quantity of aqueous solutions of each of the halogens (Cl_2, Br_2, and I_2) in a small test tube. On adding hexane, an organic liquid that does not mix with water, you will see two layers in the test tube.

After observing the color of the halogen dissolved in hexane, the next step is to mix a halogen with the salt of another halogen and then add hexane. In some cases, the halogen will oxidize the halide ion in a reaction such as

$$Cl_2(aq) + 2\ Br^-(aq) \rightarrow 2\ Cl^-(aq) + Br_2(aq)$$

When this particular reaction occurs, the bromine released in the reaction dis-

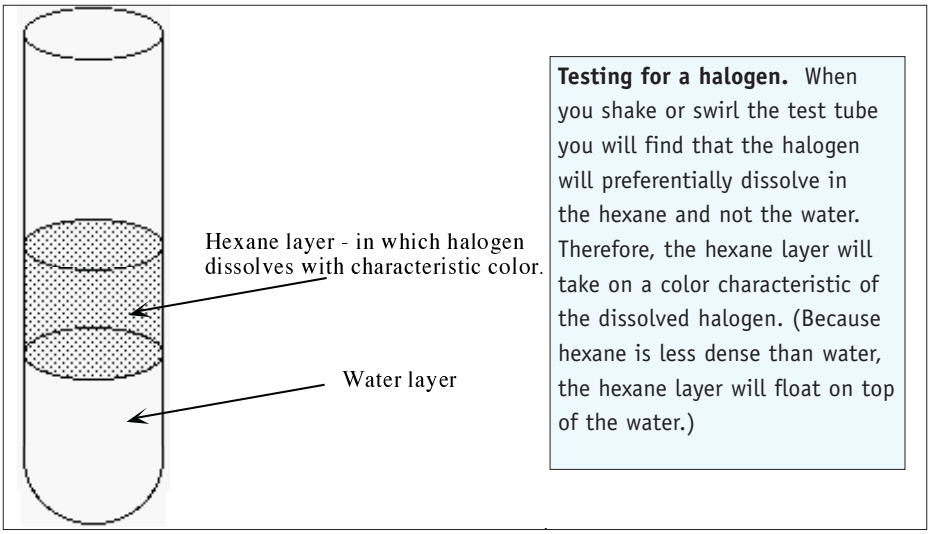
solves in the hexane layer, and you observe the characteristic color of bromine in the hexane.

Part E-1: Color of Halogens in Hexane

The purpose of this part of the experiment is to discover the color that each halogen (Cl_2, Br_2, and I_2) has in the organic solvent hexane.

1. *Add chlorine water*

   Place about 2 mL of chlorine water (chlorine dissolved in water), bromine water, and iodine water into separate test tubes. Record the appearance of each one.



Testing for a halogen. When you shake or swirl the test tube you will find that the halogen will preferentially dissolve in the hexane and not the water. Therefore, the hexane layer will take on a color characteristic of the dissolved halogen. (Because hexane is less dense than water, the hexane layer will float on top of the water.)

9 **F** 18.9984
17 **Cl** 35.4527
35 **Br** 79.904
53 **I** 126.9045
85 **At** (210)

The Group 7A elements or the halogens

2. *Add hexane*

   To each test tube, add about 2 mL of hexane. Mix the contents of each test tube by shaking or swirling it carefully. Record your observations, particularly the color of the hexane layer.

Note: hexane is flammable. Avoid physical contact.

Part E-2: Reactions of the Halogens

The purpose of this part of the experiment is to find out which halogen can oxidize which halide ions or ions. If such a reaction occurs, the product halogen will be dissolved in the organic solvent (hexane) and, from the color observed above, you can decide if the reaction occurred.

3. *Reaction of Cl_2 with Br^- and Cl_2 with I^-*

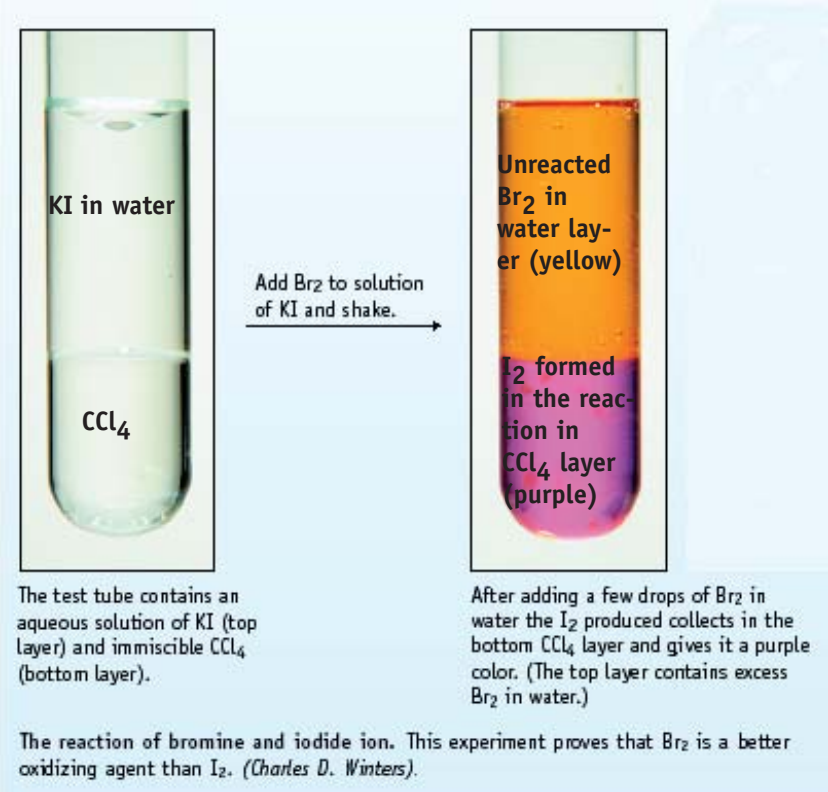
   Add a few drops of chlorine water (chlorine dissolved in water) to a clean test tube containing 1 mL of 0.2 M KBr and to a second test tube containing 1 mL of 0.2 M KI.

4. *Reaction of Br_2 with Cl^- and Br_2 with I^-*

   Add a few drops of bromine water (bromine dissolved in water) to another test tube containing 1 mL of 0.2 M NaCl and to a test tube containing 1 mL of 0.2 M KI.

5. *Reaction of I_2 with Cl^- and I_2 with Br^-*

   Add a few drops of iodine water (iodine dissolved in a KI solution) to a different test tube containing 1 mL of 0.2 M NaCl and to a second test tube containing 1 mL of 0.2 M KBr.



The reaction of bromine and iodide ion. This experiment proves that Br_2 is a better oxidizing agent than I_2. *(Charles D. Winters).*

Br_2 can oxidize I^- to I_2. The I_2 dissolves preferentially in a nonpolar solvent like CCl_4 more readily than in polar water. See *Chem & Chem Reactivity*, 5th edition, page 972.

6. *Add hexane to each test tube above*

   Add 2 mL of hexane (C_6H_{14}) to each solution from steps 3 through 5 and mix the contents thoroughly (by shaking or swirling it carefully). *Record your observation on the data sheet.* In particular look for evidence of reaction by examining the color of the hexane layer.

F. The Transition Elements–Iron, Copper, and Zinc

1. Place 5 mL of water in each of three test tubes. Now place a piece of iron (steel wool) in one test tube, copper in a second, and zinc in a third. Tap each tube. Record the observations.
2. Repeat the experiment with 2 mL of 6 M HCl and a sample of each metal. Record the observations.
3. Repeat the experiment with 2 mL of 6 M nitric acid, HNO_3 and a sample of each metal. Record the observations.