Experiment 2.
Periodic Table and Periodic Law

Experimental Procedure

- Objectives
- Introduction
- Experimental Procedure

Objectives

- ✓ To become more information familiar with the periodic table
- ✓ To observe and to generalize the trends of various atomic properties within groups and periods of elements
- ✓ To observe from experiment the trends of the chemical properties within groups and periods of elements

Experimental Procedure

SAFETY WARNING !
STRONG ACIDS AND BASES, HALOGENS

Wear safety glasses and gloves when handling with chemicals in a laboratory.

DISPOSAL:

Dispose of the waste water / halogen mixtures
in the Waste Halogens container in the chemical hood.

CLEANUP:

Rinse the test tubes with copious amounts of tap water
And twice with distilled water. Discard the rinses in the container.

A. Periodic Trends in Physical Properties (dry Lab)

The periodic trends for the elements are analyzed through a series of questions on the *Report Sheet*

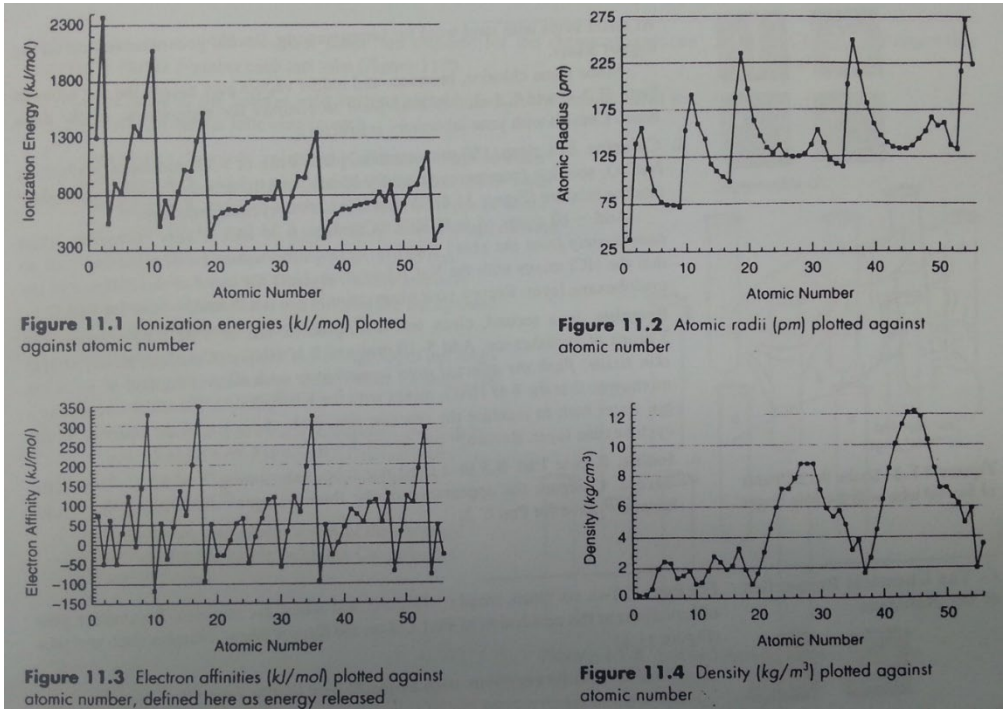


Figure 11.1 Ionization energies (*kJ/mol*) plotted against atomic number

Figure 11.2 Atomic radii (*pm*) plotted against atomic number

Figure 11.3 Electron affinities (*kJ/mol*) plotted against atomic number, defined here as energy released

Figure 11.4 Density (kg/m^3) plotted against atomic number

Summary

The periodic trends for the elements are analyzed through a series of questions on the ***Report Sheet***.

Figure 11.1: Ionization energy (KJ/mol)
Figure 11.2: Atomic radii (pm)
Figure 11.3: Electron Affinities (KJ/mol)
Figure 11.4: Density (Kg/m^3)

PART B. The Appearance of Some Representative Elements

Prepare a hot water bath for PART B-3.

B-1. Sample of elements

Na, Mg, Al, Si, S

Record your Observations on the Report Sheet.

Summary for Part B

Conduct this PART experiments in the fume hood or near the mouth of movable arm hood.

Part #	PART B.2	PART B.3	PART B.4
Preparation of Halogen	Preparation of Cl_2	Preparation of Br_2	Preparation of I_2
150-mm test tube #	#1	#2	#3
Steps	**Step 1**: In a clean test tube, Add 2 mL of 5% NaOCl solution and 10 drops of cyclohexane (Agitate the mixture) and 10 drops of 6M HCl **Step 2**: Swirl or agitate it **Step3**: Record your observation.(★1)	**Step 1**: In a clean test tube, Add 2 mL of 3M KBr and 10 drops of cyclohexane and 5-10 drops of 8M HNO_3 **Step 2**: Swirl or agitate it. **Step 3**: Place the test tube in a hot water **Step4**: Record your observation (★2)	**Step1**: In a clean test tube, Add 2 mL 3M KI and 10 drops of cyclohexane and 5-10 drops of 8M HNO_3 **Step2**: Swirl or agitate it. **Step3**: Place the test tube in a hot water **Step4**: Record your observation. (★3)
	Do not discard ! **Save for PART C.1**	*Do not discard !* **Save for PART C.2**	*Do not discard !* **Save for PART C.3**

- ***Prepare a hot bath for Part B.3.***

1. **Samples of elements**

   1) Samples of the third period elements (Na, Mg, Al, Si, S) on the table
      a. Na is stored under a non-aqueous liquid to prevent rapid air oxidation
      b. Polish the Mg and Al metal strips with steel wool for better viewing.

   2) Record your observations on the ***Report Sheet.***

2. Chlorine (In the fume hood or near the arm hood)

1) In a clean, 150 mm test tube, place 2 ml of a sodium hypochlorite, NaOCl, solution and 10 drops of cyclohexane.

2) Agitate the mixture.

3) Add ~ 10 drops of 6 M HCl (***Caution!***).

4) Agitate the mixture (with the stirring rod).

5) Note the color of the chlorine in the cyclohexane layer.

6) Record your observation and save the mixture for **Part C.1**.

3. Bromine (In the fume hood or near the arm hood)

1) Clean test tube, place 2 ml of 3 M KBr solution and 10 drops of cyclohexane

2) Add 5-10 drops of 8 M HNO_3 (*Caution !*)

3) Agitate the mixture and place the test tube in a hot water bath to increase the reaction rate

4) Note the color of the bromine in the cyclohexane layer.

5) Do not discard – save for **Part C.2**.

4. Iodine

1) Clean test tube, place 2 ml of 3 M KI solution and 10 drops of cyclohexane.

2) Add 5-10 drops of 8 M HNO_3 (*Caution !*).

3) Agitate the mixture and place the test tube in a hot water bath to increase the reaction rate.

4) Record compare the appearance of the three halogens dissolved in the cyclohexane.

5) Save for **Part C.3**.

C. The Chemical Properties of the Halogens

Summary for Part C

PART C.1

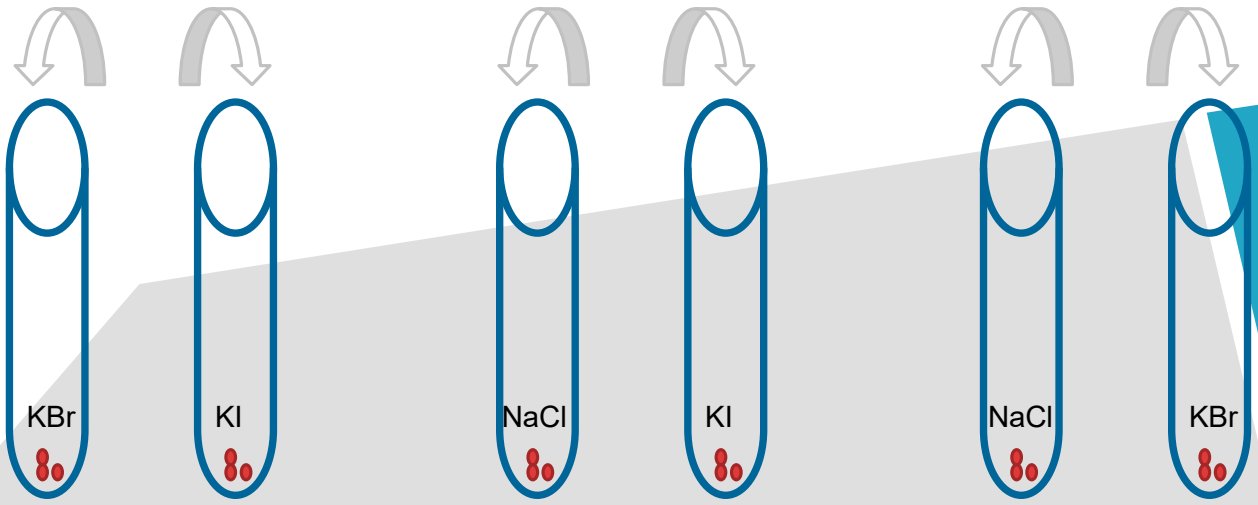
Cl_2/Cyclohexane
Solution From **PART B.2**

PART C.2

Br_2/Cyclohexane
Solution From **PART B.3**

PART C. 3

I_2/Cyclohexane
Solution From **PART B.4**



100-mmTest tube #1 #2 #3 #4 #5 #6

Step1. Add a pinch of solid
Step2: Add an equal portion of the halogen/cyclohexane solution
Step3: Swirl the solution, observe, and record.

Write appropriate net ionic equations. (★4)(★5)(★6)

- ***Prepare six clean, small (~100 mm) test tube.***

1. Chlorine and its reactions with bromide and iodide ions

1) In Clean two small test tubes
   a. Add a pinch of solid **KBr** to the **first** test tube.
   b. Add a pinch of solid **KI** to the **second** test tube.
2) Use a dropping pipet to withdraw the chlorine/cyclohexane layer from **Part B.2.**
3) Add an equal portion to the two test tubes.
4) Agitate the solution, observe, and record.
5) Write appropriate net ionic equations.

2. Bromine and its reactions with chloride and iodides ions

1) Clean two small test tubes.
   a. Add a pinch of solid **NaCl** to the **third** test tube
   b. Add a pinch of solid **KI** to the **fourth** test tube

2) Use a dropping pipet to withdraw the bromine/cyclohexane layer from **Part B.3.**

3) Add an equal portion to the two test tubes.

4) Agitate the solution, observe, and record.

5) Write appropriate net ionic equations.

3. Iodine and its reactions with chloride and bromide ions

1) 1) In Clean two small test tubes,
   a. Add a pinch of solid **NaCl** to the **fifth** test tube.
   b. Add a pinch of solid **KBr** to the **sixth** test tube.

2) Use a dropping pipet to withdraw the iodine/cyclohexane layer from **Part B.4.**

3) Add an equal portion to the two test tubes.

4) Agitate the solution, observe, and record.

5) Write appropriate net ionic equations.

D. The Chemical Properties of the Halides

Summary for PART D

1. The reactions of the halides with various metal ions

Reactions	**PART D.1-a**) Slowly add 10 drops of 2 M $Ca(NO_3)_2$. (Vary the color of the background of the test tubes for observation)	**PART D.1-b)** Add slowly 10 drops of 0.1 M $AgNO_3$. After 1min, add 10 drops of 3 M NH_3.	**PART D.1-c)** Add 1 drop of 6 M HNO_3 and slowly add 10 drops of 0.1M $Fe(NO_3)_3$.
NaF + 10 drops of distilled water	100-mm test tube # 1	#2	#3
NaCl + 10 drops of distilled water	#4	#5	#6
KBr + 10 drops of distilled water	#7	#8	#9
KI + 10 drops of distilled water	#10	#11	#12

Step 1: Add a pinch of solid + 10 drops of distilled water
Step 2: Add drops of the metal ion solution to each test tubes
Step 3: Observe closely and over a period of time. (★7) (★8) (★9)
Step 4: Record and summarize your observations of chemical activity with the halides with the Ca^{2+}, Ag^{+}, and Fe^{3+} ions.

- ***Prepare twelve clean, small (~100 mm) test tube***

1. **The reactions of the halides with various metal ions**

   Label 12 clean, small test tubes

- Test tubes 1, 2 and 3 : a pinch of **NaF** and 10 drops of water
- Test tubes 4, 5 and 6 : a pinch of **NaCl** and 10 drops of water
- Test tubes 7, 8 and 9 : a pinch of **KBr** and 10 drops of water
- Test tubes 10, 11 and 12 : a pinch of **KI** and 10 drops of water

a) Slowly add 10 drops of 2 M **$Ca(NO_3)_2$** to test tubes 1, 4, 7 and 10.

b) Slowly add 10 drops of 0.1 M **$AgNO_3$** to test tubes 2, 5, 8 and 11.

c) Add 1 drop of 6 M HNO_3 (Caution) and slowly add 10 drops of 0.1 M **$Fe(NO_3)_3$** to the test tubes 3, 6, 9 and 12.

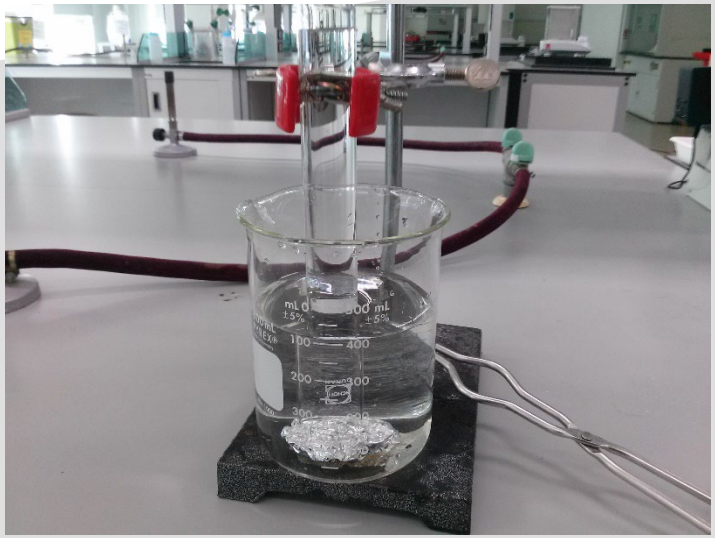
d) Summarize your observations of the chemical activity for halides with the Ca^{2+}, Ag^{+} and Fe^{3+} ions.

E. Chemical Reactivity of Some Representative Elements

E.1. Na

TA Demonstration Only

Test the gas by holding the mouth of the inverted test tube over a Bunsen flame.
(★10) Account for the appearance of the color change in the solution.



E.2. Mg and Al

Reactions	**PART E.2-a)** With Acid	**PART E.2-b)** With Base
Mg	clean 100-mm test tube # 1	#1
Al	#2	#2
Steps	**Step 1:** Cut 5-mm pieces and place them into separate small test tubes. **Step 2:** Add 1 mL of 6 M HCl to each tube. Which metal reacts more rapidly? **(★12)** What is the gas that is evolved? **(★13)** Record your observation.	**Step 1:** Add (count) drops of 6 M NaOH to the test tube with Al ion solution until precipitate appears. **Step 2**: Add the same number of drops to the test tube containing the Mg ion solution. Record your observations. **(★14)** Step 3. Add drops of 6 M NaOH until both solutions are again colorless. Observe closely as each drop is added. Record and explain.

E.3. Solubilities of Alkaline-earth cations

Solubility	0.1 M $MgCl_2$	0.1 M $CaCl_2$	0.1 M $Sr(NO_3)_2$
PART E.3-a)	test tube # 1 (+ 5 drops of 0.10M NaOH + 1 ~ 2 drops of 1.0 M NaOH)	#2 (+ 5 drops of 0.10M NaOH + 1 ~ 2 drops of 1.0 M NaOH)	#3 (+ 5 drops of 0.10M NaOH + 1 ~ 2 drops of 1.0 M NaOH)
PART E.3-b)	#4 (+5 drops of 0.10 M Na_2SO_4 + a pinch of solid Na_2SO_4)	#5 (+5 drops of 0.10 M Na_2SO_4 + a pinch of solid Na_2SO_4)	#6 (+5 drops of 0.10 M Na_2SO_4 + a pinch of solid Na_2SO_4)

Step 1: Place 10 drops of each cation in three separate, clean 100-mm test tubes.

Step 2: Count and add 5 drops of 0.10 M NaOH or 0.10 M Na_2SO_4 until a cloudiness appears in each test tube. You can observe a change in appearance about one of three cations.

Step 3: Add 1 ~ 2 drops of 1.0 M NaOH or a pinch of solid Na_2SO_4 to determine the order of one of two cations.

Step 4: Predict the trend in the solubility of the hydroxides (★15) and the sulfates (★16) of the Group 2A cations.

E.4. Sulfurous acid and sulfuric acid (In a hood or near arm hood)

Solubility	5 drops of 6 M HCl
PART E.4-a) Na_2SO_3	#1
PART E.4-b) Na_2SO_4	#2

Step 1: Place a double pinch of each solid in two separate, clean 100-mm test tubes.

Step 2: Add 5 drops of 6 M HCl.

Step 3: Test the evolved gas with wet blue litmus paper. Write a balanced equation for the reaction. **(★17)**

Step 4: Account for any differences or similarities in your observations. **(★18)**

• *TA Demonstration Only*

1. Sodium

1) Place a pea-sized piece of aluminum foil and add 2 mL of 6 M NaOH in a 100-mm test tube.

2) Place it in a 250-mL beaker and cover the test tube up with a 150-mm test tube. It will bubble slowly. Allow the reaction to proceed for 5 minutes. Stopper the test tube.

3) Test the gas by holding the mouth of the inverted test tube over a Bunsen flame or another open flame. (A loud pop indicates the presence of hydrogen gas.)

2. Magnesium and aluminum

1) Reaction with acid

a. Polish 5 cm strips of Mg and Al metal.
b. Cut 5 mm pieces and place them into separate small test tubes.
c. Add 1 mL of 6 M HCl to each test tube.
d. Which metal reacts more rapidly? What is the gas that is evolved?

2) Reaction with base

a. Add drops of 6 M NaOH to each test tube until a precipitate appears.
b. Continue to add NaOH to the test containing the aluminum ion until a change in appearance occurs.
c. Add the same number of drops to the test tube containing the magnesium ion .
d. Add drops of **6 M NaOH** until both solution are again colorless.

3. Solubilities of alkaline-earth cations

1) Solubility of alkaline-earth cations

a. Place 10 drops of 0.1 M $MgCl_2$, 0.1 M $CaCl_2$ and 0.1 M $Sr(NO_3)_2$ in three separate, clean test tubes.
b. Count and drops of 0.10 M NaOH until a cloudiness appears in each test tube.
c. Predict the trend in the solubility of the hydroxides of the Group 2A cations.

2) Solubility of the sulfates

a. Place 10 drops of 0.1 M $MgCl_2$, 0.1 M $CaCl_2$ and 0.1 M $Sr(NO_3)_2$ in three separate, clean test tubes
b. Count and add drops of 0.10 M Na_2SO_4 until a cloudiness appears in each test tube
c. Predict the trend in the solubility of the sulfates of the Group 2A cations

4. Sulfurous acid and sulfuric acid

1) Place a double pinch of solid sodium sulfite, Na_2SO_3, into a clean, small or medium-sized test tube.

2) Add 5-10 drops of 6 M HCl.

3) Test the evolved gas with wet blue litmus paper.

4) Write the balanced equation for the reaction.

5) Repeat the test, substituting solid sodium sulfate, Na_2SO_4, for the Na_2SO_3.

DISPOSAL:

Dispose of the waste water / halogen mixtures in the Waste Halogens container.

CLEANUP:

Rinse the test tubes with copious amounts of tap water And twice with distilled water. Discard the rinses in the container.