PERIODIC LAW (IT'S ALL IN THE FAMILY)

INTRODUCTION

By now you have learned that elements appearing in the same column on the Periodic Table of the Elements form a "family". Membership is based on common behavior due to similar chemical and physical properties that recur periodically. Doing electron configurations for members of the same family will reveal that they all have the same number of electrons in their outermost shell (valence electrons). Thus similarity of properties is related to this same outer-shell electron configuration.

For a given property, though, you may notice slight variations or trends within a family. For instance, as you proceed down Group/Family 17, the boiling points increase. This is called a trend. In each of today's activities, you are to discover trends in three properties: chemical activity (Family 1), density (Family 14), and solubility (salts of elements in Family 2).

First you will observe a teacher demo showing the chemical behavior of two members of Family 1, the alkali metals, in the presence of water. See if there is a relationship between chemical activity and the relative position in the family. Does the chemical activity of Family 1 increase or decrease as you proceed down the family?

Next, you will perform an experiment with aqueous solutions of four members of Family 2, the alkaline earth metals. You will be reacting them with four different reagents to compare their solubilities. If a precipitate forms, you will conclude that the new salt of that Family 2 ion is insoluble. By comparing all your results, you should be able to rank the ions from very soluble to insoluble and relate that to the element's position in Family 2 (top of the family, middle of the family, bottom of the family). In other words, as you proceed from top to bottom in the family, what is the trend in solubility that you observe? Does the solubility increase or decrease as you go down the family?

The third part of this lab involves manipulating data regarding the densities of three members of group 14, the carbon group. You will calculate their density, graph the results, and then predict the density of the other two members of Family 14 from the graph.

OBJECTIVES

1. To examine the periodic variation of chemical activity, density, and solubility of elements or compounds within groups of elements.
2. To determine solubilities of certain salts of Group 2 elements.
3. To determine the densities of three elements in Group 14.
4. To make predictions of densities of untested Group 14 elements and to predict the solubility of an unknown Group 2 salt, based on determinations made.

MATERIALS

GROUP 2 NITRATE SOLUTIONS		REAGENTS	
0.1 *M* magnesium nitrate	$Mg(NO_3)_2$	1 *M* sulfuric acid	H_2SO_4
0.1 *M* calcium nitrate	$Ca(NO_3)_2$	1 *M* sodium carbonate	Na_2CO_3
0.1 *M* strontium nitrate	$Sr(NO_3)_2$	1 *M* potassium chromate	K_2CrO_4
0.1 *M* barium nitrate	$Ba(NO_3)_2$	1 *M* ammonium oxalate	$(NH_4)_2C_2O_4$

distilled water
sodium metal Na
lithium metal Li
unknown salt solution
phenolphthalein indicator

EQUIPMENT

safety goggles
spot plate
gloves
dropper bottles

SAFETY

1. Wear safety goggles and gloves. Aprons optional.
2. Some of the chemicals are toxic and/or irritation to the skin. Avoid direct contact with these chemicals. Wash your hands thoroughly after use.
3. Sulfuric acid is corrosive and can cause severe injury. If you spill acid on yourself, immediately flush the affected area with water for 2-3 minutes and notify the teacher. If acid should get into your eyes, begin flushing your eyes with running water immediately and continue doing so for at least 20 minutes. Use the eye wash fountain.
4. Wash your hands thoroughly after completing this experiment.

PROCEDURE

PART A: Teacher demo using sodium metal and lithium.

1. Record your observation of each metal in Data Table 1 before any reaction. What is it's color? Texture? General appearance?
2. The teacher will cut a small piece of lithium and place it in distilled water that has the chemical indicator, phenolphthalein, added to it. (Phenolphthalein remains colorless in solutions that are neutral or acidic. A color change of pink indicates that a base is formed.)
3. Step #2 will be repeated with sodium metal. Be sure to record your observations in Data Table 1 before and after the reaction occurs.

Analysis Questions

1. Does the reactivity of metals increase or decrease going down a group?_____

2. What would be one good reason why this is the case (please talk about shielding and nuclear attraction)?

DATA TABLE 1: OBSERVATIONS OF FAMILY 1 METALS

NAME OF METAL	BEFORE REACTION	AFTER REACTION

PART B: Solubilities of Salts of Group 2 Elements

1. Obtain four dropper bottles of Group 2 nitrate solutions (See the materials section if you do not know the formulas).
2. Obtain four dropper bottles of the reagents to be reacted with Group 2 salts (See the materials section if you do not know the formulas).
3. Obtain a plastic spot plate (there are only 12 wells, so you will have to use it twice). Make sure it is clean before each use—do this by using water, dishwashing liquid and a sponge… then drying the plate off with a paper towel.
4. You will dispose of your test liquids (there isn't that much) by dumping the liquids into the trash and then using a paper towel to sponge up any excess liquid. Clean the spot plate as you did in step 3.
5. Test the solubility of each Group 2 ion with each of the reagents by placing **THREE** drops of each different Group 2 nitrate with **TWO** drops of each reagent (sulfuric acid (SO_4^{2-}), sodium carbonate (CO_3^{2-}) solution, ammonium oxalate ($C_2O_4^{2-}$) solution, and potassium chromate (CrO_4^{2-}) solution) .
6. Do not touch the dropper bottles to the liquids in your spot plate.
7. For each reaction, record your observations on **Data Table 2**. Write **S** (if soluble—no precipitate) or **I** (if insoluble—cloudy precipitate forms). You can tell if a participate has formed if you can see through the spot plate to your lab table. If it is cloudy, a solid precipitate was formed.
8. Repeat step 4 but put three drops of an unknown sample (be sure to indicate the letter of the unknown).
9. Compare all four results of your unknown with an entire row of results of your known samples. In **Data Table 2,** identify which Group 2 member your unknown is.
10. Return your chemicals and place them NEATLY where you picked them up.

DATA TABLE 2: SOLUBILITIES OF SALTS OF GROUP 2 ELEMENTS

	SO_4^{-2}	CO_3^{-2}	$C_2O_4^{-2}$	CrO_4^{-2}
Mg^{+2}				
Ca^{+2}				
Sr^{+2}				
Ba^{+2}				
unknown ____				
Identity of cation of unknown _____				

Analysis Questions.
1. Does the solubility of ions increase or decrease as you go down a group?_____
2. Define soluble and insoluble.

PART C

1. From **Data Table 3**, determine the densities for each of the three metals.

2. **SHOW ALL MATHEMATICAL CALCULATIONS. INCLUDE UNITS WITH YOUR NUMBERS.**

DATA TABLE 3

mass of container and **lead** Pb	53.400 g	volume of water and lead	31.2 mL
mass of container (empty)	14.915 g	volume of water (alone)	27.7 mL
mass of lead		volume of lead	
Density of lead			
Percent Error:			

container and **Tin** Sn	105.115 g	volume of water and Sn	51.8 mL
mass of container (empty)	14.915 g	volume of water (alone)	39.0 mL
mass of Sn		volume of Sn	
Density of Sn =			
Percent Error:			

mass of **silicon** Si	18.465 g
volume of water and Si	48.8 mL
volume of water (alone)	41.0 mL
volume of Si	
Density of Si	
Percent Error:	

Accepted values for the density of: lead 11.3 g/mL

tin 7.28g/mL

silicon 2.33 g/ml

DATA ANALYSIS AND CONCLUSIONS (Density)

1. Prepare a graph of density (y –axis) versus period number (x-axis) for Sn, Si, and Pb using Excel.

2. Use 0,0 as the origin and be sure to have your curve pass through it..

3. Based on your graph, manually locate the carbon and germanium on the curve and determine (by using your graph and estimating) the density for each.

5. Since carbon exists in different forms, compare your graph density (experimental value) with these accepted values: $D_{c \text{ as diamond}} = 3.52 \text{ g/cm}^3$

$D_{c \text{ as graphite}} = 2.6 \text{ g/cm}^3$ and $D_{c \text{ as amorphous}} = 1.6 \text{ g/cm}^3$

Select the value above that is closest to yours and determine your % error.

$$\% \text{ error} = \frac{|\text{accepted value} - \text{experimental value}|}{\text{accepted value}} \times 100\%$$

6. The accepted value for the density of germanium is 5.46 g/cm^3. Determine the % error for germanium's density.

Reference: Adaptation of Addison-Wesley, 1995, Experiments #4 and #23.