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CH201
Lab 5

Lab 5: Periodic Properties

Data:

Data Table 1

Element: Si	**Trial 1**	**Trial 2**	**Trial 3**
Intial Mass (g)	36.57	34.93	32.13
Final Mass (g)	34.93	32.13	29.35
Initial Volume (mL)	50.0	51.0	52.1
Final Volume (mL)	51.0	52.1	53.0

Data Table 2

Element: Sn	**Trial 1**	**Trial 2**	**Trial 3**
Intial Mass (g)	56.56	50.73	44.15
Final Mass (g)	50.73	44.15	30.52
Initial Volume (mL)	49.0	50.0	51.0
Final Volume (mL)	50.0	51.0	52.9

Data Table 3

Element: Pb	**Trial 1**	**Trial 2**	**Trial 3**
Intial Mass (g)	71.27	63.72	52.38
Final Mass (g)	63.72	52.38	33.25
Initial Volume (mL)	55.0	56.0	57.5
Final Volume (mL)	56.0	57.5	58.9

Data Table 4		
Metal	**Observations with O_2**	**Observations with H_2_O**
Na	Starts shiny, slowly dulls over time	Fizzes, moves around the surface of the water, pops
Li	Starts shiny, slowly dulls over time	Aggressive reactivity, loud fizz, releases gas
K	Starts shiny, slowly dulls over time	Sparks, fire(white/yellow), releases gas, sparks and pops

Data Table 5	
Metal	**Observations with O_2**
Ca	Fizzes and bubbles, some gas released
Cu	No visible reaction
Fe	No visible reaction for several minutes until small bubbles began to form on the surface of the sample
Mg	White, fizzy, fast reaction, some gas released
Sn	No visible reaction
Zn	Moderate fizzy reaction, some gas released, sample turned dark blue/black

Calculations:

All calculations were done using Google Sheets. The equations used were as follows:

Sample Mass (g) = Initial Mass (g) - Final Mass (g)

Sample Volume (cm^3) = (Final Volume (mL) - Initial Volume (mL)) * (1 (cm^3)/ 1 (mL))

Sample Density (g/cm^3) = Sample Mass (g)/Sample Volume(cm^3)

Average Density (g/cm^3) = (Trial 1 Density + Trial 2 Density + Trial 3 Density)/3

Percent Error (%) = |(Average Density - Theoretic Density)/Theoretic Density| * 100

Results:

Part A:

Results Table 1					
Element: Si Density:	**Trial 1**	**Trial 2**	**Trial 3**	**Theoretic Density (g/cm^3)**	
Intial Mass (g)	36.57	34.93	32.13	2.33	
Final Mass (g)	34.93	32.13	29.35		
Initial Volume (mL)	50.0	51.0	52.1		
Final Volume	51.0	52.1	53.0		
Sample Mass (g)	1.64	2.8	2.78		
Sample Volume (cm^3)	1.0	1.1	0.9	**Average Density (g/cm^3)**	**Percent Error (%)**
Sample Density (g/cm^3)	1.6	2.5	3.1	2.42	4.1

Results Table 2					
Element: Sn	**Trial 1**	**Trial 2**	**Trial 3**	**Theoretic Density (g/cm^3)**	
Intial Mass (g)	56.56	50.73	44.15	7.31	
Final Mass (g)	50.73	44.15	30.52		
Initial Volume (mL)	49.0	50.0	51.0		
Final Volume	50.0	51.0	52.9		
Sample Mass (g)	5.83	6.58	13.63		
Sample Volume (cm^3)	1.0	1.0	1.9	**Average Density (g/cm^3)**	**Percent Error (%)**
Sample Density (g/cm^3)	5.8	6.6	7.2	6.5	10.7

Results Table 3					
Element: Pb	**Trial 1**	**Trial 2**	**Trial 3**	**Theoretic Density (g/cm^3)**	
Intial Mass (g)	71.27	63.72	52.38	11.35	
Final Mass (g)	63.72	52.38	33.25		
Initial Volume (mL)	55.0	56.0	57.5		
Final Volume	56.0	57.5	58.9		
Sample Mass (g)	7.55	11.34	19.13		
Sample Volume (cm^3)	1.0	1.5	1.4	**Average Density (g/cm^3)**	**Percent Error (%)**
Sample Density (g/cm^3)	7.6	7.6	13.7	9.6	15.5

Part B:
Order of Reactivity with O_2:
Na = Li = K

Order of Reactivity with H_20:
Na < Li < K

The ionization energy of elements in a column decreases as you increase the period. From the observations made they lower the ionization energy correlates with an increase in reactivity.

I did not predict the same order of reactivity. My prediction had Na greater than Li.

Part C:
Order of reactivity with $HCl_{(aq)}$:
Cu = Sn < Fe < Zn < Ca < Mg

I did not predict the same order of reactivity. In fact I thought Sn would be the most reactive when in the lab it was tied with the least reactivity.

$Ca_{(s)} + 2\ HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_{2(g)}$
$Fe_{(s)} + 6\ HCl_{(aq)} \rightarrow 2FeCl_{3(aq)} + 3H_{2(g)}$
$Mg_{(s)} + 2\ HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$
$Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

Discussion and Conclusion:

This lab sought to observe the reactivity of various elements and compare them to theoretical periodic table properties. In Part A, density was calculated through measurements of mass and volume of Si, Sn, and Pb. This demonstrates the property of increasing density as you increase both the group and the period. In Part B, three metals (Li, Na, K) were observed in O_2 and then placed in H_2O to observe any possible reactivity. This portion aims to relate ionization energy and reactivity. The higher the ionization energy, the lower the reactivity. Observing that increase in reactivity of the elements that were tested matched this trend. In Part C, reactivity is again observed and it was observed that the lower the group number the higher the reactivity. By understanding the ionization energy of an element, it becomes possible to predict its reactivity and stability. This is useful in designing materials for various applications, such as catalysts, batteries, and solar cells.

The estimation of density in Part A for Si, Sn, and Pb had a percentage error of 4.1%, 10.7%, 15.5% for each element respectively. These values may be too inaccurate to be useful. Errors may have occurred during measurement, such as user error and misreading of values. The predictions made from lowest density to highest were the same as what was calculated. This aligns with the periodic trend for density, as the periodic number increases so does the density of the element. This information can be used to estimate the density of other elements. For example, the element Ge is atomic number 32, Si is atomic number 14. Each atomic weight can create a ratio, 32/14, which when multiplied with the density of Si to find a predicted value. By this method Ge would have a density of 5.51 g/cm^3. Compared to the theoretical density of 5.32 g/cm^3 the percent error of the prediction is 3.57%.

In Part B, the elements Li, Na, and K were observed when exposed to oxygen and then placed in water. From what is understood about periodic properties when an element requires less energy to ionize then its reactivity increases. This trend explains the difference between Na and K. The increased ease of electron loss leads to increased reactivity in metals, as they require less energy to achieve a full outer electron shell. Based on these trends Rb would require less energy to ionize, therefore Rb would be more reactive than K.

In Part C, reactivity was tested again. It was observed that elements in a lower period showed greater reactivity, as would be expected from periodic table trends of reactivity and ionization energy. From what is predicted by reactivity trends it would be expected that Ca would be more reactive than Mg, but during the experiment it was observed to be inverse. From what is predicted by observations made in this experiment, Sr would be predicted to be the most reactive out of all the elements tested in Part C.

Supplementary Problems:

1. The trend in first ionization energy across the second period (row) of the periodic table is that it increases as you move from left to right.
2.

Element	Abbrev. Electron Config	Atomic Orbital Diagram	Orbital Diagram 1st Ionization	Classify 1st Ionization (1-8; 1 being lowest, 8 being highest)	Orbital Diagram 2nd Ionization	Classify 2nd Ionization (1-8; 1 being lowest, 8 being highest)
Li	[He] $2s^1$	1s↑↓2s↑	1s↑↓	Low ; 1	1s↑	High; 8
Be	[He] $2s^2$	1s↑↓2s↑↓	1s↑↓2s↑	High; 3	1s↑↓	Low; 1
B	[He] $2s^2$ $2p^1$	1s↑↓2s↑↓ 2p↑	1s↑↓2s↑↓	Low; 2	1s↑↓2s↑	High; 3
C	[He] $2s^2$ $2p^2$	1s↑↓2s↑↓ 2p↑ ↑	1s↑↓2s↑↓ 2p↑	Neutral; 4	1s↑↓2s↑↓	Low; 2
N	[He] $2s^2$ $2p^3$	1s↑↓2s↑↓ 2p↑ ↑ ↑	1s↑↓2s↑↓ 2p↑ ↑	High; 6	1s↑↓2s↑↓ 2p↑	Neutral; 4
O	[He] $2s^2$ $2p^4$	1s↑↓2s↑↓ 2p↑↓↑ ↑	1s↑↓2s↑↓ 2p↑ ↑ ↑	Low; 5	1s↑↓2s↑↓ 2p↑ ↑	High; 6
F	[He] $2s^2$ $2p^5$	1s↑↓2s↑↓ 2p↑↓↑↓↑	1s↑↓2s↑↓ 2p↑↓↑ ↑	Neutral; 7	1s↑↓2s↑↓ 2p↑ ↑ ↑	Low; 5
Ne	[Ne]	1s↑↓2s↑↓ 2p↑↓↑↓↑↓	1s↑↓2s↑↓ 2p↑↓↑↓↑	High; 8	1s↑↓2s↑↓ 2p↑↓↑ ↑	Neutral; 7

3. Boron
4. Beryllium