

# **Chapter 8:**

## **Periodic**

### **Relationships**

#### **Among the**

##### **Elements**



# Honors Chemistry

## Homework: Periodic Trends

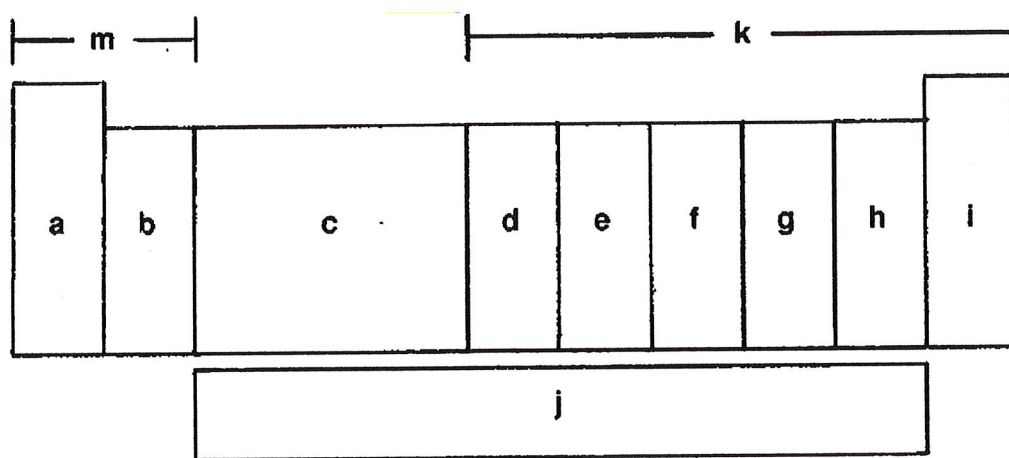
Name \_\_\_\_\_

### I. Structure of the Periodic Table

The modern periodic table is a listing of elements in a gridlike chart arrangement. The elements are placed in order of atomic number, and fall into certain positions in the table that reveal many of their properties and their relationships to each other.

On the line at the left, write the letter of the appropriate location of each group of elements on the periodic table below. Some letters will be used more than once.

- |                                  |  |
|----------------------------------|--|
| _____ 1. carbon family           | _____ 8. f-block elements                        |
| _____ 2. alkaline earth metals   | _____ 9. noble gases                             |
| _____ 3. inner transition metals | _____ 10. p-block elements                       |
| _____ 4. halogens                | _____ 11. nitrogen family                        |
| _____ 5. d-block elements        | _____ 12. s-block elements                       |
| _____ 6. oxygen group            | _____ 13. transition metals                      |
| _____ 7. alkali metals           | _____ 14. group of one semimetal and four metals |



15. WHY is a row called a period? \_\_\_\_\_

16. WHY is a column called a family? \_\_\_\_\_

Identify each of the following as a metal (M), nonmetal (NM), or as a metalloid (ML)

\_\_\_\_\_ 17.  $[\text{Ar}] 4s^2 3d^{10} 4p^4$

\_\_\_\_\_ 18.  $[\text{Ne}] 3s^2 3p^5$

\_\_\_\_\_ 19.  $[\text{Ar}] 4s^2 3d^8$

\_\_\_\_\_ 20. Neon

\_\_\_\_\_ 21. Silicon

\_\_\_\_\_ 22. Nitrogen

## II. Relating Electron Configuration to the Periodic Table

The electron configuration of an atom reveals the placement of electrons within the orbitals of the atom and is a key to chemical behavior. The filling order of these orbitals is 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, etc.

1. Write electron configurations for atoms that have the following atomic numbers:

3:

19:

11:

What do these configurations have in common with each other? \_\_\_\_\_

What would you expect about the relative properties of these elements? \_\_\_\_\_

Where are these atoms located in the periodic table? \_\_\_\_\_

2. Write electrons configurations for atoms that have the following atomic numbers:

9:

35:

17:

What do these configurations have in common with each other? \_\_\_\_\_

What would you expect about the relative properties of these elements? \_\_\_\_\_

Where are these atoms located in the periodic table? \_\_\_\_\_

## III. Oxidation Number and the Periodic Table

Gaining or losing electrons can electrically charge atoms. The typical number of electrons gained or lost is related to electron configuration and to position in the periodic table. The charge of a monatomic ion is known as the oxidation number of the atom.

1. Calcium, Ca, element 20, tends to form a  $2+$  ion. Write the electron configuration of neutral Ca and of the  $\text{Ca}^{2+}$  ion.

Ca:

$\text{Ca}^{2+}$ :

Explain why the  $2+$  ion is the one that tends to typically form. \_\_\_\_\_

In what group is Ca located? \_\_\_\_\_

2

2. Sulfur, S, element 16, tends to form a 2- ion. Write the electrons configuration of the sulfur atom and of the sulfur ion.

S:

S<sup>2-</sup>

Why does the 2- ion usually form? \_\_\_\_\_

In what group of the periodic table is S located? \_\_\_\_\_

What oxidation number would other atoms in the group be assigned? \_\_\_\_\_

3. Predict the oxidation number for the following groups:

\_\_\_\_\_ IA

\_\_\_\_\_ IIIA

\_\_\_\_\_ VIIA

\_\_\_\_\_ IIA

\_\_\_\_\_ IVA

\_\_\_\_\_ VIIIA

#### IV. Atomic Radius and the Periodic Table

The size of atoms is measured in terms of atomic radius, in units such as nanometers (1 nm =  $1 \times 10^{-9}$  m) or angstroms (1 Å =  $1 \times 10^{-10}$  cm). The ionization energy, or energy needed to remove an electron from a gaseous atom, is typically measured in kilojoules per mole of atoms. These quantities are related to position in the periodic table.

1. The radius of the first few atoms in Group 17 have been estimated to have the following values:

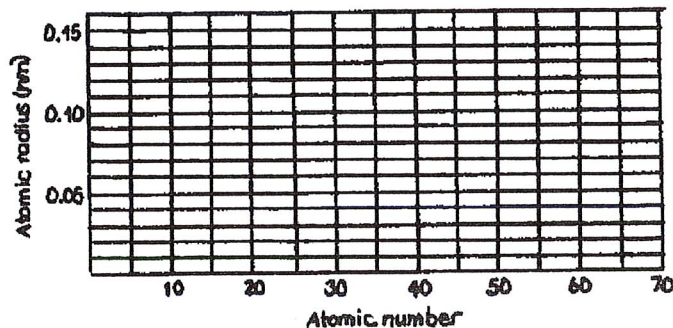
F (element 9): 0.064 nm

Cl (17): 0.099 nm

Br (35): 0.114 nm

I (53): 0.133 nm

Graph these values versus atomic number in the grid.



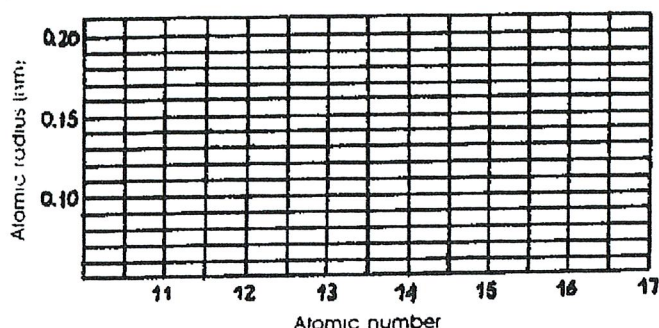
What do you notice about the relationship between atomic radius and atomic number within a family? \_\_\_\_\_

Account for this relationship in terms of atomic forces and structure. \_\_\_\_\_



2. The radii of the first seven elements in Period 3 have been estimated to have the following values:

|          |          |
|----------|----------|
| Na (11): | 0.186 nm |
| Mg (12): | 0.160 nm |
| Al (13): | 0.143 nm |
| Si (14): | 0.117 nm |
| P (15):  | 0.110 nm |
| S (16):  | 0.104 nm |
| Cl (17): | 0.099 nm |



Plot these values.

What do you notice about the relationship between atomic radius and atomic number within a period? \_\_\_\_\_

Account for this relationship in terms of atomic forces and structure. \_\_\_\_\_

4. **HELP!!!** You have been banished from Earth and sent to live on a distant planet. Aliens living on this planet have discovered and named the six elements described below, but will tell you no more about the elements:

Bobble (Bo) is a noble gas but does not have 8 valence electrons.  
 Wobble (Wo) is also an inert gas but has a greater atomic mass.  
 Doggone (D) has the electron configuration  $1s^2 2s^2 2p^6 3s^2 3p^1$ .  
 Kratt (Kr) is a halogen in the same period as Doggone.  
 Nuute (N) forms a crystalline solid with Kratt that is found in seawater.  
 Quakzil (Q) is in the same period as Wobble and contains only one valence electron.

Luckily for you, you have had Chemistry 315 (We told you it would be useful!) and have determined that this distant planet is composed of the same elements as Earth. Based on this observation, place the elements in their correct positions on the periodic table.

|   |    |    |  |  |  |  |  |    |
|---|----|----|--|--|--|--|--|----|
|   | 1A |    |  |  |  |  |  | 8A |
| 1 |    | 2A |  |  |  |  |  |    |
| 2 |    |    |  |  |  |  |  |    |
| 3 |    |    |  |  |  |  |  |    |
| 4 |    |    |  |  |  |  |  |    |

- Use what you know about electron configurations to explain why an atom of Nuute is smaller than an atom of Quakzil. \_\_\_\_\_
- Which would you expect to be a larger atom, Bobble or Wobble? \_\_\_\_\_
- Nuute is the largest atom in its period and Kratt is one of the smallest. Predict the relative size of an atom of Doggone. \_\_\_\_\_

## V. Ionization Energy and the Periodic Table

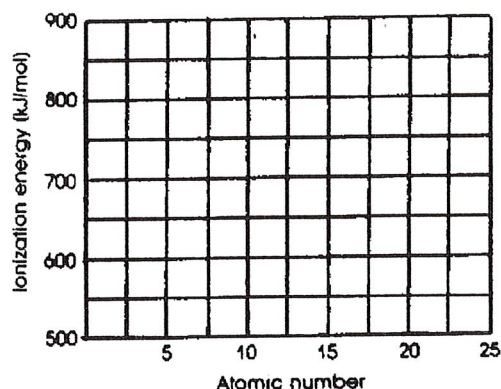
1 The ionization energies of the first three atoms in Group II are as follows

Be: 900 kJ/mol

Mg: 736 kJ/mol

Ca: 590 kJ/mol

Plot these values versus atomic number in the grid



What do you notice about the relationship between ionization energy and atomic number within a family?

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Account for this relationship in terms of atomic forces and structure. \_\_\_\_\_

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2. The ionization energies of the elements in Period 2 are as follows.

Li: 519 kJ/mol

Be: 900 kJ/mol

B: 799 kJ/mol

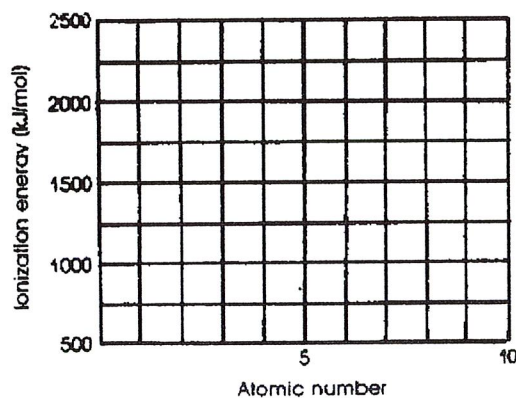
C: 1088 kJ/mol

N: 1406 kJ/mol

O: 1314 kJ/mol

F: 1682 kJ/mol

Ne: 2080 kJ/mol



What do you notice about the relationship between ionization energy and atomic number within a period?

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Account for this relationship in terms of atomic forces and structure. \_\_\_\_\_

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## VI. Electron Affinity and the Periodic Table

1. Which has a greater electron affinity, Lithium or Cesium? Why? \_\_\_\_\_  
\_\_\_\_\_
2. Which has a greater electron affinity, Sodium or Chlorine? Why? \_\_\_\_\_  
\_\_\_\_\_
3. Which has a greater electron affinity, Chlorine or Iodine? Why? \_\_\_\_\_  
\_\_\_\_\_
4. Do metals tend to have low or high electron affinities? Based on this, would you expect metals to be more reactive if their electron affinities are high or low?
5. Do nonmetals tend to have high or low electron affinities? Based on this would you expect nonmetals to be more reactive if their electron affinities are high or low?
6. Using what you know about electron configurations, explain the very low affinities of family II. \_\_\_\_\_  
\_\_\_\_\_

## VII. Ionic Radius and the Periodic Table

1. How does the size of the Li atom compare to that of a Li ion? \_\_\_\_\_  
How can this be explained? \_\_\_\_\_  
\_\_\_\_\_
2. In general how do the sizes of metal ions compare with the sizes of the atoms from which they were formed? How can this be explained? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
3. In general how do the sizes of <sup>non-</sup>metal ions compare with the sizes of the atoms from which they were formed? How can this be explained? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
3. In general, how do the ions of the elements within a specific period vary in size? \_\_\_\_\_  
\_\_\_\_\_
4. In general, how do the ions of the elements within a specific ~~family~~ vary in size? \_\_\_\_\_

6



## VIII. Size Change in Ion Formation

- 1 How do Na and  $\text{Na}^+$  compare in relative size? Explain any difference. \_\_\_\_\_  
\_\_\_\_\_
- 2 How do Cl and  $\text{Cl}^-$  compare in relative size? Explain any difference. \_\_\_\_\_  
\_\_\_\_\_
- 3 How do  $\text{Na}^+$  and  $\text{Cl}^-$  compare in relative size? Explain any difference. \_\_\_\_\_  
\_\_\_\_\_
- 4 On the basis of the information you have found, make a general statement about the size of positive ions compared to their corresponding neutral atoms. \_\_\_\_\_  
\_\_\_\_\_
- 5 On the basis of the information you have found, make a general statement about the size of negative ions compared to their corresponding neutral atoms. \_\_\_\_\_  
\_\_\_\_\_

## IX. A Quick Review

A. Circle the atom in each pair that has the larger atomic radius.

1. Li or K
2. Ca or Ni
3. Ga or B
4. O or C
5. Cl or Br
6. Be or Ba
7. Si or S
8. Fe or Au

B. Circle the ion in each pair that has the smaller atomic radius.

9.  $\text{K}^+$  or  $\text{O}^{2-}$
10.  $\text{Ba}^{2+}$  or  $\text{I}^-$
11.  $\text{Al}^{3+}$  or  $\text{P}^{3-}$
12. ~~K<sup>+</sup>~~ or  $\text{Cs}^+$
13.  $\text{Fe}^{2+}$  or  $\text{Fe}^{3+}$
14.  $\text{F}^-$  or  $\text{S}^{2-}$

C. Circle the atom or ion in each pair that has the larger first ionization energy.

15. Na or O
16. Be or Ba
17. ~~F or Cl~~
18. Cu or Ra
19. I or Ne
20. K or V
21. Ca or Fr
22. W or Se



# Review

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Periodic Trends Worksheet

- 1.) Rank the following elements by increasing atomic radius: carbon, aluminum, oxygen, potassium.
  
- 2.) Rank the following elements by increasing electron affinity: sulfur, oxygen, neon, aluminum.
  
- 3.) What is the difference between electron affinity and ionization energy?
  
- 4.) Why does fluorine have higher ionization energy than iodine?
  
- 5.) Why do elements in the same family generally have similar properties?
  
- 6.) In the modern periodic table, elements are ordered according to \_\_\_\_\_.
- 7.) Mendeleev is said to be the father of the periodic table but \_\_\_\_\_ arranged it in the fashion that we use today.

8.) The discovery of noble gases changed Mendeleev's periodic table by adding a new \_\_\_\_\_ (period, series, group, sublevel block).

9.) The most distinctive property of noble gases is that they are \_\_\_\_\_ (metallic, radioactive, metalloids, largely unreactive).

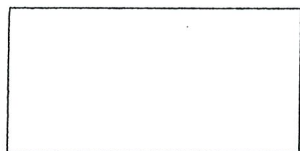
10.) What is the name of the group that Lithium belongs to. \_\_\_\_\_

11.) On the periodic table, a horizontal row is a \_\_\_\_\_ a vertical column is a \_\_\_\_\_.

12.) Explain the distinction between atomic mass and atomic number.

13.) The energy to add an electron to an atom is called \_\_\_\_\_. This energy is \_\_\_\_\_.

14.) The trend for the above property is (Use arrows and words).

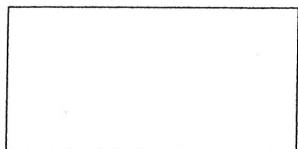


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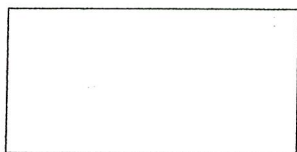


15) The energy required to remove an electron is \_\_\_\_\_.  
This energy is \_\_\_\_\_.

16.) The trend for the above property is (Use arrows and words).



17.) What happens to atomic radii as you move from left to right across the period? (Use arrows and words).



18.) Why is this? (Use complete sentences)

19.) Name the following:

Halogen with the least negative electron affinity \_\_\_\_\_

Alkaline earth metal with the highest ionization energy \_\_\_\_\_

Element in period three with the smallest atomic radii \_\_\_\_\_

20.) Compare and explain the size of  $\text{Ca}^+$ ,  $\text{Ca}^-$ , and  $\text{Ca}$ . (use complete sentences)

21.) Which element has the greater ionization energy?

Ca or Mg

Te or I

22.) What is the relationship between atomic radii and ionization energy?

23.) Which element has a greater Electron affinity?

Cl or S

Si or C

24.) Write the electron configuration (short or long way) for the following.

Na

$\text{Na}^+$

$\text{O}^{2-}$

Cl

$\text{Cl}^-$

25.) Compare the electron configuration of  $F^-$ ,  $Ne$ , and  $Na^+$

26.) DRAW THE ORBITAL DIAGRAM FOR THE FOLLOWING AND PREDICT WHETHER EACH ELEMENT IS EXPECTED TO BE PARAMAGNETIC OR DIAMAGNETIC. (use your book to look up these words)

1. argon

2. silicon

