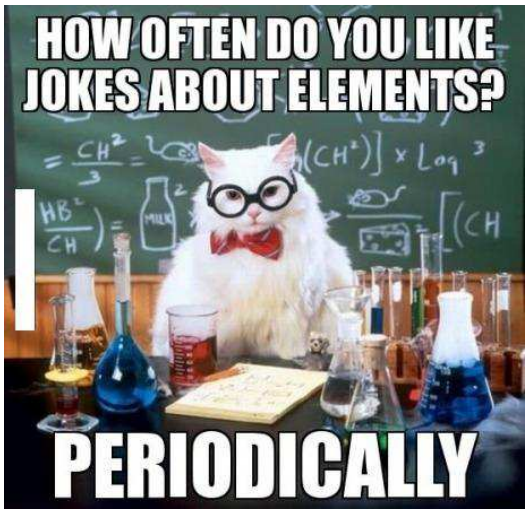
NAME: _____ Date: _____Period: _____

# Unit 06: Periodic Trends




## DRIVING QUESTIONS:

- How is the periodic table organized according to trends?
- How can we predict properties of elements based on their position in the periodic table?

## CONNECTIONS TO PAST/ FUTURE UNITS:

- Practice of graphing skills and data analysis
- Conceptualize the atom using past and new information
- Understand the layout and use of the periodic table

## OBJECTIVES: SWBAT…

- ☐ display and analyze data in tables and graphs
- ☐ relate properties of elements to the formation of the periodic table
- ☐ experimentally determine how density changes within periods and groups.
- ☐ compare properties of elements based on their position in the periodic table.
- ☐ compare the size of atoms of different elements based on their position in the periodic table.
- ☐ compare the ionization energy and electronegativity of elements based on their position in the periodic table.
- ☐ create and analyze graphs of elemental properties

## ESSENTIAL VOCABULARY:

Trend
Period
Group
Periodic law
Atomic radius
Ion
Ionization energy
Electronegativity
Electron affinity
Noble gas
Metals
Non-metals
Metalloids
Alkali metals
Alkaline earth metals
Lanthanide series
Actinide series
Rare earth metals
Halogens

**PERSONAL OBJECTIVE:** Looking at the objectives above, what more do you want to learn this unit?

**REFLECTION**: Did you accomplish your personal objective? What further questions do you have about this unit?

SWBAT display and analyze data in tables and graphs

One of the most important tools for a successful life is being able to predict outcomes based on limited data. Being able to look at data, rearrange it and form a useful opinion is something that we do from childhood through to adulthood. This is generally learned at a young age; through structured discipline, small children are able to predict the consequences of their actions. A good financial analyst is someone who can "predict" market trends, and capitalize on the up and down movements. You have already done some predictions in your math class, if you have graphed a simple equation; depending on the slope of the line you can say that the trend is increasing, decreasing, or constant. Knowing the trend allow you to generalize what will happen for data that is not represented.

Scientists (and the ACT) also have conventions on what good graphs look like. Whenever you graph data in this class, you should make sure to include the following things.

Here is a data set. Organize the data into a table. Graph the data. Then, answer the questions.

**Correctly Labeled Axis**

- 
- 
- 

**Title**

- 
- 

**A "KEY"**

- .

**PRACTICE:**

1. If we graph how the number of hours spent studying affects your grade on next class period's quiz, what would we title our graph?
    a. What would we measure on our X-axis? **Hours Spent Studying (Time)** or **Grade on Quiz**
    b. What would we measure on our Y-axis? **Hours Spent Studying (Time)** or **Grade on Quiz**
    c. So, what would be an appropriate title for our graph? _____

2. If we graphed how temperature affects the pressure of air at a defined volume, how would we graph that?
    a. What would we measure on our X-axis? **Temperature** or **Pressure?**
    b. What would we measure on our Y-axis? **Temperature** or **Pressure?**
    c. **S**o, what would be an appropriate title for our graph? _____

3. If we graphed how amount of sunlight affects plant growth, how would we graph that?
    a. What would we measure on our X-axis? **Hours of sunlight** or **Plant growth**
    b. What would we measure on our Y-axis? **Hours of sunlight** or **Plant growth**
    c. **S**o, what would be an appropriate title for our graph? _____

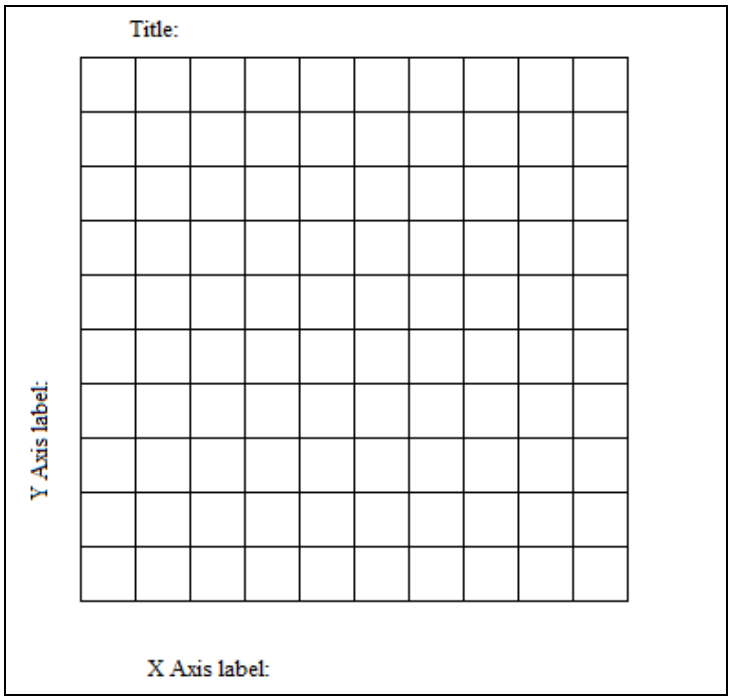
**Data Set 1: Gasoline prices**

You may not be currently concerned about gasoline prices. However, you should be when you start to drive, and even if you are not driving, increased fuel prices will drive up the cost of cab rides, bus, and train fares. Here are some actual prices of gasoline. They represent the average pump price for one gallon of regular gasoline in the Midwest for the given date.

| | | | |
|---|---|---|---|
| Sept. 02, 1996: $1.164 | Sept. 03, 2001: $1.707 | Sept. 04, 2006: $2.572 | Sept. 05, 2011: $3.697 |

First, put the data into the data table below. Then, graph the data points:

| | |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |




Based on the data table, what is your observation of the historical price of gasoline? _____

_____

Using the graph, how can you predict the price of gasoline on September 04, 2003? _____

_____

What do you predict the price of a gallon of gas will be on September 04, 2003 _____.

You just practiced an important ACT skill called interpolation!

Using the graph, how can you predict the price of gasoline on September 06, 2016? _____

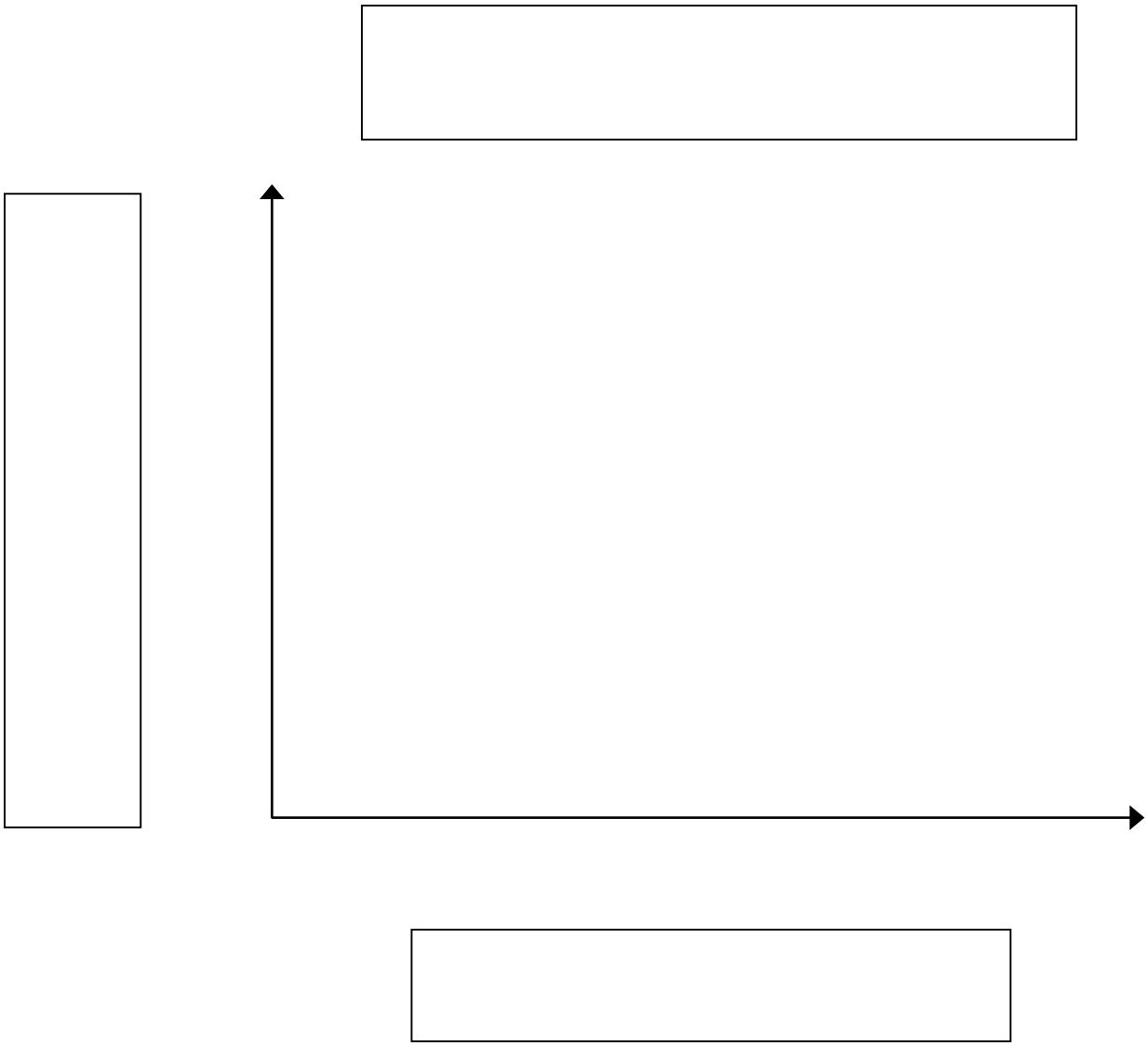
_____

What do you predict the price of a gallon of gas will be on September 06, 2016 _____.

You just practiced an important ACT skill called extrapolation!

**Data Set 2: Sand and Water warming**

| | **Starting Temp. (Celcius)** | 1 min | 2 min | 3 min | 4 min | 5 min | 6 min | 7 min | 8 min | 9 min | 10 min/ **Final Temp.** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sand** | 18 | 19 | 21 | 22 | 24 | 25 | 26 | 28 | 30 | 31 | 32 |
| **Water** | 20 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 26 | 27 |



Which substance absorbs heat more quickly?

How do you know? (use evidence!)

There was a time when the periodic table did not exist. People did experiments with substances they called elements, and they catalogued the elements' properties. However, no one had yet arranged them in any significant way. Also, not all elements had been discovered which would cause "holes" in any arrangement system.

To see how this may have caused problems arrange the following eight symbols in the 3x3 grid provided. You must write the symbol and mass in each square. You should put the symbols in their appropriate boxes by considering both their mass and color. Once you have written in the symbols you will notice that there is an empty box. Based on your arrangement you should determine where the missing symbol belongs.

| Symbol | Mass | Color |
|---|---|---|
| Se | 1 | Blue |
| Te | 23 | Blue |
| N | 28 | Green |
| Et | 4 | Red |
| T | 15 | Red |
| He | 7 | Green |
| R | 26 | Red |
| Pa | 12 | Blue |

| | | |
|---|---|---|
| | | |
| | | |
| | | |

Based on your arrangement, where is the missing box? _____

What is the color and approximate mass of the missing symbol? _____

_____

**READING ASSIGNMENT:** Read and take notes on pages _____ in your textbook.

| SEE | THINK |
|---|---|
| | |

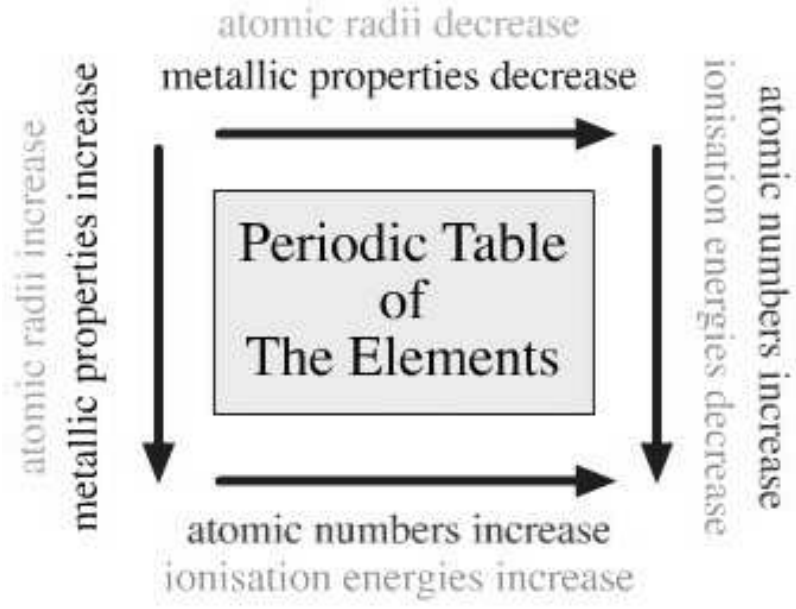
SWBAT relate properties of elements to the formation of the periodic table

The Periodic Table was developed by Dmitri Mendeleev in the mid-1800s. Mendeleev, a Russian, put all of the elements in order based on mass, and noticed a periodic recurrence of chemical and physical properties. He arranged the elements in columns. Elements in each column have similar properties. Occasionally, he would find a hole in the table. He could use the surrounding information to predict the properties of a yet to be discovered element. As new elements were discovered, they neatly filled holes in the periodic table.

As scientists began to work with Mendeleev's table, some changes were made. The vertical columns became known as families or groups. Horizontal rows are known as periods. Most importantly, instead of putting elements in order of mass, elements are now arranged in order of atomic number.

Similar electron configurations are found in vertical columns. The elements of the first columns end in $s^1$. The elements of the second column end in $s^2$. The similarity of the electron configurations of atoms in vertical columns is why atoms are similar, vertically.

The repetitive nature of the periodic table allows scientists to know something about an element based on where it is located in the periodic table. The diagram on the right summarizes some of the more important repeating trends found in the periodic table.




**READING ASSIGNMENT:** Read and take notes on pages _____ in your textbook.

| SEE | THINK |
| --- | --- |
| | |

**Laboratory Experiment: Density is a Periodic Property** Name: _____

SWBAT experimentally determine how density changes within periods and groups.

## Materials

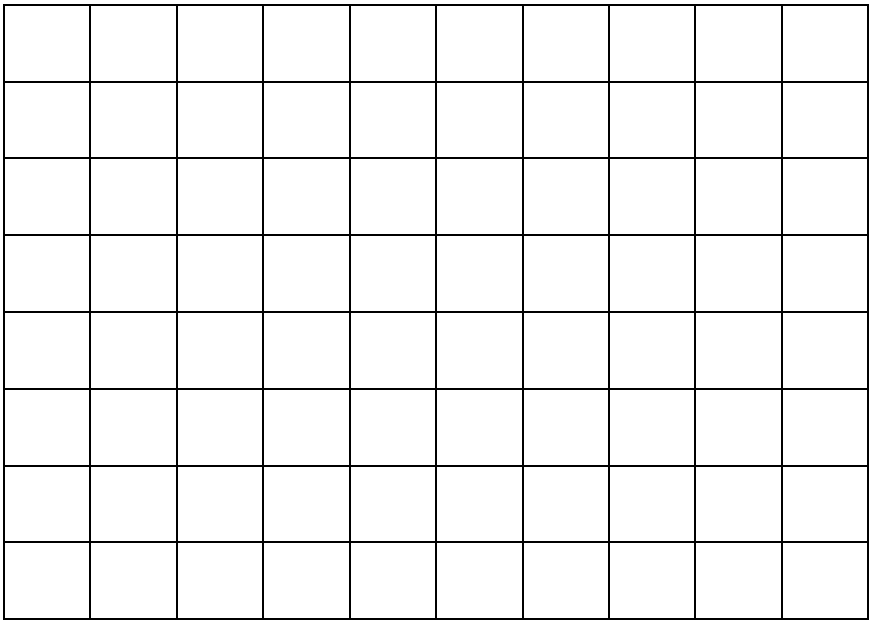
| | | | |
|---|---|---|---|
| Carbon | Lead | Tin | Copper |
| Aluminum | Colored pencils | Iron | Balance |
| Graph paper | Graduated cylinder | Ruler | Calculator |

## Procedure

1. Determine the mass and volume of each sample. Record in your data table.
2. Calculate the density of each sample. (Density =mass/volume)
3. Determine the period for each of the samples.
4. Graph density vs. period number for your samples.

## Data

| Element | Period # | Mass (g) | | Volume (mL) | | Calculated Density |
|---|---|---|---|---|---|---|
| Carbon | | | / | | = | |
| Lead | | | / | | = | |
| Tin | | | / | | = | |
| Copper | | | / | | = | |
| Aluminum | | | / | | = | |
| Iron | | | / | | = | |



**KEY**

- ☐ Carbon
- ☐ Lead
- ☐ Tin
- ☐ Copper
- ☐ Aluminum
- ☐ Iron

## Analysis and Conclusions

1. Which elements are in the same group?

2. How does density change as you move down this group in the periodic table?

3. Which elements are in the same period?

4. How does density change as you move from left to right across the period?

5. Use your graph to predict the density of germanium and silicon.

6. Calculate the percent error of your densities you determined as compared with accepted values.
   Percent error = I accepted – experimental I /accepted x 100%
   a. Carbon 2.266 g/$cm^3$

   b. Lead 11.342 g/$cm^3$

   c. tin 7.265 g/$cm^3$

   d. copper 8.961g/ $cm^3$

   e. aluminum 2.701 g/$cm^3$

   f. iron 7.871g/ $cm^3$

7. What are some possible sources of error for your experiment?

SWBAT compare the size of atoms of different elements based on their position in the periodic table.

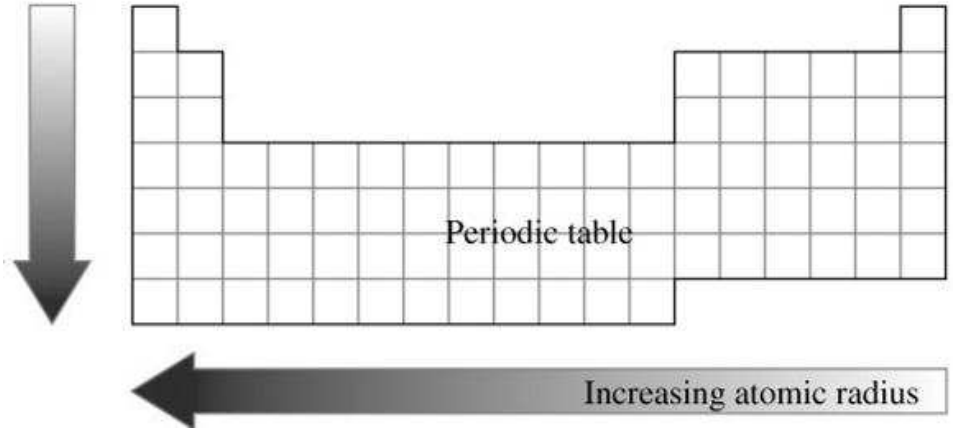
The relative size of an atom or ion can be determined based on its location in the periodic table. The radius of an atom is half the distance between the nuclei of two like atoms. Therefore, radius is directly proportional to size.

Atomic size generally increases as you move down a group of the periodic table. As you descend, electrons are added to successively higher principal energy levels and the nuclear charge increases. The outermost orbital is larger as you move downward. **Atoms at the bottom of the table are bigger than atoms at the top.**

Atomic size generally decreases as you move from left to right across a period. As you go across a period, the principal energy level remains the same. Each element has one more proton and one more electron than the preceding element. The electrons are added to the same principal energy level. The effect of the increasing nuclear charge on the outermost electrons is to pull them closer to the nucleus. **Atoms on the left of a period are bigger than atoms on the right.**

This trend is more pronounced as you move through a group (up or down) than through a period (right or left), because of the addition of new orbitals as you move down the table. **An up/down move in the periodic table is a much more important change in atomic size than a left/right move.**

The trend described above is also true for positive and negative ions. However, there is one fundamental difference caused by the formation of the ions. Positive ions are formed when an atom loses electrons. Therefore, the relative nuclear charge of the ion is more than that of a neutral atom. **Positive ions are always smaller than neutral atoms.** In a similar fashion, negative ions are formed when an atom gains electrons. The relative hold of the nucleus is less in a negative ion than it is for a neutral atom. **Therefore, negative ions are always bigger than neutral atoms.**



For each of the following pairs, circle the atom or ion that is larger. Use the periodic table to assist you.

| | |
|---|---|
| Magnesium atom or Sodium atom | $Cs^{1+}$ ion or $Ca^{2+}$ ion |
| $Mn^{2+}$ ion or $Fe^{2+}$ ion | Strontium atom or Lithium atom |
| Nitrogen atom or Phosphorus atom | $O^{2-}$ ion or $P^{3-}$ ion |
| Iodine atom or Chlorine atom | Silicon atom or Fluorine atom |
| Positive $Sr^{2+}$ ion or Neutral Sr atom | Selenium atom or Gold atom |
| Fluorine atom or Sulfur atom | Aluminum atom or Helium atom |
| Sodium atom or Barium atom | Xenon atom or Silver atom |
| Neutral Co atom or Positive $Co^{2+}$ ion | $N^{3-}$ ion or $S^{2-}$ ion |
| $P^{3-}$ ion or $Al^{3+}$ ion | Cobalt atom or Cesium atom |
| Negative $S^{2-}$ ion or Neutral S atom | Barium atom, Ba or Sulfide ion, $S^{2-}$ |
| Carbon atom or Selenium atom | Barium ion, $Ba^{2+}$ or Sulfide ion, $S^{2-}$ |
| Argon atom or Sulfur atom | Ti atom or Copper atom |
| $K^{1+}$ ion or $Cl^{1-}$ ion | Lithium atom, $Li^{1+}$ or Fluoride ion, $F^{1-}$ |
| Gadolinium atom or Plutonium atom | $Fe^{3+}$ ion or $Fe^{2+}$ ion |

SWBAT compare the ionization energy and electronegativity of elements based on their position in the periodic table.

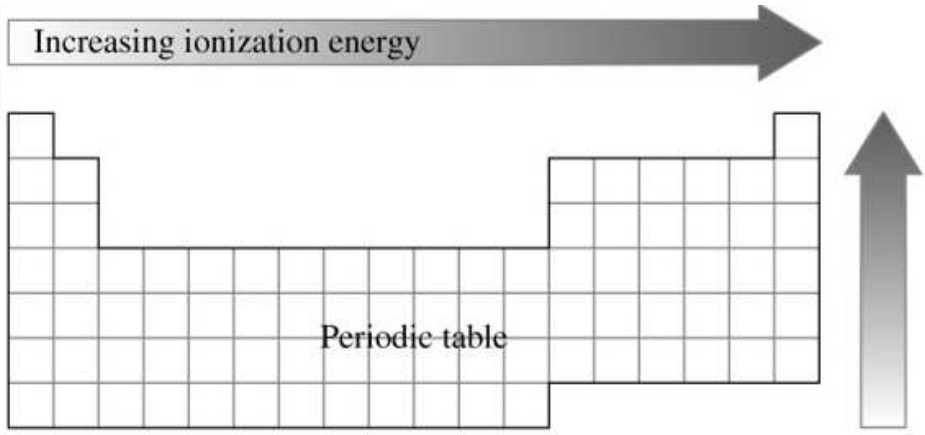
The degree to which an atom holds onto its outermost electrons can also be determined based on its location in the periodic table. This hold a nucleus has on its outermost electrons can be expressed in three ways:

1. The *electronegativity* of an atom is the tendency for atoms of an element to attract electrons when they are chemically bonded to atoms of another element.

2. The *ionization energy* is the amount of energy required to remove an electron from an atom to make a positive ion.

3. The *electron affinity* is the tendency for an atom to take hold of an electron in order to form a negative ion.

The differences between these three things is nuanced, depending on what the atom is, and what type of chemical bond it will form (or has formed). As should be expected, this trend is exactly the opposite of the radius trend, as summarized by the following table.




As with atomic radius, **an up/down move in the periodic table is a much more important change in ionization energy, electronegativity, or electron affinity than a left/right move.**

**READING ASSIGNMENT:** Read and take notes on pages _____ in your textbook.

| SEE | THINK |
| --- | --- |
| | |

For each of the following pairs, circle the element that has the larger ionization energy.

| | |
|---|---|
| Li or N | Cl or Se |
| Li or K | Cl or B |
| Li or Sc | Br or Pd |
| Mg or Rb | F or Fe |
| Mg or C | F or Na |
| Mg or Cl | V or Mo |
| Cs or Al | Zr or Y |
| Rb or At | Li or Sn |
| P or As | Ga or Al |
| P or S | Ga or Cd |

Answer the following questions.

1. Restate in one or two words: "The amount of energy required to remove one electron from the valence shell of a neutral atom."

2. Restate in one or two words: "The tendency of an atom to hold on to its valence electrons while engaged in a chemical bond."

3. Which is larger, Au or Cu? Why? _____

4. Which has greater ionization energy, Cu or Ag? Why? _____

5. Which is larger, Ca or Cs? Why? _____

6. Which is larger, Mg or P? Why? _____

7. Which has greater ionization energy, Fe or K? Why? _____

13. Which has greater ionization energy, Cl or Hf? Why? _____

**Periodic Trends Graphing Activity**

SWBAT create and analyze graphs of elemental properties

On a sheet of graph paper, plot the following information. Be sure to consider the range and domain of your graph before you start, in order to waste as little space as possible. Specific instructions follow below.

Part I: Periodic Trend Graphing Activity

| Atomic Number | Element | Ionization Potential (eV) | Atomic Radius (Å) |
|---|---|---|---|
| 1 | H | 13.60 | 0.30 |
| 2 | He | 24.59 | 0.93 |
| 3 | Li | 5.39 | 1.52 |
| 4 | Be | 9.32 | 0.89 |
| 5 | B | 8.30 | 0.88 |
| 6 | C | 11.26 | 0.77 |
| 7 | N | 14.53 | 0.70 |
| 8 | O | 13.62 | 0.66 |
| 9 | F | 17.42 | 0.64 |
| 10 | Ne | 21.56 | 1.12 |
| 11 | Na | 5.14 | 1.86 |
| 12 | Mg | 7.65 | 1.60 |
| 13 | Al | 5.99 | 1.43 |
| 14 | Si | 8.15 | 1.17 |
| 15 | P | 10.49 | 1.10 |
| 16 | S | 10.36 | 1.04 |
| 17 | Cl | 12.97 | 0.99 |
| 18 | Ar | 15.76 | 1.54 |
| 19 | K | 4.34 | 2.31 |
| 20 | Ca | 6.11 | 1.97 |
| 21 | Sc | 6.54 | 1.60 |
| 22 | Ti | 6.82 | 1.46 |
| 23 | V | 6.74 | 1.31 |
| 24 | Cr | 6.77 | 1.25 |
| 25 | Mn | 7.44 | 1.29 |
| 26 | Fe | 7.87 | 1.26 |
| 27 | Co | 7.86 | 1.25 |

| Atomic Number | Element | Ionization Potential (eV) | Atomic Radius (Å) |
|---|---|---|---|
| 28 | Ni | 7.64 | 1.24 |
| 29 | Cu | 7.73 | 1.28 |
| 30 | Zn | 9.39 | 1.33 |
| 31 | Ca | 6.00 | 1.22 |
| 32 | Ge | 7.90 | 1.22 |
| 33 | As | 9.81 | 1.21 |
| 34 | Se | 9.75 | 1.17 |
| 35 | Br | 11.81 | 1.14 |
| 36 | Kr | 14.00 | 1.69 |
| 37 | Rb | 4.18 | 2.44 |
| 38 | Sr | 5.70 | 2.15 |
| 39 | Y | 6.38 | 1.80 |
| 40 | Zr | 6.84 | 1.57 |
| 41 | Nb | 6.88 | 1.41 |
| 42 | Mo | 7.10 | 1.36 |
| 43 | Tc | 7.28 | 1.30 |
| 44 | Ru | 7.37 | 1.33 |
| 45 | Rh | 7.46 | 1.34 |
| 46 | Pd | 8.34 | 1.38 |
| 47 | Ag | 7.58 | 1.44 |
| 48 | Cd | 8.99 | 1.49 |
| 49 | In | 5.79 | 1.62 |
| 50 | Sn | 7.34 | 1.40 |
| 51 | Sb | 8.64 | 1.41 |
| 52 | Te | 9.01 | 1.37 |
| 53 | I | 10.45 | 1.33 |
| 54 | Xe | 12.13 | 1.90 |

1. On a sheet of graph paper, graph the ionization potential (y-coordinate) versus atomic number (x-coordinate). Make sure to properly label the graph.

2. On a sheet of graph paper, graph the atomic radius versus the atomic number. Label the graph.

3. What do the units “eV” and “Å” stand for? These terms are in the book, look them up…DON’T GUESS.

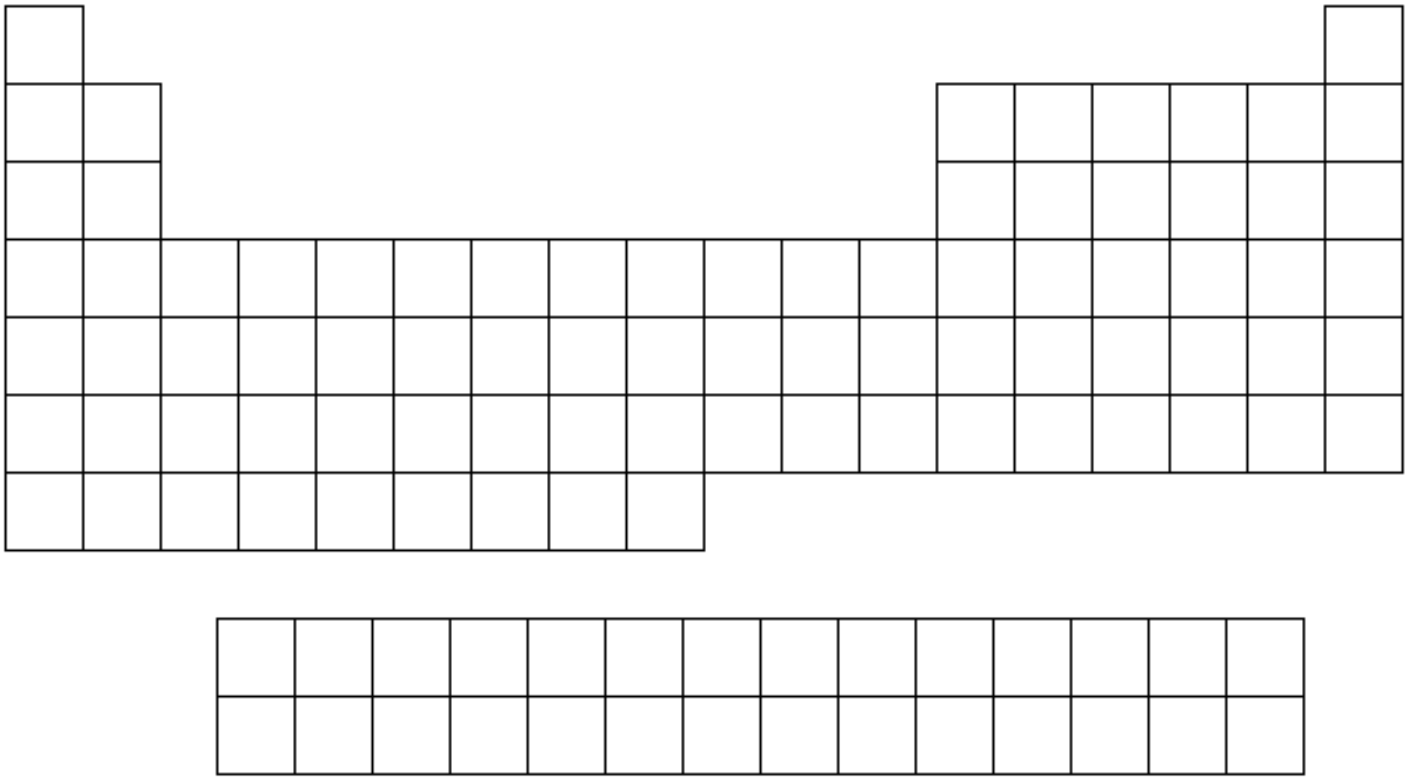
Part II: Periodic Table Identification Activity

1. On the blank Periodic Chart below, clearly locate the following, using a color code:

   a. Representative elements
   b. Transition elements
   c. Metallic elements
   d. Nonmetallic elements
   e. Metalloids
   f. Alkali metals
   g. Alkaline-earth metals
   h. Halogens
   i. Noble gases

2. On the same periodic chart, locate these elements and write in their atomic symbols:

| | | |
|---|---|---|
| a. sodium | f. phosphorus | k. barium |
| b. potassium | g. carbon | l. aluminum |
| c. chlorine | h. magnesium | m. silicon |
| d. nickel | i. sulfur | n. zinc |
| e. bromine | j. calcium | o. lead |



NAME: _____

Part III: Interpretation Questions

1. Notice that the graph of first ionization potential versus atomic number consists of generally rising values followed by sharp drops. List the elements on the five major peaks in this graph. What name is given to this group of elements?

2. List four elements located at the bottom of the sharp drops. What name is given to this group of elements?

3. Assuming that the periodic trends indicated on the graph continue, what value do you predict for the first ionization potential of cesium, Cs, atomic number 55?

4. What generalization can be made about the change in first ionization potential as the atomic number increases in a period (such as Na to Ar)?

5. What generalization can be made about the change in first ionization potential as the atomic number increases in a group (family)?

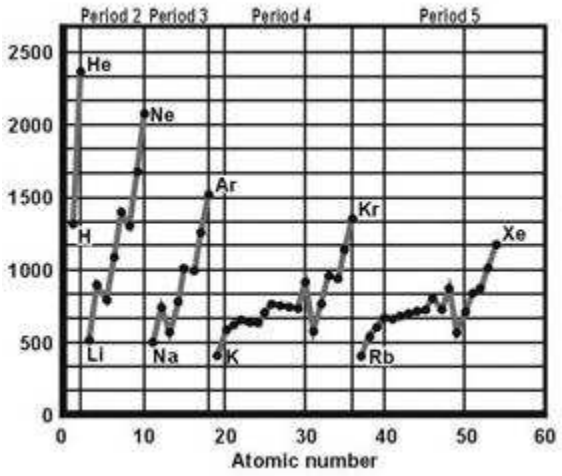
6. Looking at the atomic radius versus atomic number, what would you predict for the atomic radius of Cs, atomic number 55? (Use Cl-Ar-K and Br-Kr-Rb as examples.)

**Unit 6—Periodic Trends** – Take Away Sheet Name:_____

**Complete the following questions as a review for your test.**

1. In general the electronegativity _____ as you move from left to right across the periodic table and _____ as you move from top to bottom.
2. The electronegativity of an atom is defined as
3. What is an atomic radius?
4. In general the atomic radius of an element _____ as you move from left to right across the periodic table and _____ as you move from top to bottom.
5. In general the ionization energy _____ as you move from left to right across the periodic table and _____ as you move from top to bottom.
6. Ionization energy is defined as the energy required to…?
7. Elements in the same group have the same number of _____ _____ and similar properties.
8. **Identify the highest energy level, number of valence electrons, and write the shorthand electron configuration for the following elements.**
    a. Sn
    b. O
    c. W

**9. Explain how you can use this diagram to explain the periodic trend of ionization energy.**

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