Unit 06: Periodic trends

Unit 13: Chemical Periodicity

Driving Question:

- How do I read the periodic table?
- How does nuclear charge and energy level play a role in periodic trends

Connection to past and future units:

- Being able to write electron configuration
- Using electronegativity to explain polarity in a bond

Objectives

- Describe trends and groups using the periodic table
- Write a short hand electron configuration
- Apply support as to why a trend happens

Essential Vocabulary

Periodic trend	Periodic group	Electron Configuration
Periodic Property	Atomic size	Ionic size
Electronegativity	Ionization energy	Shielding
Nuclear charge	Energy Level	

KWL

What do you known about the periodic table?	What do you want to know about the periodic table?	What have you learned about the periodic table?

What goal do you have for yourself for this unit?

Write a goal for yourself for the end of the semester.

Unit 06 – Periodic Trends NAME: _____
Reading Comprehension Sheet

13.1 Development of the Periodic Table

Dmitri Mendeleev

Henry Mosley

13.2 The Modern Period Table

Period

Groups

Periodic Law

Representative Elements

Periodic (use a dictionary not in the book)

Use the definition of dictionary to explain how the periodic table got its name.

13.3 Electron Configuration and Periodicity

Noble Gas

Representative Element

Alkali Metal

Alkaline earth metal

Halogen

Transition Metal

Inner transition metal

How can you tell an element belongs to group 1A

How can you tell an element belongs to group 4A

13.4 Periodic Trends in Atomic Size

Atomic Radii

Atomic Size _____ as you move _____ a group.
Why?

Atomic Size _____as you move _____ a period..
Why?

13.5 Periodic Trends in Ionzation Energy

Ionization Energy

Ionization Energy _____ as you move _____ a group.
Why?

Ionization Energy _____as you move _____ a period..
Why?

13.6 Periodic Trends in Ionic Size

Ionization Energy

Ionic Size _____ as you move _____ a group.
Why?

Ionic Size _____as you move _____ a period..
Why?

13.7 Periodic Trends in Electronegativity

Ionization Energy

Electronegativity _____ as you move _____ a group.
Why?

Electronegativity _____as you move _____ a period..
Why?

Draw Figure 13.10 on page 367

Unit 06 – Periodic Trends NAME: _____
Worksheet 6.01 – Periodic Groups

Answer the following questions.

1. With short answers, relate these terms to the periodic table:

   A. Group: _____

   B. Period: _____

   C. Representative Element: _____

   D. Transition Element: _____

2. Define the terms *cation* and *anion* and show how they are related to the terms *metal* and *nonmetal*.

3. Use the periodic table to determine the charge on the following ions:

Magnesium ion = *2+*	Oxide ion = *2−*	Fluoride ion = ____	Lithium ion = ____
Sodium ion = ____	Aluminum ion = ____	Sulfide ion = ____	Cesium ion = ____

4. Distinguish between a polyatomic ion and a monatomic ion.

5. Circle the choice that makes the following statements true.

   Elements that are nonlustrous and are poor conductors of electricity are called (metals/nonmetals).

   The Group B elements are known as the (representative/transition) elements.

   A (cation/anion) is any atom or group of atoms with a positive charge.

   The metals in Groups 1A, 2A, and 3A (gain/lose) electrons when they form ions.

   The one common polyatomic ion that is positively charged is the (ammonium/ammonia) ion.

   The formula for the hydrogen carbonate ion is (CO_3^{2-}/HCO_3^{1-}).

Unit 06 – Periodic Trends NAME: _____

Worksheet 6.02 – Short-hand Electron Configuration

Element	Long Configuration	Short Configuration
Na		
Br		
Mo		
K		
C		
Ar		
Sr		
Ne		
He		
Dy		
Ag		
Be		
O		

Unit 06 – Periodic Trends NAME: _____

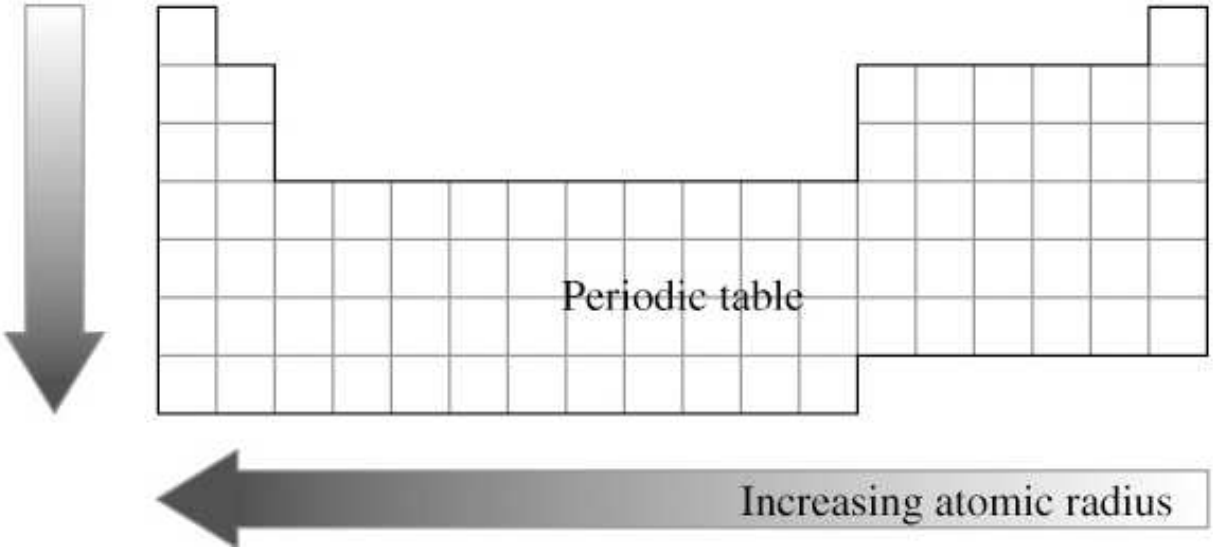
Discussion Sheet 6a – Atomic Radius and Ionic Radius

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.**

Unit 06 – Periodic Trends NAME: _____

Worksheet 6.03 – Atomic Radius and Ionic Radius

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
Calcium atom or Selenium atom	Nitrogen atom or Rubidium atom
Radium atom or Francium atom	Barium atom, Ba or Sulfur atom, S
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	Titanium atom or Copper atom
K^{1+} ion or Cl^{1-} ion	Lithium ion, Li^{1+} or Fluoride ion, F^{1-}
Gadolinium atom or Plutonium atom	Fe^{3+} ion or Fe^{2+} ion

Unit 06 – Periodic Trends NAME: _____

Discussion Sheet 6b – Ionization Energy, Electronegativity, and Electron Affinity

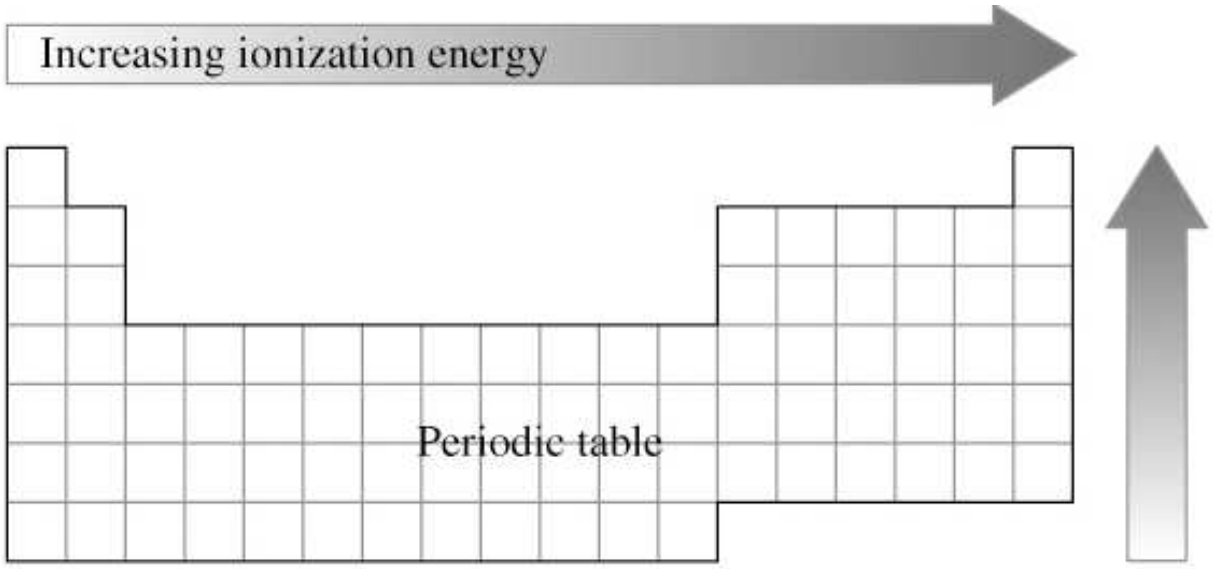
The degree to which an atom holds onto its outermost electrons can also be determined based on its location in the periodic table. This hold a nucleus has on its outermost electrons can be expressed in three ways:

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.**

Unit 06 – Periodic Trends NAME: _____

Worksheet 6.04 – Ionization Energy

For each of the following pairs, circle the element that has the larger ionization energy. Use the periodic table to assist you.

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 Se	Sc or Hf
Rb or I	Pb or Ge
Rb or At	Li or Sn
P or As	Ga or Al
P or S	Ga or Cd
P or Si	Au or Mo
P or N	Ca or Ba
P or In	Sr or Mg
P or B	Ag or Ti

Unit 06 – Periodic Trends NAME: _____

Laboratory Activity 6A – Density is a Periodic Property

You should create a complete lab report for this Laboratory Activity.

The Periodic Table was developed by Dmitri Mendeleev in the mid-1800s. Mendeleev put all of the elements in order based on mass, and noticed a periodic reoccurance 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.

You will be given samples of Silicon, Tin, and Lead. All of these elements are in the same column of the Periodic Table, and have similar properties. Using a balance, you will find the mass of a sample of each element. Using a graduated cylinder and some water, you will then find the volume of each sample. Then, you can determine the density of each element using calculations you have already mastered.

Your goal for this lab is to determine the density of Germanium, element #32, based on what you learn about the other elements in the same column. Watch for patterns. Use this sample data table below to guide your experimental design.

Symbol	Element	Qualitative Observations	Mass of Weigh Boat (g)	Mass of WB and Element (g)	Volume of water (cm^3)	Volume of water and Element (cm^3)
Si	Silicon					
Ge	Germanium	XXXXXXX XXXXXXX XXXXXXX	XXXXXX XXXXXX XXXXXX	XXXXXX XXXXXX XXXXXX	XXXXXX XXXXXX XXXXXX	XXXXXXX XXXXXXX XXXXXXX
Sn	Tin					
Pb	Lead					

Unit 06 – Periodic Trends NAME: _____
Worksheet 6.05 – Completion

Use this completion exercise to check your knowledge of the terms and your understanding of the concepts introduced in this chapter. Each blank can be completed with a term, short phrase, or number.

The periodic table organizes the elements into vertical _____ and horizontal _____ in order of increasing _____. The table is constructed so that elements that have similar chemical properties are in the same _____. The elements in Groups 1A through 7A are called the _____. The _____ make up Group 0. The elements in Groups 2A and 3A are interrupted in periods 4 and 5 by the _____ and in periods 6 and 7 by the _____.

The atoms of the noble gas elements have their outermost *s* and _____ sublevels filled. The outermost *s* and *p* sublevels of the representative elements are _____.

Atomic radii generally _____ as you move from left to right in a period. Atomic size generally _____ within a given group because there are more _____ occupied and an increased _____ effect, despite an increase in nuclear _____.

The energy required to remove an electron from an atom is known as the _____ energy. This quantity generally _____ as you move left to right across a period. The ease with which an atom gains an electron, or the _____, decreases as you move _____. The ability of a bonded atom to attract electrons to itself is known as _____, and this quantity _____ as we move from left to right across a period.

Unit 06 – Periodic Trends NAME: _____

Worksheet 6.06 – Trend Review

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. Restate in one or two words: "The actions of the non-valence electrons, diluting the force of the attraction between nucleus and valence electrons."

4. Which has greater shielding, Au or Cu?

5. Which is larger, Au or Cu?

6. Which has greater ionization energy, Cu or Ag?

7. Which has greater shielding, Xe or Ar?

8. Which is larger, Ca or Cs?

9. Which has greater shielding, Se or Ra?

10. Which has greater nuclear charge, Zn or Se?

11. Which is larger, Mg or P?

12. Which has greater ionization energy, Fe or K?

13. Restate in one or two words: "Half the distance between the nuclei of two like atoms."

14. Which has greater ionization energy, Cl or Hf?

15. Which has greater shielding, P or Ar?

16. Which is larger, Os or Ta?

17. Which is a larger ion, sulfur ion or phosphorus ion?

18. Which has greater shielding, Ge or Ra?

19. Which has greater nuclear charge, Sb or Se?

Unit 06 – Periodic Trends NAME: _____

Laboratory Activity 6B – Periodic Trends – Page One

Part I: Periodic Trend Graphing Activity

Atomic Number	Element	Ionization Potential (eV)	Atomic Radius (Å)	Atomic Number	Element	Ionization Potential (eV)	Atomic Radius (Å)
1	H	13.60	0.30	28	Ni	7.64	1.24
2	He	24.59	0.93	29	Cu	7.73	1.28
3	Li	5.39	1.52	30	Zn	9.39	1.33
4	Be	9.32	0.89	31	Ca	6.00	1.22
5	B	8.30	0.88	32	Ge	7.90	1.22
6	C	11.26	0.77	33	As	9.81	1.21
7	N	14.53	0.70	34	Se	9.75	1.17
8	O	13.62	0.66	35	Br	11.81	1.14
9	F	17.42	0.64	36	Kr	14.00	1.69
10	Ne	21.56	1.12	37	Rb	4.18	2.44
11	Na	5.14	1.86	38	Sr	5.70	2.15
12	Mg	7.65	1.60	39	Y	6.38	1.80
13	Al	5.99	1.43	40	Zr	6.84	1.57
14	Si	8.15	1.17	41	Nb	6.88	1.41
15	P	10.49	1.10	42	Mo	7.10	1.36
16	S	10.36	1.04	43	Tc	7.28	1.30
17	Cl	12.97	0.99	44	Ru	7.37	1.33
18	Ar	15.76	1.54	45	Rh	7.46	1.34
19	K	4.34	2.31	46	Pd	8.34	1.38
20	Ca	6.11	1.97	47	Ag	7.58	1.44
21	Sc	6.54	1.60	48	Cd	8.99	1.49
22	Ti	6.82	1.46	49	In	5.79	1.62
23	V	6.74	1.31	50	Sn	7.34	1.40
24	Cr	6.77	1.25	51	Sb	8.64	1.41
25	Mn	7.44	1.29	52	Te	9.01	1.37
26	Fe	7.87	1.26	53	I	10.45	1.33
27	Co	7.86	1.25	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? What do these measurements mean, in your own words.

Unit 06 – Periodic Trends NAME: _____

Laboratory Activity 6B – Periodic Trends – Page Two

Part II: Graph Extrapolation Activity

Year	Rabbit Population (in thousands)
1994	2.1
1995	5.0
1996	6.8
1997	9.1
1998	11.0
1999	12.3
2000	15.1
2001	18.3
2002	20.2
2003	22.9

1. Plot the rabbit population data given above. Label each axis.
2. Extend the trend indicated on your graph to 2007. How many rabbits does this predict?

Part III: Periodic Table Identification Activity

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

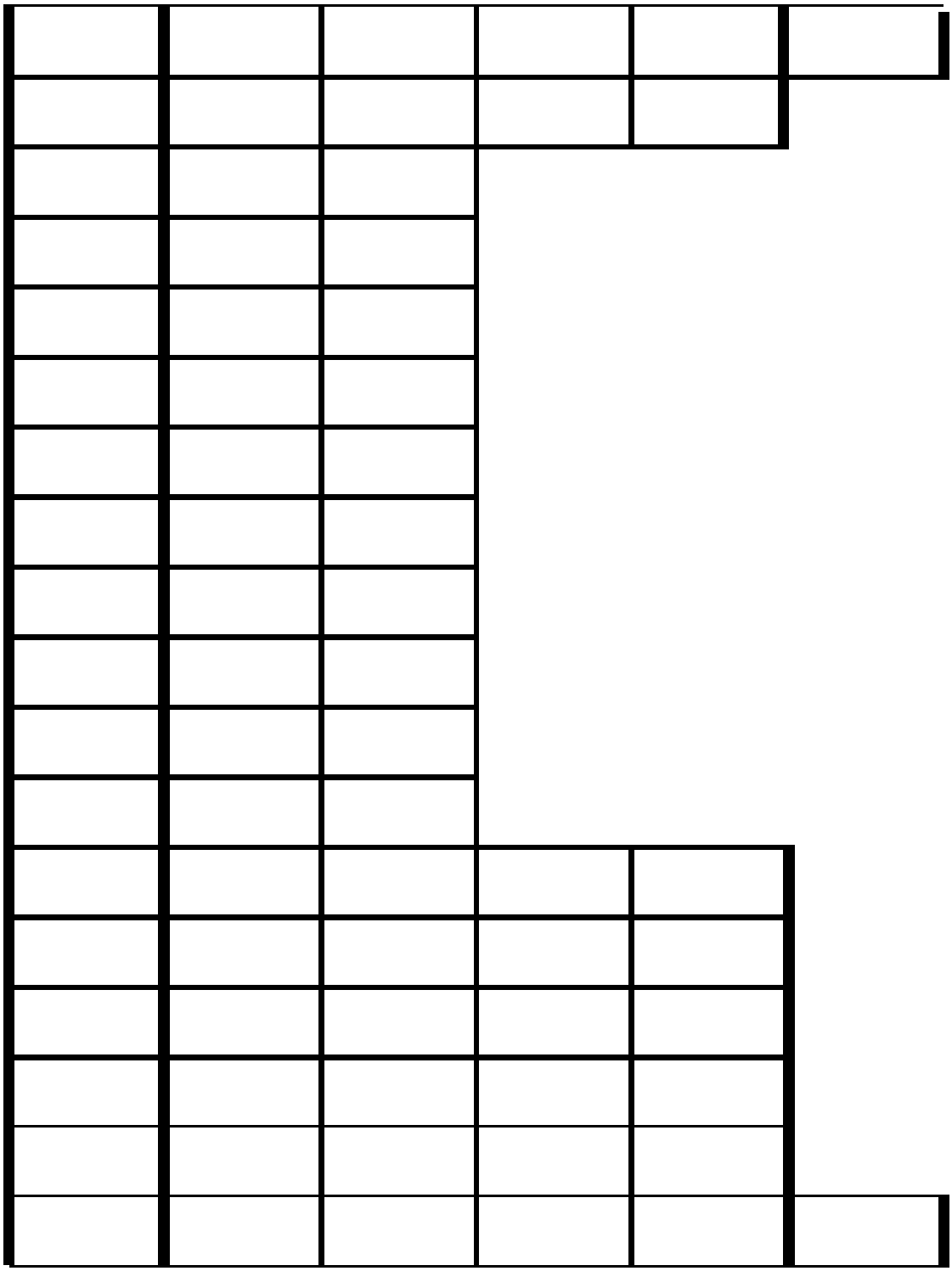
   a. Representative elements
   b. Transition elements
   c. Metallic elements
   d. Nonmetallic elements
   e. Metalloids
   f. Alkali metals
   g. Alkaline-earth metals
   h. Halogens
   i. Noble gases

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

Unit 06 – Periodic Trends NAME: _____

Laboratory Activity 6B – Periodic Trends – Page Three



Unit 06 – Periodic Trends NAME: _____

Laboratory Activity 6B – Periodic Trends – Page Four

Part IV: 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.)