Chapter 14 – Chemical Periodicity and Trends

Watch the **Professor Dave Explains** video, *The Periodic Table: Atomic Radius, Ionization Energy, and Electronegativity* at https://www.youtube.com/watch?v=hePb00CqvP0

Arrangement of the Periodic Table

1. Why was Dimitri Mendeleev's model for the period table more powerful than other models proposed during the mid-to-late 1800's?

2. Elements arranged in columns are called _____, and those arranged in rows are called _____.

3. The arrangement of the table in this manner, enabled chemists to predict the properties of elements never before discovered, which represented gaps in the table. True or false? Circle one.

4. Why do elements in the same group (such as Li, Na, K) all behave similarly?

5. Every element in Group II, has how many electrons? _____ Name three of those elements:
      (1)   (2)   (3)

Periodic Trends in Atomic Radius

The atomic radius is one-half the distance between the nuclei of two like atoms in a real or theoretical diatomic molecule (Wilbraham, Staley, Matta, & Waterman, 2002, p. 398).

6. Describe the trend in atomic radius as you move down a group; as you move from hydrogen, to lithium, to sodium, etc.
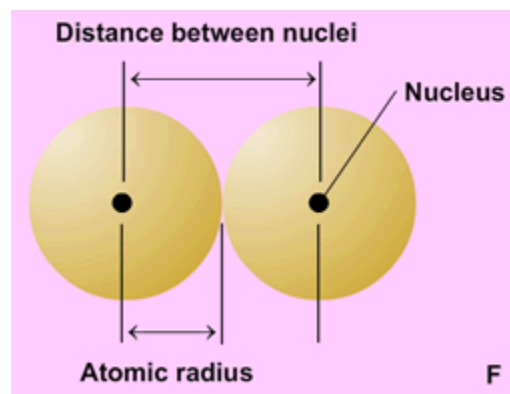

7. Why does this trend exist?

8. Describe the trend in atomic radius as you move across a period; from sodium to magnesium, to aluminum, silicon and phosphorus.

9. What explains this trend? What role does the increasing number of protons play?

Trend: **Atomic Radius**
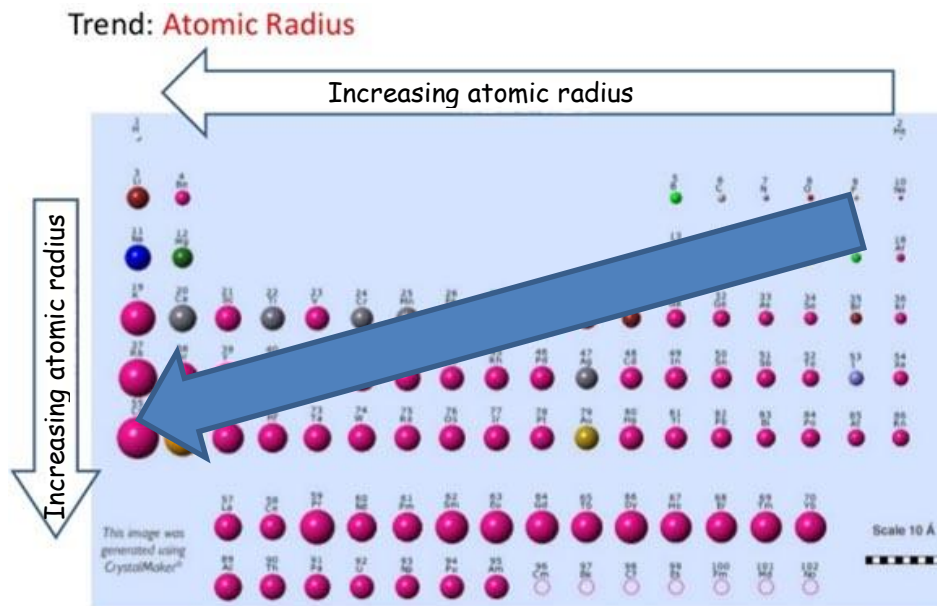
10. Write in the arrows above, the trend of atomic size along a period and group, using the words *increasing* or *decreasing*. Then, write a single arrow on the table summarizing this trend.
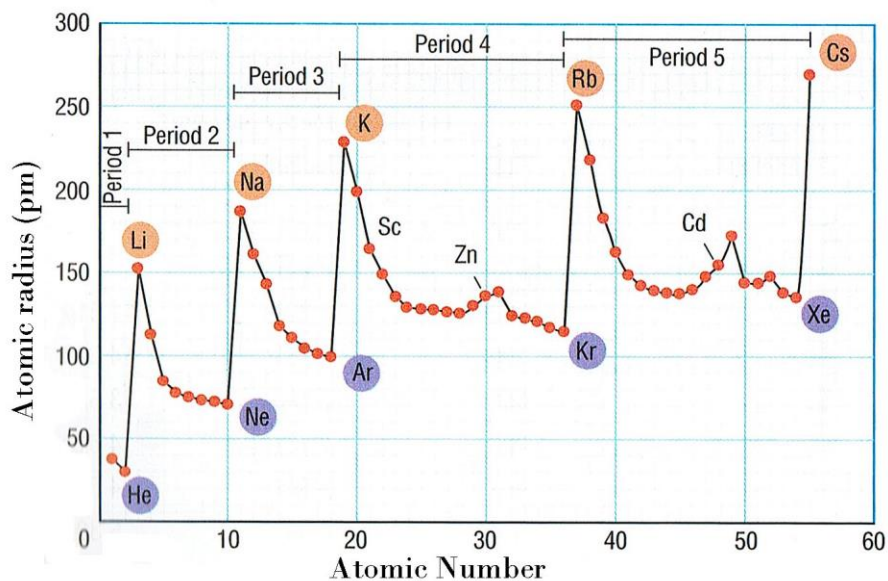
11. Summarize the spikes in the graph plotting atomic number (x) verses atomic radius (y).

Periodic Trends in Ionic Radius
12. When an electron is removed from an atom, the radius gets _____; when an electron is added to an atom, the radius gets _____.

13. What is the electron configuration of these ions (and neon atom)? O^{2-}, F^-, Ne, Na^+, Mg^{2+}
    Hint: the electron configuration is the same for all these. _____

14. What accounts for the trend in ionic radius?
    When the two valence electrons are removed from Mg, making it Mg^{2+}, the outermost energy level is no longer n = 3, but then becomes n = 2. When two electrons are added to O, making it O^{2-}, the ionic radius increases because the added repulsion forces makes the valence electrons move farther apart from one another, increasing the atomic radius.

Periodic Trends in Ionization Energy
The energy required to overcome the attraction of the nuclear charge and remove an electron from a gaseous atom is called the ionization energy. Removing one electron results in the formation of a positive ion with a 1+ charge (Wilbraham et al., 2002, p. 401).

$$Na(g) \rightarrow Na^+ (g) + e^-$$

The energy required to remove the first outermost electron is called the *first ionization energy*.

15. What happens to the electromagnetic force attracting electrons to protons as the distance between outer electrons and the nucleus increases?

16. As you move down a group, from lithium to cesium, first ionization energy _____, and as you move across a row, from sodium to argon, the first ionization energy _____.

17. Why is a francium outermost electron so much easier to pull off than an outermost electron from helium?

18. Why is the second ionization energy typically higher than the first?

19. Once all the electrons are removed from an outer shell, there is a huge jump in ionization energy.

As an example, once the two outer electrons from Mg are removed, ionization energy goes from 1,451 kJ/mol to 7,733 kJ/mol. Why?

successive ionization energies (kJ/mol)

	Na	Mg	Al	Si	P	S	Cl	Ar
1st IE	496	738	578	787	1,012	1,000	1,251	1,520
2nd IE	4,562	1,451	1,817	1,577	1,903	2,251	2,297	2,665
3rd IE	6,912	7,733	2,745	3,231	2,912	3,361	3,822	3,931
4th IE	9,543	10,540	11,575	4,356	4,956	4,564	5,158	5,770
5th IE	13,353	13,630	14,830	16,091	6,273	7,013	6,540	7,238
6th IE	16,610	17,995	18,376	19,784	22,233	8,495	9,458	8,781
7th IE	20,114	21,703	23,293	23,783	25,397	27,106	11,020	11,995
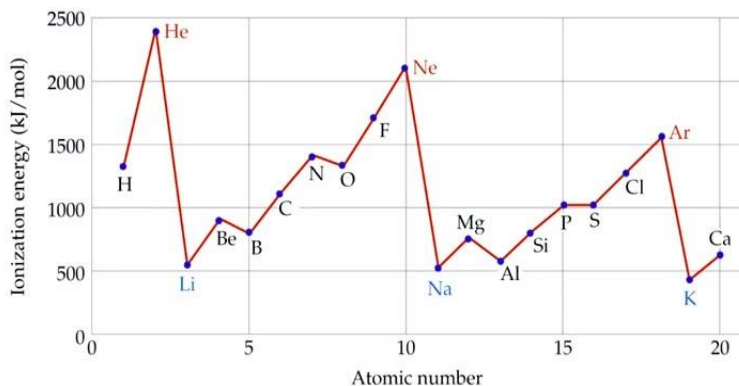
20. Note the graph at left. There is a trend in ionization energy that is obvious, with a few deviations within periods. Explain why it requires less ionization energy to pull an electron off of oxygen, than it does off of nitrogen?

Trends in Electron Affinity

21. Define *electron affinity*.

22. Which element has the greatest affinity for electrons? _____

Trends in Electronegativity

23. Disregarding the noble gases, electronegativity _____ as you move across a period, and _____ as you move down a group.

Comprehension Check (from video)

1. List the following atoms in order of increasing atomic radius:

Si, Kr, Cl, K, Ca

2. Choose the larger atom in each pair:

Br and Br^- Cl^- and Ar   K and K^+

Chapter Review (from text)

13. Write the electron configuration of these elements, using a periodic table only.

a. the inert gas in period 3

b. the element in Group 4A, period 4

c. the element in Group 2A, period 6

20. Indicate which element in each pair has the greater first ionization energy, by circling it.

a. lithium, boron   b. magnesium, strontium   c. cesium, aluminum

Briefly define the following, indicating which outermost sublevels are filled or partially filled (p. 394, 395 in text).

Noble gases –

Representative elements –

Transition metals –

Inner transition metals –