Periodic Trends: Advanced

Name **KEY**

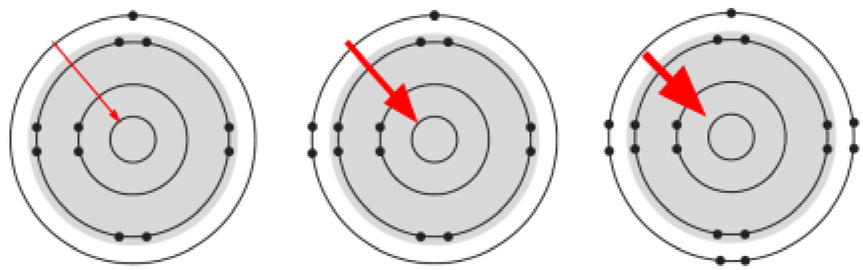
Chemistry

Date __________________ Hour _____

Background - *Read and annotate (highlight and write in the margins) the paragraph below.*

Previously you have learned about Coulombic attraction and how it governs the trends in properties among the elements of the periodic table. For example, as you move across a period, atoms have more protons in the nucleus, which pulls the electrons in tighter making smaller, more electronegative atoms. As atomic number increases in a group/family of the periodic table, the valence electrons get farther away due to additional energy level, and the atoms get larger and less electronegative. Inquisitive students may ask, "If more protons in the nucleus pull electrons in tighter, then why don't atoms get smaller when atomic number increases in a group/family?" That is a good question, and one that you will investigate in this activity.

Model 1 – Period 3 Elements



1) The three elements in **Model 1** are in the same ***period*** / *group/family* .

2) Refer to a periodic table to complete the first **three** rows of the table below.

Element Name and Symbol	Sodium (Na)	Aluminum (Al)	Chlorine (Cl)
Atomic Number	**11**	**13**	**17**
Number of valence electrons	**1**	**3**	**7**
Number of core electrons	**10**	**10**	**10**
Number of shielding electrons	**10**	**10**	**10**
Effective nuclear charge (Z*)	1+	**3+**	**7+**
Atomic radius *(pm)*	186 pm	143 pm	99 pm
1st ionization energy *(kJ/mol)*	496 kJ/mol	578 kJ/mol	1251 kJ/mol
Electronegativity *(no unit)*	0.9	1.5	3.0

3) Consider the **charge** and **location** of protons in an atom.

a) In a ***different color***, indicate on the atomic drawings in **Model 1** the total charge provided by the protons in the proper location for each atom. **Sodium +11 Aluminum +13 Chlorine +17**

b) The number you just added to the diagrams in **Model 1** is called the **nuclear charge, Z**. Explain why this is an appropriate name for this value.

There are only neutrons and protons in the nucleus. Neutrons are neutral in charge and protons have a positive charge. The protons are the only subatomic particles that have a charge in the nucleus, so the charge of the nucleus is equal to the number of protons.

4) Circle the valence electron(s) in each of the atomic diagrams in **Model 1**.

5) In **Model 1**, the shaded circle in each atom indicates the core of the atom – the nucleus and the core electrons which are also known as **shielding electrons**. Complete the fourth row in **Model 1**.

The Shielding Effect & Effective Nuclear Charge - *Read and annotate (highlight and write in the margins) the paragraph below.*

The valence electrons in an atom are influenced not only by the attractive power of the nucleus but also by the repulsive power of neighboring and core electrons. The shielding effect of the core electrons reduces the attractive power of the nucleus. The pulling force that a valence electron actually feels, the **effective nuclear charge (Z^*)**, is much less than the nuclear charge because of this **shielding effect** from core electrons. Although this effective nuclear charge is difficult to calculate directly due to complex quantum effects within the atom, it is approximately equal to the difference between the nuclear charge and the number of shielding electrons.

6) In your own words, define the shielding effect. **When core electrons block the effect of the nucleus on the ve$^-$**

a) Why do you think this is an appropriate name? **The e$^-$ shield the nucleus' attractive power, decreasing force of attrxn**

7) In your own words, define effective nuclear charge. **how much the attractive force the nucleus has on the valence electrons. A measure of how effective the attractive force of the nucleus is.**

a) Why do you think this an appropriate name? **If the strength of the protons is blocked by something then it will be not as effective in attracting e$^-$.**

b) How can you approximate the value of the effective nuclear charge of an atom? **Equal to the number of ve$^-$**

8) Complete the fifth row in **Model 1**. **(see page one)**

9) Use arrows like those to the right to illustrate the relative strength of the effective nuclear charge on the valence electrons in the atoms of **Model 1**. **The arrows are shown in red on the model on page 1**

10) As the atomic number increases across a period, the effective nuclear charge of atoms ***increases*** / *decreases*.

11) **Explain** each of the trends below (and on the next page) as you increase the atomic number across a *period*. Use your knowledge of Coulombic attraction, the structure of the atom, and **effective nuclear charge**.

AR: Atomic Radius	**ENC: Effective Nuclear Charge**	**↑: increases**
IE: Ionization Energy,	**SE: Shielding Effect**	**↓: decreases**
EN: Electronegativity	**FofA: Force of Attraction**	**=: stays constant**

a) Atomic radius

The Trend: **↑ A# in a period, ↓ AR**

The Why: **~~# of Energy Levels =, so SE =~~**

 # p$^+$ ↑, so ENC ↑

↑ FofA

↓ AR (ve$^-$ are pulled closer to the nucleus)

b) Ionization energy **(energy needed to rip off an electron from an atom)**

The Trend: **↑ A# in a period, ↑ IE**

The Why: **~~# of Energy Levels =, so SE =~~**

 # p$^+$ ↑, so ENC ↑

↑ FofA

↑ IE (need more energy to rip an e$^-$ off of an atom.)

c) Electronegativity (**The ability for an atom to steal electrons from another atom.)**

The Trend: **↑ A# in a period, ↑ EN**

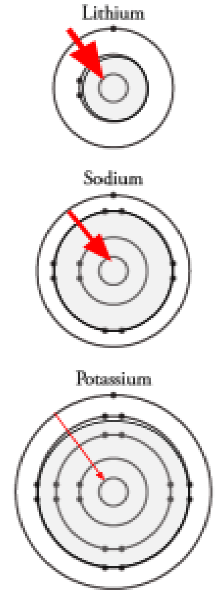
The Why: **~~# of Energy Levels =, so SE =~~**

 # p$^+$ ↑, so ENC ↑

↑ FofA

↑ EN (more likely to attract e$^-$ from another atom)

Model 2 – The Alkali Metals



12) The three elements in **Model 2** are in the same *period* / ***group/family*** .

13) Draw a circle and lightly shade the area representing the core of each atom in **Model 2** – the nucleus and shielding electrons (core electrons).

14) Refer to a periodic table to complete the table below in **Model 2**.

	Atomic Number (Z)	Effective Nuclear Charge (Z*)	Atomic Radius	1st Ionization Energy	Electronegativity
Lithium	3	1	152 pm	520 kJ/mole	0.91
Sodium	11	1	186 pm	496 kJ/mole	0.87
Potassium	19	1	227 pm	419 kJ/mole	0.73

15) As atomic number increases in a group/family on the periodic table, the effective nuclear charge of atoms *increases* / *decreases* / ***stays the same***

16) Is effective nuclear charge a factor in how periodic properties change within a group/family? If no, propose another factor that would influence the attractive forces between the nucleus and valence electrons in an atom.
YES ***NO*** *(circle one)*

Explain/Propose: **ENC remains constant down a group; it can't possibly be the reason we see variation in attractive forces within an atom. The only factors that impact the attractive forces are the number of protons in the nucleus and distance between the nucleus and valence electrons. Refer to Introduction to Coulombic Attractions worksheet.**

Shielding Effect would better explain the trends observed down a group.

17) Use arrows like those in Question 9 of **Model 1** to illustrate the relative strength of the force of attraction between the nucleus and the valence electrons in the atoms of **Model 2**. **The arrows are drawn in red in the images for Model 2.**

18) **Explain** each of the trends below as you increase the atomic number in a *group./family*. Use your knowledge of Coulombic attraction, the structure of the atom, and **effective nuclear charge**.

a) Atomic radius

The Trend: ↑ A# in a group, ↑ AR

The Why: ~~# p⁺ ↑, AND ↑ e⁻ so ENC =~~

# of Energy Levels ↑ , so SE ↑

↓ FofA

↑ AR (ve$^-$ are NOT close to the nucleus)

b) Ionization energy

The Trend: ↑ A# in a group, ↓IE

The Why: ~~# p⁺ ↑, AND ↑ e⁻ so ENC =~~

# of Energy Levels ↑ , so SE ↑

↓ FofA

↓ IE (need less energy to remove e$^-$)

c) Electronegativity

The Trend: ↑ A# in a group, ↓EN

The Why: ~~# p⁺ ↑, AND ↑ e⁻ so ENC =~~

# of Energy Levels ↑ , so SE ↑

↓ FofA

↓ EN (less likely to steal e$^-$ from other atoms)

19) Answer the question posed in the box at the start of the activity: "If more protons in the nucleus pull electrons in tighter, then why don't atoms get smaller as atomic number increases in a group/family?"

Even though we are adding protons to the nucleus as we go down a group, the ENC is not increasing. This is because there are shielding electrons "blocking" the amount of force the protons can *actually* use to attract electrons.