HONORS CHEMISTRY: ELECTROMAGNETIC RADIATION DATE:_____

Learning Activities: **SWBAT. . .**

…define and mathematically calculate basic wave characteristics.
…describe the properties of electromagnetic radiation.
…explain the historical development of our view of light and matter.

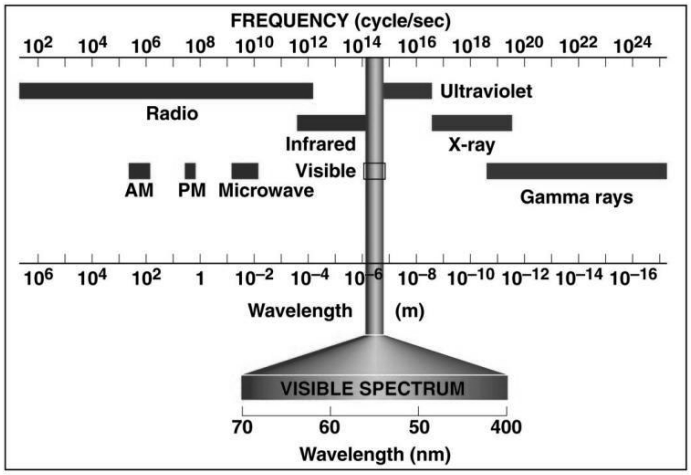
Much of our modern view of the atom was developed in response to laboratory observations of…

ELECTROMAGNETIC RADIATION:

ex)

TOUR THE ELECTROMAGNETIC SPECTRUM

ELECTROMAGNETIC SPECTRUM:



What are 'wavelike properties'?

- Wavelength (lambda, λ):

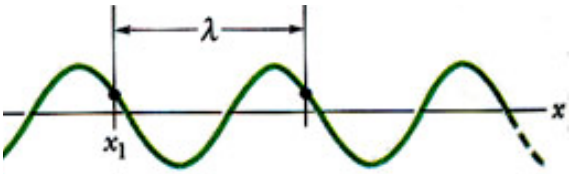
- Frequency (nu, ν):

All electromagnetic radiation travels at _____ in a vacuum

$\mathbf{c = \lambda\nu}$ where λ is in _____ ν is in _____)

Note the inverse relationship between _____ and _____.

Try this: Calculate the frequency of red light at 650 nm.



Try this: Calculate the wavelength of a radio wave with a frequency of 30 MHz.

The energy of electromagnetic radiation is proportional to frequency: $E \propto \nu$

- ex) X-rays have a high frequency ∴ _____
- ex) radio waves have a low frequency ∴ _____

At the turn of the 20 TH century, matter and energy were thought to be distinct and separate.

- Matter acted like particle and energy acted like a wave.
- However, in 1901 **MAX PLANCK** made observations that couldn't be explained with the physics of his time (and would eventually earn him the 1918 Nobel Prize in Physics).
- He found that…

- This didn't agree with the popular belief that any quantity of energy could be emitted.
  (Think of it as a violin vs. a xylophone)

He found the change in energy could be described by the equation: $\Delta E = h\nu$

where ΔE = ν = h=

This meant that energy could not be transferred in just any amount, but <u>quantized</u> in discrete units.

- These 'packets' of energy are called a _____

Try this: When heated, a copper salt emits a blue light at a wavelength of 450 nm. What quantum is emitted?

DID YOU KNOW... "Planck's recognition of the quantized nature of energy was his most important work and a turning point in the history of physics. The importance of the discovery, with its far-reaching effect on classical physics, was not appreciated at first. However the evidence for its validity gradually became overwhelming as its application accounted for many discrepancies between observed phenomena and classical theory.

Planck faced a troubled and tragic period in his life during the period of the Nazi government in Germany, when he felt it his duty to remain in his country but was openly opposed to some of the Government's policies, particularly as regards the persecution of the Jews... He suffered a personal tragedy when one of his sons was executed for his part in an unsuccessful attempt to assassinate Hitler in 1944. Planck died on October 4, 1947."

http://nobelprize.org

"Every man is guilty of all the good he didn't do." ~ Voltaire

HONORS CHEMISTRY: GOOD-BYE RUTHERFORD, HELLO BOHR DATE:_____

Learning Activities: **SWBAT. . .**

…describe the properties of electromagnetic radiation.
…explain the historical development of our view of light and matter.
…discuss the importance of Bohr's Model of the Hydrogen atom.

ALBERT EINSTEIN built on the work of Planck and suggested that electromagnetic radiation could be viewed as a stream of 'particles' called_____

$$\Delta E = E_{photon} = h\nu = hc/\lambda$$

In 1905 he published his **Special Theory of Relativity** and with it his famous equation, _____ The main significance…

We can now solve the above equation for relativistic mass of a photon of a given wavelength…

Try this: What is the relativistic mass of an x-ray photon with a wavelength of 10. nm?

EINSTEIN WINS A PRIZE

In 1922, American physicist **ARTHUR COMPTON** verified Einstein's mass predictions through experimentation. Hence the ***DUAL NATURE OF LIGHT:***

REMEMBER, NOT ALL ELECTROMAGNETIC RADIATION IS VISIBLE! MOST IS OUTSIDE OUR SENSORY RANGE.

Radiant energy can be emitted different ways:

MONOCHROMATIC:

ex)

POLYCHROMATIC:

ex)

SPECTRUM:

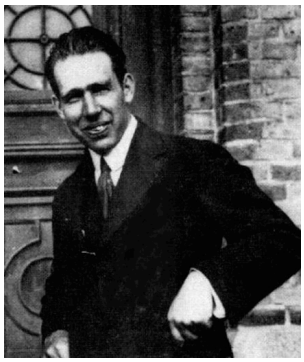
CONTINUOUS SPECTRUM:

ex)

LINE SPECTRUM:

ex)

- In 1885, Swiss schoolteacher **JOHANN BALMER** determined a mathematical relationship for the four lines in hydrogen's bright-line spectrum. It would take another 30 years for someone to explain it.



- In 1914, Danish physicist **NIELS BOHR** attempted to explain the hydrogen spectrum by incorporating two important and recent developments:

A) Rutherford's recognition of...

- The problem was that classical physics predicted orbiting electrons would lose energy and quickly crash into the nucleus.

B) Planck's/Einstein's realizations that...

- It could be thought of a stream of discrete bundles of energy called photons.

Bohr's Quantum Model of the Hydrogen Atom had two main ideas:

1) The electron moves around the central proton in a circular orbit, but…
   - These orbits correspond to definite or _____ energy states.
2) The electron can change from one allowed state to another by…
   - The frequency of the radiant energy…

- So imagine the area around the nucleus as a _____. Electrons can only exist on the rungs ® cannot spiral down into nucleus because they cannot exist below the bottom energy level.
- Bohr was awarded the Nobel Prize in Physics in 1922.
- Although promising, Bohr's model failed because…
- Though incorrect, Bohr's model is important because…

DID YOU KNOW... "...A so - called massless particle such as a photon, moves at the speed of light in every frame of reference... they have no rest mass, because they can never be measured in a frame where they are at rest. This property of having no rest mass is what causes these particles to be termed "massless." However, even massless particles have a relativistic mass, which varies with their observed energy in various frames of reference." http://en.wikipedia.org/wiki/Mass_in_special_relativity

DID YOU KNOW... "... Bohr studied under both J.J. Thomson and Rutherford.

... Albert Einstein never accepted the probabilistic nature of quantum mechanics and debated Bohr with phrases such as "God does not play dice." On one occasion Bohr answered, "Einstein, stop telling God what to do."

... Bohr's son Aage was the co - winner of the Nobel Prize for Physics in 1975.

"If I have seen farther than others, it is because I have stood on the shoulders of giants." ~ Sir Isaac Newton

HONORS CHEMISTRY: THE THREE WISE MEN DATE:_____

Learning Activities: **SWBAT. . .**

… explain the contributions of de Broglie, Schrödinger, and Heisenberg to the wave Mechanical Model of the atom.

"IF THAT TURNS OUT TO BE TRUE, I'LL QUIT PHYSICS."
- MAX VON LAUE, NOBEL LAUREATE PHYSICS 1914, OF DE BROGLIE'S THESIS

IN THE YEARS FOLLOWING BOHR, THE DUAL NATURE OF RADIANT ENERGY BECAME WIDELY ACCEPTED.

- Depending on the circumstances, radiant energy could behave like…

In his 1924 doctoral thesis, **LOUIS DE BROGLIE** made a bold extension of the dual nature concept:

- What if…
- What if…

He proposed the equation for wavelength (m): $\lambda = h/(mv)$

where…

h = **m =** and **v =**

(note:)

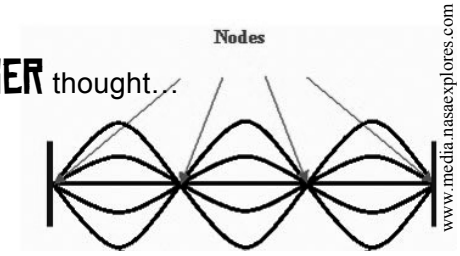
Basic idea:

BLAME DE BROGLIE!

Try this: What is the wavelength of an electron ($m=9.11\times10^{-28}$ g) with a velocity of 5.97×10^{6} m/s?

In 1927 de Broglie's work was experimentally verified separately by **CLINTON DAVISSON** and **G.P. THOMSON** (Yes, J.J. Thomson's son). De Broglie won it the Nobel Prize in Physics 1929, the other two won it in 1937.

Based on de Broglie's work, **ERWIN SCHRÖDINGER** thought…



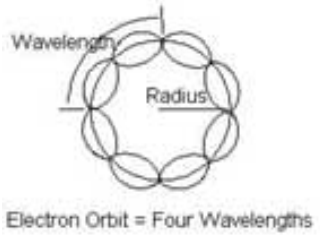
www.media.nasaexplores.com

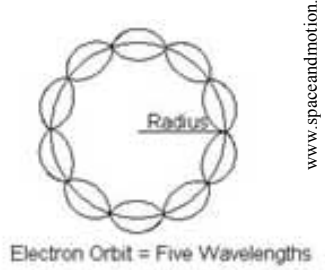
- Only certain orbits have…

WAVE FUNCTIONS

- Schrödinger's work involved highly complex mathematical treatments of different **wave functions**.

The wave functions that 'fit' were called **ORBITALS:**





www.spaceandmotion.com

-

- You cannot predict the exact path of electrons. (Think of a strobe photograph of a bee and a flower.)
- Often drawn as electron clouds; darker the color,
- A solid-looking orbital model represents…

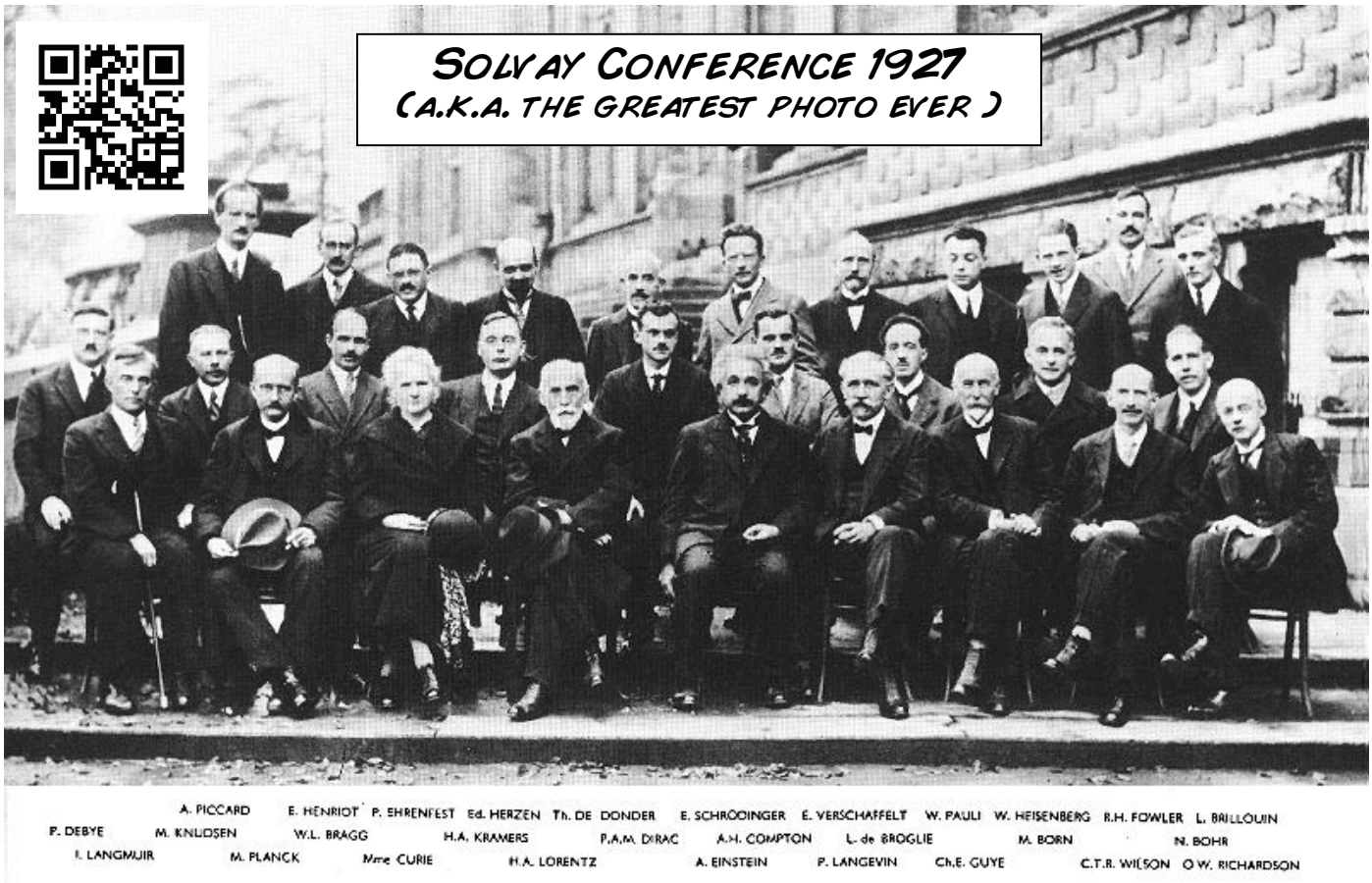
Schrödinger, with **PAUL DIRAC**, co-won 1933 Nobel Prize in Physics for his work. (and later would strongly oppose to the evolution of his natural wave theory into a statistical/probability explanation.)

"I don't like it, and I'm sorry I ever had anything to do with it."
- Erwin Schrodinger, on the probability interpretation of the waves

WERNER HEISENBERG won the 1932 Nobel Prize in Physics for his recognition of…

- If you shine a flashlight on a bowling ball, the energy comes back at you. The bowling ball doesn't move.
- But if you hit an electron with energy, it will change the electron's motion.
- ***Heisenberg's Uncertainty Principle:***

I'M UNCERTAIN



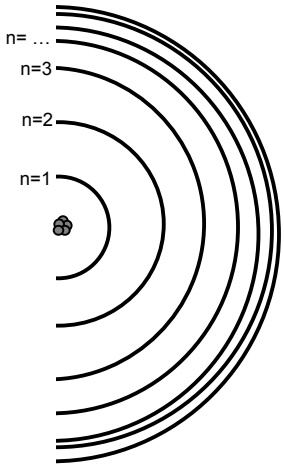
"The very act of observing disturbs the system." Werner Heisenberg

HONORS CHEMISTRY: How to Become a Quantum Ranger! DATE:_____

Learning Activities: **SWBAT. . .**

… use the four quantum numbers to define an electron's position.
… explain the Pauli Exclusion Principle.

We use addresses to find people. Electrons have addresses too. We call them **QUANTUM NUMBERS**.
The different classifications are represented by four letters: n, ℓ, m_ℓ , m_s



PRINCIPAL QUANTUM NUMBER (n):

n =

- *Electron Shell:*

- The larger the value of *n*, the further from the nucleus ∴

- n =2 occupies higher level of n = 1 ∴

SECOND QUANTUM NUMBER (ℓ):

ℓ =

- Letters often used in place of numbers. (0 = *s*, 1= *p*, 2 = *d*, 3 = *f*)

What are the different types of orbitals?

***s*:**

***p*:**

ORBITALS

d and ***f*:**

Orbital images from Visualizing Chemistry; (Tocci & Viehland) and www.geo.arizona.edu

Electrons with same n and ℓ occupy the same _____ or _____.

MAGNETIC QUANTUM NUMBER (m_ℓ):

m_ℓ = ex) a p orbital has an ℓ =1 ∴ m_ℓ can be…

These represent the different p orbital orientations available on that energy level.

SPIN QUANTUM NUMBER (m_s):

- Each orbital can hold only two electrons; designated spin up and spin down. (m_s = +1/2 or -1/2)

Just like students, electrons can't occupy the exact same spot.

Pauli Exclusion Principle:

Wolfgang's work would earn him the 1945 Nobel Prize in Physics.

Try filling in the blanks...

principal energy level (n)	subshells available (l)	Possible magnetic quantum numbers (m_l)	# of possible electrons in subshell	total electrons in energy level
_____	_____ ( )	___	_____	_____
_____	_____ ( )	___	_____	_____
	_____ ( )	___ ___ ___	_____	
_____	_____ ( )	___	_____	_____
	_____ ( )	___ ___ ___	_____	
	_____ ( )	___ ___ ___ ___ ___	_____	
_____	_____ ( )	___	_____	_____
	_____ ( )	___ ___ ___	_____	
	_____ ( )	___ ___ ___ ___ ___	_____	
	_____ ( )	___ ___ ___ ___ ___ ___ ___	_____	

PAULI EXCLUSION FIGHT

Review & Reflection

"One does not discover new lands without consenting to lose sight of the shore for a very long time."
~ Andre Gide

HONORS CHEMISTRY: ORBITAL DIAGRAMS

DATE:_____

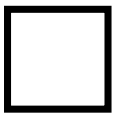
Learning Activities: **SWBAT. . .**
…draw and interpret orbital diagrams.

A DIFFERENT TAKE

ORBITAL DIAGRAMS:

- Basic idea: *THE AUFBAU PRINCIPLE:*

ex) if you drop M&Ms into a sugar cone, they'll fill the bottom, before stacking.



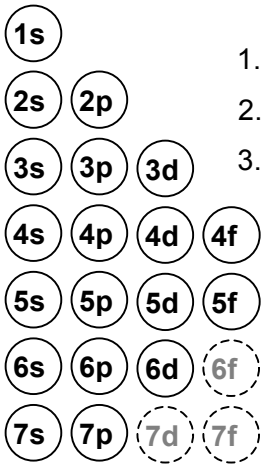
- Each orbital is represented by _____ and, like any orbital, can hold _____electrons.
- The 1st electron is represented by a half arrow up; the 2nd, by a half arrow down.

From last class we know that each subshell in made up of a different number of orbitals, based on m_ℓ …

s orbital	p subshell	d subshell	f subshell
☐	☐☐☐	☐☐☐☐☐	☐☐☐☐☐☐☐

m_ℓ :
max e⁻:

Due to overlapping energy levels you need to figure out the order in which the orbitals fill. You can always recreate the Handy Orbital Filling Chart :



1. List subshells in columns, recognizing not all subshells are available in earlier levels.
2. Draw lines at left downward angles. This is the order they will fill in.
3. All atom's use the same filling order; only show subshells used.

HUND'S RULE:

- This arrangement minimizes repulsion between electrons ∴ it is the most stable.
- The 1st electron in each orbital is spin up. The 2nd is spin down.

ex) Carbon has six electrons. Which orbital diagram is correct?

Try this… Draw orbital diagrams for each of the following elements: N, Ne, Mg, P, Cl, Rb, Ag, Pb

"It is my task to convince you not to turn away because you don't understand it…
…I don't understand it. Nobody does."
~ Richard P. Feynman, Physics Nobel Laureate, 1965

HONORS CHEMISTRY: E⁻ CONFIGS & NOBLE GAS ABBREVIATIONS DATE:_____

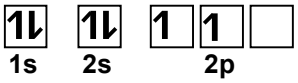
Learning Activities: **SWBAT. . .**

…write out electron configurations for any orbital diagram.
…write out a noble gas abbreviation of any electron configuration.

ELECTRON CONFIGURATION:

ANOTHER TAKE

CARBON'S ORBITAL DIAGRAM:



CARBON'S ELECTRON CONFIGURATION: $1s^2 2s^2 2p^2$

coefficient= **letter =** **superscript =**

Try drawing the orbital diagram and electron configuration for aluminum:

NOBLE GAS ABBREVIATION:

ANOTHER TAKE

To save even more space, electron configurations can be written in terms of…

ex) Ne =

and Al = …so we can rewrite aluminum as…

REVIEW & REFLECTION

"This isn't right. This isn't even wrong."
~ Wolfgang Pauli (on a paper submitted by a physicist colleague)

HONORS CHEMISTRY: CONNECTING THE PERIODIC DOTS... DATE:_____

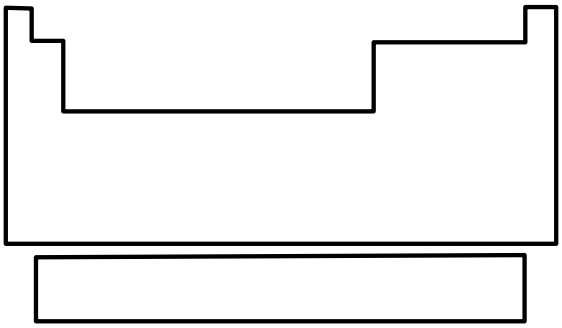
Learning Activities: **SWBAT. . .**

…apply quantum information to prior periodic table knowledge.
…explain the periodic table trends for atomic radius.

HOW CAN YOU TIE THE QUANTUM INFORMATION INTO YOUR PRIOR PERIODIC KNOWLEDGE?

FILLING ORDER CORRELATES TO THE SHAPE OF THE PERIODIC TABLE.

- Regions of the periodic table are also known as…
- The **d blocks** are shifted down one period to…
- The **f blocks** are shifted down yet again
- Electron filling order matches what you already know about the number of electrons per row. (i.e. 2, 8, 8, 18, 32,…)
- Elements in the same family or group have…



- Helps explain similar properties within families.
- Example:

- Valance electrons are…
- That makes 8 for everyone except hydrogen and helium.

Note #1: Inner electrons are sometimes called _____

Note #2: There are exceptions to the predicted filling order in the transition metals. (Ex, Cr, Cu)

REVIEW OF 4 CATEGORIES OF THE PERIODIC TABLE:

1. NOBLE GASES:

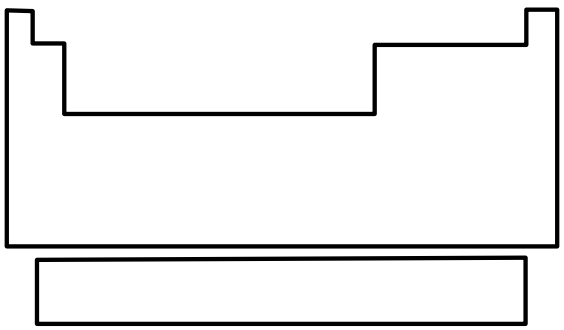
- _____ due to their full valence shell (a.k.a. outermost 's' and 'p' subshells).

2. METALS:

- Want to lose the few valence electrons they have.
- The metallic region is so large is because…

∴

∴



3. NON-METALS:

- Have a fuller valence shell ∴

4. METALLOIDS:

- Intermediate properties due to…

Why do the reactivity of families change as you go down a column?
Why are the metalloids spread across several families instead of concentrated in just one?

ALL PERIODIC TRENDS CAN BE DERIVED FROM THE ATOMIC RADIUS.

THE BEGINNING OF A LARGE SERIES OF VIDEOS ON PERIODIC TRENDS

- Must be indirectly determined from bond lengths since…

VERTICAL TREND:

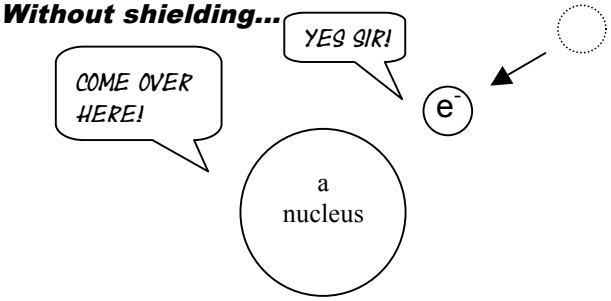
Why?

- On top of this, the radius is bigger due to_____.

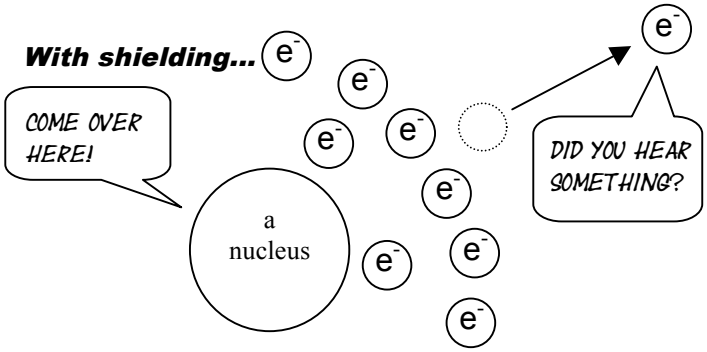
Core electrons reduce the nucleus' ability to…

∴

Without shielding...



With shielding...



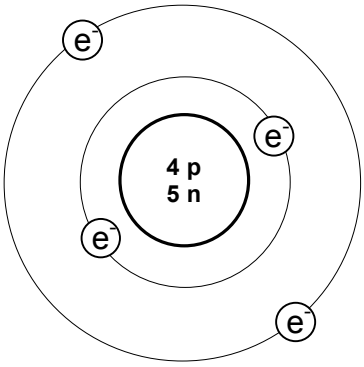
HORIZONTAL RADIUS:

Why?

∴

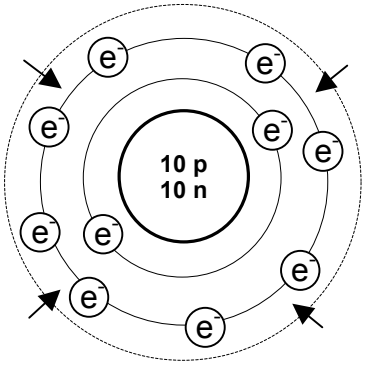
∴

∴



Final note: The radius of an ion will be different than that of the neutral atom.

- Anions are _____.
- Cations are_____.



Can you figure out why?

"Make up your mind to act decidedly and take the consequences.
No good is ever done in this world by hesitation." ~ Thomas H. Huxley

HONORS CHEMISTRY: Ionization Energy & Electron Affinity DATE:_____

Learning Activities: **SWBAT. . .**

…describe periodic trends with respect to ionization energy and electron affinity.

IONIZATION ENERGY:

STEALING PURSES

For any element (A): A + energy → $A^+ + e^-$

Vertical trend:

-

Why? As you go down a family…

∴

∴

∴

Horizontal trend:

-

Why? The number of protons in the nucleus…

∴

∴

∴

NOTE:

ELECTRON AFFINITY:

NO PURSES HERE

For any element (A): A + e^- → A^- + energy

- Equals…
- Electron affinity values are either zero or negative:

ex) Beryllium has an electron affinity of _____ while fluorine has a value of _____ .

When talking about electron affinity to make sure you distinguish between _____ and _____. As the numerical value _____, the _____!

Vertical trend:

-

Why? The greater nuclear pull from more protons is…

∴

Horizontal trend:

-

Why? The number of protons _____ while…

…the atomic radius _____,

…and the shielding effect _____ ,

∴ the nuclear pull on new electrons _____.

Remember, these are general trends. There will be exceptions.

Review & Reflection

DID YOU KNOW... Mendeleev was not the first scientist to try and organize elements?

Johann Dobereiner (1780 - 1849) found several different groups of three elements that had similar properties. For example, chlorine, bromine and iodide all had similar properties. However, his attempts to expand his model of triads, as he called them, were largely unsuccessful.

John Newlands (1837 - 1898) suggested in 1864 that elements could be arranged in octaves. This idea was based around his observation that certain properties repeated every eight elements (not bad, considering there are eight valence electrons...). While more promising than the idea of triads, octaves still proved generally unsuccessful at explaining elemental properties.

Though Mendeleev is given credit for the foundation of the modern periodic table, he was not alone. **Lothar Meyer** (1830 - 1895) is also recognized by many as coming up with a very similar idea. However, it was Mendeleev's emphasis of how the table could be used to predict the existence of still unKnown elements that cemented his importance in the annuals of chemistry.

"To see what is in front of one's nose needs a constant struggle." ~ George Orwell