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Section 1: Bohr Models

1. Calculate the number of electrons in the following atoms:

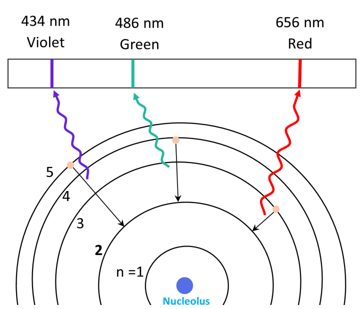
   a. In^{+3} #e = 49-3 = **46**
   b. Ru^{0} #e = 44-0 = **44**
   c. Tb^{+4} #e = 65-4 = **61**
   d. Br^{-1} #e = 35- -1 = **36**
   e. Kr^{0} #e = 36-0 = **36**
   f. Rf^{+4} #e = 104-4 = **100**

2. Draw a **Bohr Model** of the following elements or ions:

   a. Ge^{0} 32e →)2)8)8)14
   b. Nb^{+3} 38e →)2)8)8)18)2
   c. S^{-2} 18e →)2)8)8
   d. Ca^{+2} 18e →)2)8)8
   e. Ru^{0} 44e →)2)8)8)18)8
   f. N^{-2} 9e →)2)7

Section 2: Spectroscopy

3. Draw a model of a Bohr atom showing how it can absorb and release energy, creating a visible light spectrum like we observed in class.



Atoms can absorb energy for many diff sources (electricity, heat, chemical, etc…), and use that energy to promote electrons to higher levels.
Electrons will then naturally relax down to their orig level (ground state) and give off the diff in energy between the levels as light we can see!
The color of that light corresponds to the gap between the rings. Each jump gives off a diff color of light we see as lines on the spectrometer.

4. What would be the most noticeable difference in the observable spectrum produced between two atoms if one of those atoms **had more possible jumps** between rings than the other?
   More jumps means more diff colors of ight released by your atom. This would show up as a **larger number of lines** on the spectrometer!

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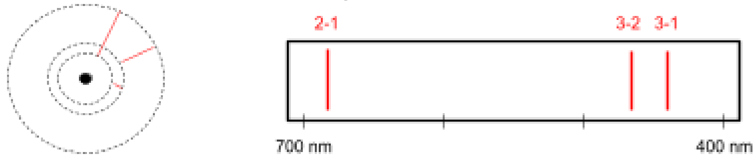
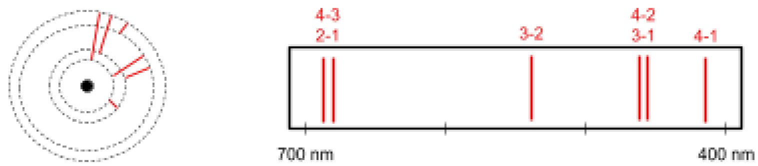
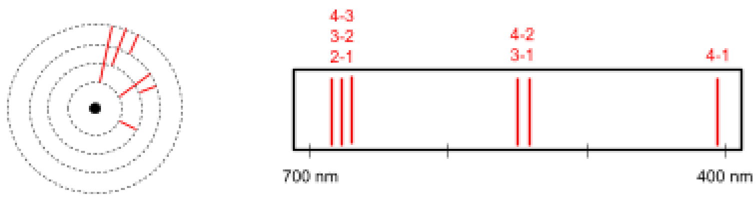
5. Predict the spectra for the following Bohr Models:
   a.


   b.


   c.


Section 4: Schrodinger Model

6. Describe **Heisenberg's Uncertainty Principle** in a few sentences. What did it show was wrong with the Bohr Model of the atom?
   HUP tells us that we can never know all of the needed information about an electron based on it's quantum mechanical nature. The more we try to measure one property, the less we can know about the other.

   This means that the Bohr Model's very predictable circular orbits cannot be the correct description of electron movement. Instead, the rings are replaced with orbitals that show the probable location of an electron, not where it actually is.

7. Describe **Wave Particle Duality** in a few sentences. What did it show was wrong with the Bohr Model of the atom?
   WPD suggests that electrons have the properties of both a particle AND a wave. Electrons have a mass and location (particle), but also a wavelength and frequency (waves).

   The Bohr model assumes that an electron is simply a particle. By ignoring the wave characteristics of an electron the model cannot fully describe electron behavior.

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8. Describe **electron-electron repulsion** in a few sentences. What did it show was wrong with the Bohr Model of the atom?
   As electrons orbit the nucleus they are attracted to the positively charged nuclues, which holds them into the atom. Electrons ALSO repel against one another due to the like charges.

   Bohr ignored this repulsion force because it was very complex to track AND because the space between electrons is very large. He surmised that this would make that force negligible.

   In reality, electron repulsion is a very important factor in atomic behavior, and ignoring it will not produce accurate pics of electron configs.

9. What is the **Wave Equation**? What type of data did you input into this equation? When you solved it what did you get as a result?
   The Schrodinger Wave Equation is a function that tries to model electron behavior around a nucleus. It includes components from the Bohr model, HUP< and WPD to make a better model/pic of an atom.
   When you solve the wave equation for a particular electron and plot the answer it creates the 3D orbitals we drew in Section 3. These orbitals represent the new volume of space that that electron will occupy around the nucleus, replacing the old ring from the Bohr Model.

10. Draw some examples of the **orbitals** used to hold electrons in the Schrodinger Model of the Atom. What do these orbitals represent? What role does probability play in the shapes of these orbitals?
    Any of the 16 orbital shapes would work here. I would give you full credit if the shape was even close to one of the 16 we drew. You do NOT need to memorize those pics, just be familiar with them!
    These orbitals represent the 3D volume that electrons occupy around the nucleus instead of living on a ring from the Bohr Model.
    Because of HUP, these orbitals represent where an electros is most likely. In reality the electron occupies ALL of the locations inside the orbital, as well as all other locations in the universe… simultaneously! The orbital represents the more likely locations. This is how probability fits into this discussion.

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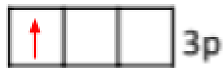
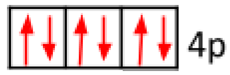
Section 4: Box Diagrams

11. Draw **box diagrams** of the following elements and ions. Use this blank box diagram as a template.
    Answers show the last orbital ONLY! Your box diagram should have a matching Last orbital!

    a. Al^{0} #e = 13 - 0 = 13

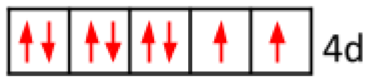
    b. As^{-3} #e = 33 - -3 = 36

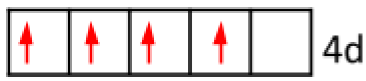
    c. V^{+3} #e = 23 - 3 = 20

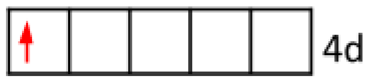
    d. Pd^{0} #e = 46 - 0 = 46

    e. Pd^{+4} #e = 46 - 4 = 42

    f. Y^{0} #e = 39 - 0 = 39

12. Draw an example of a box diagram that **breaks** the following rules. Use this blank box diagram as a template.
    a. Aufbau Principle
       This diagram should have higher boxes/orbitals filled before you completely fill any of the lower levels.
    b. Pauli Exclusion Principle
       This would have any one box/orbital with 2 arrows pointing in the same direction.
    c. Hund's Rule
       This example would have a box diagram that has pairs of electrons in a p, d, or f orbital level without first filling each box at the level with at least 1 electron.

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13. Write out a **shorthand configuration** of the following elements and ions. Use this blank box diagram as a template.

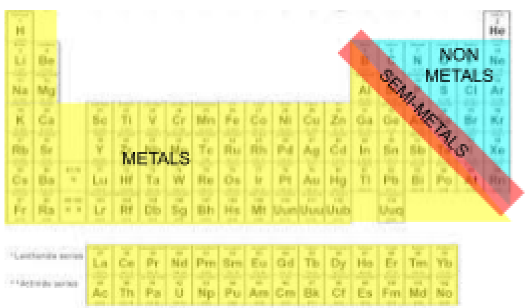
a. Sn^0 → #e = 52 - 0 = 52 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^2$
b. Ca^{+2} → #e = 20 - 2 = 18 $1s^2 2s^2 2p^6 3s^2 3p^6$
c. Ag^{+1} → #e = 47 - 1 = 46 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^8$
d. Ni^0 → #e = 28 - 0 = 28 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
e. Si^{-2} → #e = 14 - -2 =16 $1s^2 2s^2 2p^6 3s^2 3p^4$
f. Ga^{+3} → #e = 31 - 3 = 28 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$

14. Write out a **noble gas configuration** of the following elements and ions. Use this blank box diagram as a template.

a. Rb^0 → #e = 37 - 0 = 37 $[Kr]5s^1$
b. In^{+3} → #e = 49 - 3 = 46 $[Kr]5s^2 4d^8$
c. Br^{-1} → #e = 35 - -1 =36 $[Ar]4s^2 3d^{10} 4p^6$
d. Es^0 → #e = 99 - 0 = 99 $[Rn]7s^2 5f^{11}$
e. Tb^{+4} → #e = 65 - 4 = 61 $[Xe]62^2 4f^5$
f. As^{-3} → #e = 33 - -3 =36 $[Ar]4s^2 3d^{10} 4p^6$

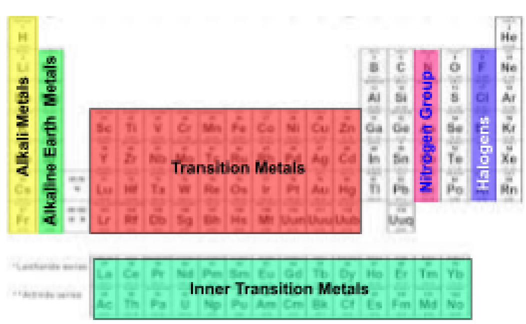
Section 5: The Periodic Table

15. Color code the periodic table below for the following groups of elements:



- Metals
- Non-metals
- Semimetals or Metalloids

16. Color code the periodic table below for the following groups of elements:



- Alkali Metals
- Alkaline Earth Metals
- Nitrogen Group
- Halogens
- Transition Metals
- Inner Transition Metals

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17. Define the following terms connected to the periodic table:

   a. Families
   b. Groups
   c. Periodic Trend
   d. Atomic Radius
   e. Electronegativity
   f. Ionization Energy

Section 6: Periodic Trends

18. Write out the formula for [Coulomb's Law](). Describe each of the variables.

constant

These represent the charges of the two charged particles, the nucleus (+) and the electron (-)

Force acting between charged particles

$$F = \frac{k\, q_1\, q_2}{d^2}$$

This is the distance separating the charged particles.

19. Use Coulomb's Law to explain the trend in either **Atomic Radius** or **Electronegativity**. Make sure to include **which variables are relevant** to the explanation as well as **how those variables are mathematically related to one another**, according to the equation.

Atomic Radius

As we go across the PT from left to right, each step adds one more proton into the nucleus, making the overall charge of the nucleus greater.

This increases the value for q in this equation.

$$\boxed{F} = \frac{k\, \boxed{q_1}\, q_2}{d^2}$$

When q increases because of the added protons, assuming other variables stay constant, algebra tells us that F, of the force acting on the electrons must get larger.

This force pulls electrons closer to the nucleus, making for a smaller AR.

Electronegativity

The distance separating the nucleus from the electrons is a way of describing Atomic Radius! Therefore as our atoms get larger or smaller AR values, we would expect the value for distance (d) to change in the same way!

$$\boxed{F} = \frac{k\, q_1\, q_2}{\boxed{d^2}}$$

When AR gets arger we are dividing by a larger value. This will result in a smaller answer for force.

We can relate this force directly to electronegativity. The def of EN is the attractive force on electrons!

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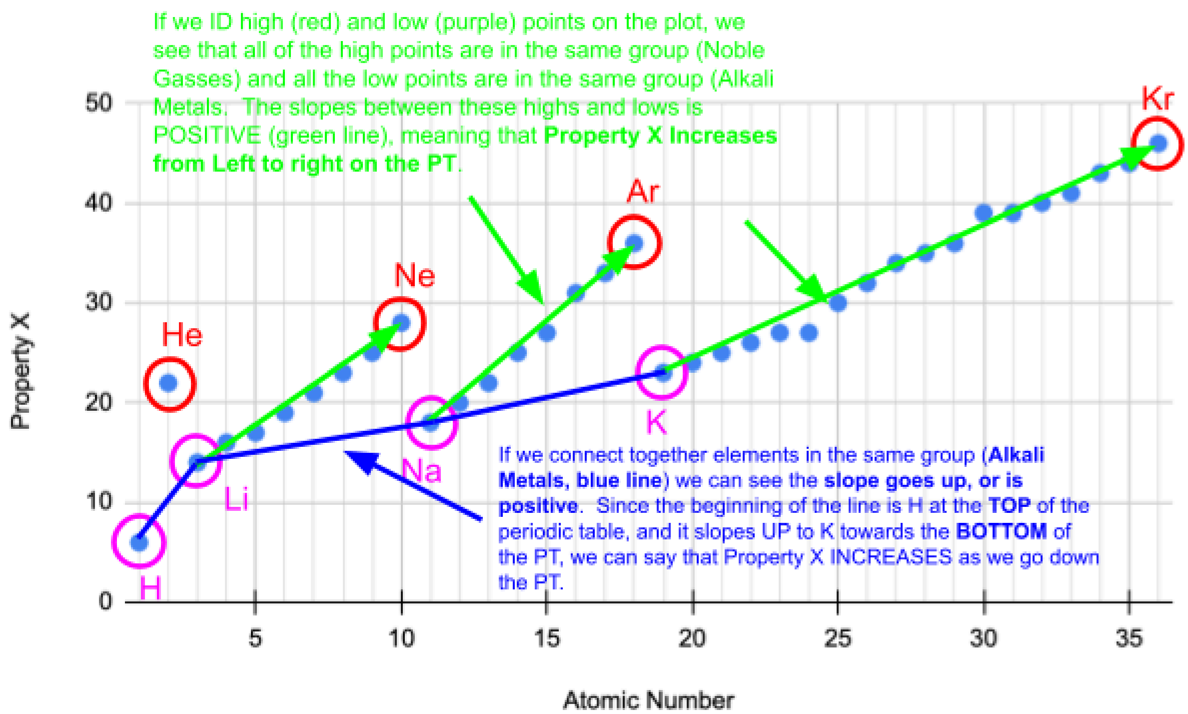
20. Using the plot below for Property X, Identify the trend in this property going across the periodic table as well as down the periodic table.



21. Put the following atoms in order as requested:
   a. **Cd, Mo, Zr, Sb, Rh** in order of **smallest** to **largest atomic radius**
      Sb, Cd, Rh, Mo, Zr (all in the same row, use horz trend for AR)
   b. **P, Bi, Sb, N, As** in order of **largest** to **smallest electronegativity**
      N, P, As, Sb, Bi (all in same colume, use vert trend for EN)
   c. **The halogens** in order of **smallest** to **largest ionization energy**
      At, I, Br, Cl, F (all in same column, use vert trend for IE)
   d. **Ca, Be, Sr, Cs, Mg** in order of **largest to smallest atomic radius**
      Cs, Sr, C, Mg, Be (Sr-Be are all in the same column, use vert trend)
      (Cs is further down that all, use vert trend)
   e. **Al, Na, O, P, Si** in order of **smallest** to **largest electronegativity**
      Na, Al, Si, P, O (Na - P are all in the same row, use horz trend for EN)
      (O is higher, use vert trend)
   f. **Pb, Fr, Os, I, Pt, Cs** in order of **largest** to **smallest ionization energy**
      I, Pb, Pt, Os, Cs, Fr (It might be easier to use both trends at the same time for this one!! Going DIAGONAL up and right on the PT, IE get larger. When you map these elements onto your PT, they follow that diagonal direction.)