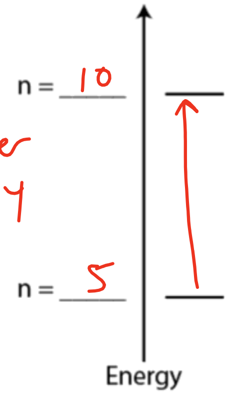
Atoms and Energy

1. Consider an electron in a hydrogen atom that is in the n = 5 energy level and moves to the n = 10 energy level.
   a. Sketch this process on the diagram



   b. Does this electron [✓ gain] energy or lose energy? How do you know?

it moves up to diagram to higher energy

   c. Calculate the energy of each level. You should be able to find an equation in your notes that allows you to do this.

$$E_5 = \frac{-2.18\times10^{-18} J (1)^2}{5^2} = -8.72\times10^{-20} J$$

$$E_{10} = \frac{-2.18\times10^{-18} J (1)^2}{10^2} = -2.18\times10^{-20} J$$

   d. Is energy [✓ required] or produced when the electron changes levels?

   e. Calculate this difference in energy.

$$\Delta E = -2.18 \times10^{-20} - (-8.72\times10^{-20}) = 6.54\times10^{-20} J$$

   f. Can this electron exist at any other energy levels? Explain your answer.

Yes. n=1, n=2, n=3, etc

   g. What is the frequency of the photon that could make this process happen?

$$E_{photon} = \Delta E = h\nu$$

$$\nu = \frac{E}{h} = \frac{6.54\times10^{-20} J}{6.626\times10^{-34} Js} = 9.87\times10^{13} s^{-1}$$

   h. What is the wavelength of the photon?

$$2.998\times10^{8} \frac{m}{s} = 9.87\times10^{13} \lambda \qquad \lambda = 3.04\times10^{-6} m$$

$$\lambda = 3087 nm$$

   i. Calculate the wavelength of the photon required to do this same process (n = 5 → n = 10) in a Li^{2+} ion. Remember to consider the atomic number of this single electron atom.

↑
Z=3

$$E_5 = \frac{-2.18\times10^{-18} J (3)^2}{5^2} = -7.848\times10^{-19} J \qquad \Delta E = 5.886\times10^{-19} J$$

$$E_{10} = \frac{-2.18\times10^{-18} J (3)^2}{10^2} = -1.962\times10^{-19} J \qquad E_{photon} = 5.886\times10^{-19} J$$

$$5.886\times10^{-19} J = \frac{(6.626\times10^{-34} Js)(2.998\times10^{8} m/s)}{\lambda}$$

$$\lambda = 3.375\times10^{-7} m \qquad \boxed{\lambda = 338 nm}$$

2. A photon with a wavelength of 1.003 μm is emitted from an excited hydrogen atom. What are the initial and final energy levels of the electron in this process? *Hint: remember that there are three distinct series of emission for hydrogen atoms.*

$$1.003\,\mu m \left| \frac{10^{-6}\,m}{1\,\mu m} \right. = 1.003\times10^{-6}\,m \left| \frac{1\,nm}{10^{-9}\,m} \right. = 1003\,nm \leftarrow IR \qquad n_{final} = 3$$

$$E_{photon} = \Delta E = \frac{6.626\times10^{-34}\,Js\,(2.998\times10^{8}\,m/s)}{1.003\times10^{-6}\,m} = 1.981\times10^{-19}\,J$$

$$E_3 = \frac{-2.18\times10^{-18}\,J}{3^2}(1)^2 = -2.422\times10^{-19}\,J$$

$$\Delta E = E_n - E_3$$

$$1.98\times10^{-19} = E_n - (-2.422\times10^{-19}\,J)$$

$$E_n = -4.417\times10^{-20}\,J = \frac{-2.18\times10^{-18}\,J}{n^2}$$

$$n^2 = 49.4$$

$$\boxed{n = 7}$$

3. Consider Gadolinium (Z = 64)
   a. Write the full (not condensed) ground state electron configuration for this element.

   $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^8$

   b. What is the condensed electron configuration? $[Xe]\,6s^2 4f^8$

   c. What is the condensed electron configuration of the **1st excited state** of Gd?

   $[Xe]\,6s^2 4f^7 5d^1$

   d. Write two possible sets of quantum numbers for the highest energy electron in the ground state.

4, 3, -3, 1/2	4, 3, -2, 1/2	4, 3, -1, 1/2	4, 3, 0, 1/2	4, 3, 1, 1/2	4, 3, 2, 1/2	4, 3, 3, 1/2
4, 3, -3, -1/2	4, 3, -2, -1/2	4, 3, -1, -1/2	4, 3, 0, -1/2	4, 3, 1, -1/2	4, 3, 2, -1/2	4, 3, 3, 1/2

   e. Write two possible sets of quantum numbers for the highest energy electron in the **1st excited state.**

5, 2, -2, 1/2	5, 2, -1, 1/2	5, 2, 0, 1/2	5, 2, 1, 1/2	5, 2, 2, 1/2
5, 2, -2, -1/2	5, 2, -1, -1/2	5, 2, 0, -1/2	5, 2, 1, -1/2	5, 2, 2, -1/2

4. In your own words, why does copper NOT have a ground state electron configuration of [Ar] $4s^2$ $3d^9$?

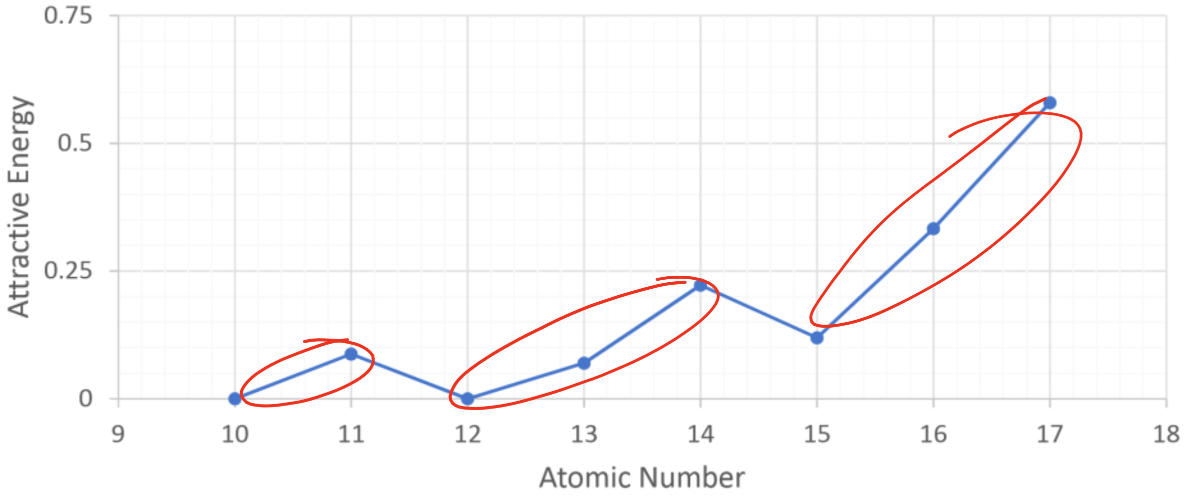
by moving the highlited e^- up to the 3d subshell, a full subshell is formed and that is really stable

3d | ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿
4s | ↿⇂
[Ar]

5. Does electron affinity refer to the tendency [✓ to gain] or lose an electron?

$X + e^- \rightarrow X^-$

6. Consider the data in the chart below:



a. Why does element 10 have an electron affinity of 0? It's a noble gas. 0 desire to gain an e^-

b. Circle the steps that obey the general rule dictated by Coulomb's law?

c. For all of steps that do not follow the general trend, use electron configurations to justify the deviation.

11: $1s^2 2s^2 2p^6 3s^1 \rightarrow 1s^2 2s^2 2p^6 3s^2$

12: $1s^2 2s^2 2p^6 3s^2 \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^1$

Mg gaining an e^- destroys a stable config and makes an unstable one

green = stable   yellow = unstable

14: $1s^2 2s^2 2p^6 3s^2 3p^2 \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^3$

15: $1s^2 2s^2 2p^6 3s^2 3p^3 \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^4$

unstable → stable = favorable

stable → unstable = unfavorable

7. Consider these isoelectronic element: Xe, Ba^{+2}, Te^{-2}, I^{-1}, Cs^{+1}, Sb^{-3}:

a. What does it mean to be isoelectronic? same # of e^- + e^- configuration

b. Which of these atoms has the largest radius? How did you reach this conclusion?

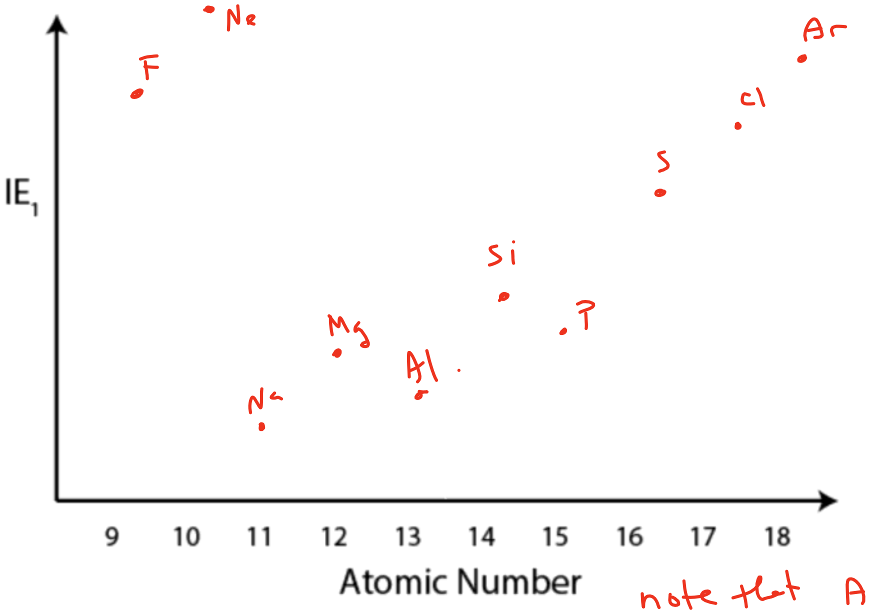
Sb^{-3} → it has the fewest # of protons

c. Which has the smallest radius? How did you reach this conclusion?

Ba^{2+} it has the most protons

8. On the graph below, predict the trend for the 1st ionization energies of the following elements:

F, Ne, Na, Mg, Al, Si, P, S, Cl, Ar



note that Ar < Ne &
Cl < F
because shell number

What unit do you think should be associated with the Y-axis?

Energy, so Joules