During Class Invention

Shell Model

Name(s) with Lab section in Group

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1. How many electrons, protons and neutrons in the following atoms?

Atom	Nuclear Charge	#protons	#neutrons	# electrons
H	**+1**	**1**	**0**	**1**
He	**+2**	**2**	**2**	**2**
Ne	**+10**	**10**	**10**	**10**

2. Describe the location of the proton, neutron and electron in an atom such at hydrogen. How do the location of the proton, neutron and electron differ for helium? For neon?

   Protons and neutrons make up the nucleus of an atom and the electrons are located in a 3-dimensional region of space surrounding the nucleus.

   This model of the atom is independent of the element.

3. Where does light come from?

   Light (a single photon) is produced when an electron falls from a higher energy level to a lower energy level.

4. How would we remove an electron from a hydrogen atom? How would we excite an electron in a hydrogen atom?

   By adding enough energy to ionize the atom (remove an electron). To excite an electron in an atom we need to add an amount of energy that is exactly equal to the energy separation between two energy level. (See Bohr Model DCI to calculate the energy required to excite an electron from n = 1 to n = 4 level.)

5. Write a chemical equation that describes the first ionization energy for

   a) a hydrogen atom

   $$\textbf{energy + H(g)} \rightarrow \textbf{H}^{+}\textbf{(g) + 1e}^{-}$$

   b) a helium atom

   $$\textbf{energy + He(g)} \rightarrow \textbf{He}^{+}\textbf{(g) + 1e}^{-}$$

   c) a neon atom

   $$\textbf{energy + Ne(g)} \rightarrow \textbf{Ne}^{+}\textbf{(g) + 1e}^{-}$$

6. Below are the first ionization energies for elements Z = 1 to Z = 19.

Symbol	Z	IE (**kJ mol^{-1}**)	Symbol	Z	IE (**kJ mol^{-1}**)
H	1	1312	Na	11	496
He	2	2372	Mg	12	738
Li	3	520	Al	13	578
Be	4	899	Si	14	786
B	5	801	P	15	1012
C	6	1086	S	16	1000
N	7	1402	Cl	17	1251
O	8	1314	Ar	18	1520
F	9	1681	K	19	419
Ne	10	2081			

What patterns do you see in the data above?

In going from hydrogen to helium the first ionization energy approximately doubled. We understood this in terms of the doubling of the nuclear charge going from hydrogen (Z = 1) to helium (Z = 2). Assuming the two electrons in helium are the same distance as the electron in hydrogen a doubling of the energy is not surprising.

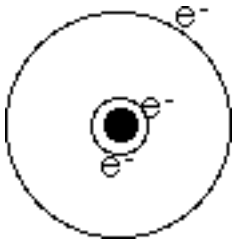
We might predict the approximate ionization energy for lithium to be three times the ionization energy for hydrogen. When we look at the experimental ionization energy for lithium it is less than half the ionization energy for hydrogen. How do we explain that!? One way is to imagine that the third electron added to lithium is somehow farther from the nucleus compared to the first two electrons. If the 3rd electron is further from the nucleus it will feel a smaller attraction to the nucleus. AND the first two electrons in lithium, which are closer to the nucleus compared to the third electron, may be shielding the third electron from some of the nuclear charge making the energy to remove the electron much less than we might have predicted.

7. Diagram each of the following atoms using the shell model.

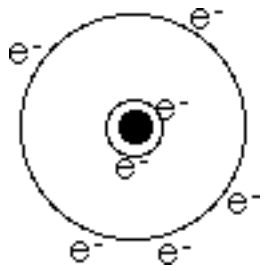
a) Hydrogen

b) helium

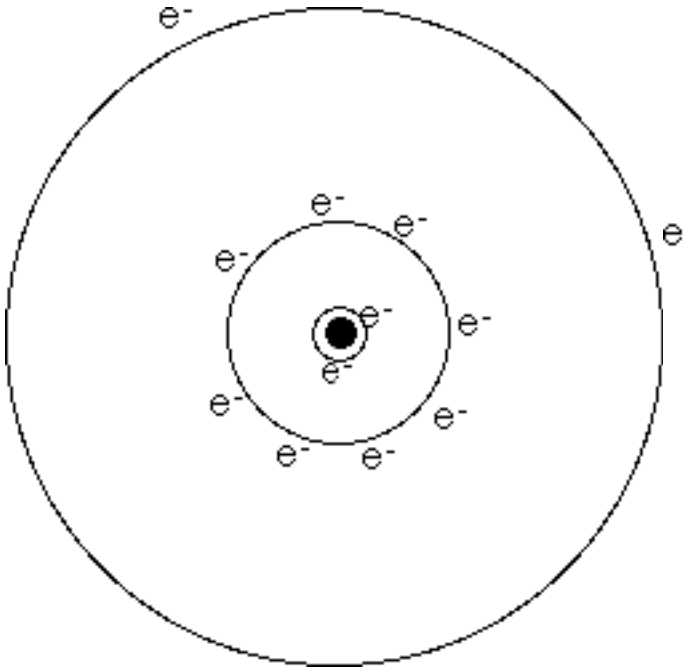
c) lithium



d) nitrogen



e) sodium



f) chlorine