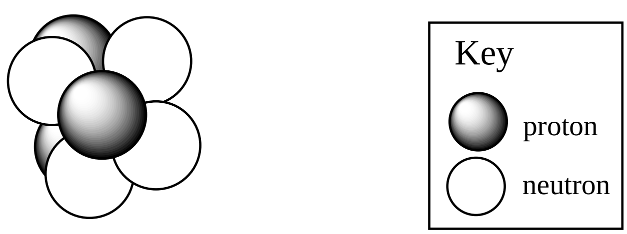
Atomic Structure

I. Subatomic particles (stability?)

A. Protons (p^+): +1 charge and relatively large mass (1.0073 amu).
B. Neutrons (n): no charge and relatively large mass (1.0087 amu).
C. Electrons (e^-): −1 charge, small mass (0.00054858 amu), ~p^+/2000.
D. Other, smaller units have been identified (quarks, charm, color, and so on), but we will not be able to consider those in CHM 109. Likewise for positrons (e^+)?

II. How p^+, n, and e^- fit together in atoms & ions

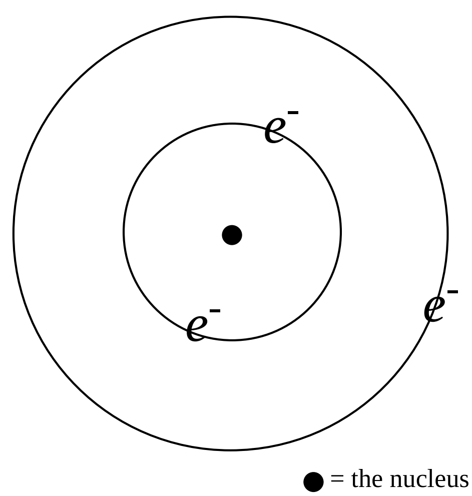
A. p^+ & n are bound together in the nucleus, located in the center of the atom. **The p^+ number = the atomic number**. See PT! Example: What is in the nucleus of the most common form of lithium (Li)?



^{7}Li nucleus

Note: ^{7}Li means that the sum of the p^+ and n in the nucleus = 7.

B. e^- are found in orbitals located outside of the nucleus. A Li atom has 3 e^-. We could use the ***Bohr model*** (planetary?) & represent the structure as:



This drawing is <u>not to scale</u>. In reality, the nucleus is actually much **smaller** (relative to the orbits) than shown in the figure.

1. The circles that the e^- are located on are called orbits.
2. e^- in orbits farther from the nucleus are less tightly bound
3. energies of e^- in the different orbitals were determined by observing light emission from atoms. (Like incandescent/fluorescent light.)

Based on your previous studies, what holds the e^- near the nucleus?

C. Analogy for size of nucleus relative to the whole atom: The whole atom is the size of a major league baseball park. The nucleus would be like a marble sitting out past second base. This means:
1. Nucleus: very small & dense. Does something re. the nucleus bother you?
2. Most of the atom's space is occupied by relatively light e^-.

III. Quantum mechanics (& viewing e^- as waves instead of particles) describes atomic behavior better than Bohr model.

A. Bohr model works really well for H atoms and not much else.

B. Using a mathematical approach that treats the atom as a box providing constraints and the e^- as waves gives a model with much better predictive capabilities. The approach *requires advanced math*.

C. We will use results from quantum mechanics. Don't sweat the math.

IV. Atomic orbitals (*where e^- hang out*) have principal quantum numbers: 1, 2, 3, *etc*..

In addition, you need to know orbital:

A. names: *1s, 2s, 3s, 4s, etc.,* *How many orbitals in each s level?*
2p, 3p, 4p, etc. " " " *p level?*
3d, 4d, 5d, etc " " " *d level?*
___*?f*, ...) (CHM 109: little interest in *f* and above.)

B. shapes: (see the Orbitron at http://winter.group.shef.ac.uk/orbitron/)
1. *s* orbitals are one lobed and spherical
2. *p* orbitals are 2 lobed. The lobes are roughly teardrop shaped.
3. *d* and *f* orbitals have relatively complicated shapes.

C. energies

I tend to think of all of the orbitals of an atom (up to and beyond 7f) as always existing, but only being interesting when they are occupied by e^-.

Orbital occupancy:

1. lowest energy (closest to nucleus) orbitals are occupied first.
2. an orbital can only contain two e^-.
3. when orbitals of equal energy (ex.: $2p_x$, $2p_y$, $2p_z$) are being filled, put one e^- in each orbital first, then add start adding additional e^- .

D. We describe the orbital occupancy of an atom (or ion) by writing its electronic configuration. In this class you will do this by direct application of the Periodic Table, see p. 4 (even though the results from this approach are wrong in a few situations [re. CHM 111]).

E. Let's try a few. (Note: Elemental identity is determined by p^+ number.)

1. How many electrons are they in a lithium (Li) atom, and where are the found? (In which orbitals? What is the electronic configuration?)

2. Same question for a magnesium (Mg) atom?

3. For a P atom?

4. For a Cu atom?

F. Important definition: The outermost *s* and *p* electrons are called ***valence electrons***. Because they are outermost, they can be involved in sharing (covalent bond formation) or they may be lost or gained (ion formation). Identify the valence electrons in 1 through 4, above.

Periodic Table of the Elements: Orbital filling

1A	**2A**	*3B*	*4B*	*5B*	*6B*	*7B*	*8B*			*1B*	*2B*	**3A**	**4A**	**5A**	**6A**	**7A**	**8A**
H																	**He**
Li	**Be**											**B**	**C**	**N**	**O**	**F**	**Ne**
Na	**Mg**											**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
K	**Ca**	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
Rb	**Sr**	**Y**	**Zr**	**Nb**	**Mo**	**Tc**	**Tc**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
Cs	**Ba**	**La**	**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
Fr	**Ra**	**Ac**															

Blue = filling *s* orbitals

Green = filling *p* orbitals

Yellow = filling *d* orbitals