The Need for a Better Model of the Atom

The table below provides ionization energies for the elements Na through Ar; this is the same data examined in the last class. Note that the electrons are identified using the *ns* and *np* notation.

	Ionization Energies in MJ/mol				
Element	1s	2s	2p	3s	3p
Na	104	6.84	3.67	**0.50**	
Mg	126	9.07	5.31	**0.74**	
Al	151	12.1	7.79	1.09	**0.58**
Si	178	15.1	10.3	1.46	**0.79**
P	208	18.7	13.5	1.95	**1.01**
S	239	22.7	16.5	2.05	**1.00**
Cl	273	26.8	20.2	2.44	**1.25**
Ar	309	31.5	24.1	2.82	**1.52**

Questions to Consider

1. What general trend to do you see in the first ionization energies for these elements? Be sure you are comparing the right numbers! Identify the relevant ionization energies by circling them and then briefly explain why this general trend exists for these atoms.

   The first IE is always the last entry in a row, as highlighted above in **bold**. *As we move from Na to Ar we see that the first IE generally becomes larger due to the increasing charge on the nucleus (Z), which increases the effective nuclear charge,* Z_{eff}. *There are glitches in this trend that we need to explain as we move from Mg to Al and as we move from P to S; in both cases, the ionization energy becomes smaller rather than larger.*

2. Provide <u>two</u> reasons why the ionization energy for a 3s electron in Na is smaller than the ionization energy for a 2s electron in Na.

   A 3s electron is further from the nucleus than is a 2s electron (increase in d) and because it experiences a smaller core charge (smaller Z_{eff}*) due to the greater screening from the 1s, 2s, and 2p electrons relative to the screening experienced by a 2s electron which comes from 1s electrons only. From Coulomb's law, both of these favor a smaller IE.*

3. The ionization energies for argon's 3*s* and 3*p* electrons are not the same. Given that the average distance of each electron from the nucleus is the same, what problem does this present for us?

   This presents us with the following problem: if the distance is the same, then Coulomb's law requires that a 3p electron sense a smaller Z_{eff} *than does a 3s electron; however, our current model that characterizes* Z_{eff} *as Z – number of core electrons suggest that the 3s and 3p electrons have identical values for* Z_{eff}