

The Need for a Better Model of the Atom

The table below gives ionization energies for the elements Na through Ar; this is the same data examined in the previous worksheet.

Element	Ionization Energies in MJ/mol				
	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	42.7	34.0	2.82	1.52

Questions to Ponder. (Hint – Consider Coulomb's law)

What general trend do you see in the first ionization energies for these elements? Be sure that you are comparing the right numbers! Briefly explain why this general trend exists for these atoms.

The first IE is always the last entry in each row. As we move from Na to Ar the first ionization energy becomes larger due to the increasing charge on the nucleus. There are some "glitches" in this general trend, which will need some further explanation.

Briefly provide *two* 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 a 2s electron, and experiences a smaller core charge due to the screening of the 3s valence electrons by the core electrons.

Provide an explanation for the difference in the ionization energies for a 2s and a 2p electron given that each electron is known to be equidistant from the nucleus.

Since distance cannot explain the difference in energy, we must assume that a 2s electron "sees" a greater charge on the nucleus (which also means that the 2p electron experiences greater screening).

The charge on the nucleus "seen" by an electron is the effective nuclear charge, Z_{eff} . If we define Z_{eff} as the charge on the nucleus minus the number of core electrons, what problem does this create for our model of the atom?

If true, then a 2s and a 2p electron should see the same Z_{eff} and have the same ionization energy.