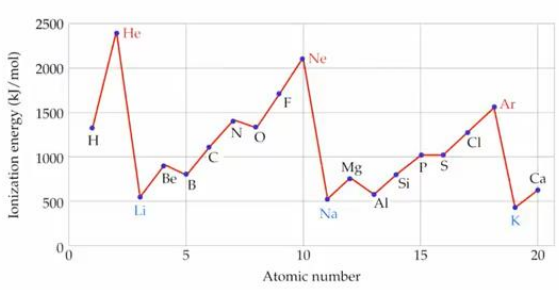
- Francium, a very large atom with only one valence electron (7s1) will be easy to ionize because the electron is so far away from the nucleus. Atoms like to have their outermost shell completely full. Losing the electron means the outermost shell is gone and the one below is completely full so elements in group 1 will easily loose 1 electron.
- Helium, on the other hand has only one shell (1s2) so the electrons are very close to the nucleus, and the shell is full so it is very stable. For this reason, it requires much more energy to ionize helium.
- **So the ionization energy increases going up and right.**
- Elements can have successive ionization energies for removing more than one electron. A second ionization energy will always be greater than the first and continue to increase until the last ionization energy since the more electrons you remove, the less stable the atom becomes.

successive ionization energies (kJ/mol)

	Na	Mg	Al	Si	P	S	Cl	Ar
1st IE	496	738	578	787	1,012	1,000	1,251	1,520
2nd IE	4,562	1,451	1,817	1,577	1,903	2,251	2,297	2,665
3rd IE	6,912	7,733	2,745	3,231	2,912	3,361	3,822	3,931
4th IE	9,543	10,540	11,575	4,356	4,956	4,564	5,158	5,770
5th IE	13,353	13,630	14,830	16,091	6,273	7,013	6,540	7,238
6th IE	16,610	17,995	18,376	19,784	22,233	8,495	9,458	8,781
7th IE	20,114	21,703	23,293	23,783	25,397	27,106	11,[illegible]	1,99[illegible]

- An element will have a huge jump in ionization energy after you take the last one in a shell because then you jump to the noble gas electron configuration from the previous shell, which is full.

There are just a couple exceptions to the ionization energy trend, but we can rationalize them.



- Look for example at the second row, from Lithium to Neon, the ionization energy should increase each time we add a proton to the nucleus and the radius contracts a little.
- But something like oxygen which deeps downward from Nitrogen's ionization energy does so because of orbital symmetry.
- In Nitrogen's orbital diagram, notice that its 2p orbitals are precisely half-full. This gives nitrogen a special stability just like elements that have a full outermost shell. If nitrogen looses an electron, it looses that special stability. But if oxygen looses an electron, it will gain the same special stability, nitrogen has. That's why oxygen's ionization energy is a little bit lower than nitrogen's even though oxygen has 1 additional proton.
- All deviations from the ionization energy trend can be explained by discrepancies in orbital symmetry like this one.

- **First Ionization energy ($\mathbf{IE_1}$)**
  The minimum amount of energy required to remove the most loosely bound electron from an isolated gaseous atom to form a 1+ ion.

Symbolically:

$$\mathbf{Atom_{(g)} + energy \longrightarrow ion^{+}_{(g)} + e^{-}}$$

Ex: $Mg_{(g)} + 738kJ/mol \longrightarrow Mg^{+}_{(g)} + e^{-}$

- **Second ionization energy ($\mathbf{IE_2}$)**
  The amount of energy required to remove the second electron from a gaseous 1+ ion.

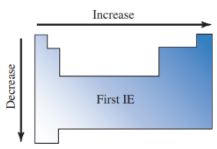
Symbolically:

$$\mathbf{ion^{+} + energy \longrightarrow ion^{2+} + e^{-}}$$

Ex: $Mg^{+} + 1451\ kJ/mol \longrightarrow Mg^{2+} + e^{-}$

PERIODIC TRENDS FOR IONIZATION ENERGY:

1. $\mathbf{IE_2 > IE_1}$
   It always takes more energy to remove a second electron from an ion than from a neutral atom.
2. $\mathbf{IE_1}$, generally increases moving from IA elements to VIIIA elements.
   Important exceptions at Be & Mg, N & P, etc. due to filled and half-filled subshells.
3. $\mathbf{IE_1}$, generally decreases moving down a family.
   IE_1, for Li>IE_1 for Na, etc.



FIRST IONIZATION ENERGIES OF SOME ELEMENTS