CH-005 - Electron Configuration Cheat Sheet

by AlexHoratio (Horatio) via cheatography.com/21127/cs/24679/

WHAT DOES ELECTRON CONFIGURATION MEAN?

Electron configuration refers to the physical layout of electrons inside an atom.
Because quantum physics ruined everything, it's really about the layout of the approximate areas where each electron is probably found.
The technical term for this 'approximate area' is the
wavefunction, since all these tiny particles actually behave like waves, and we have mathematical functions that can predict those waves' approximate positions.

FIRST SHELL

How many sub-shells are in the first shell?

> The first shell only contains the *s* sub-shell.

How many electrons can the first shell hold?

> The first shell can only contain two electrons.
> The *s* sub-shell only has a single orbital, so it's limited to only two electrons.

I HATE CHROMIUM AND COPPER. WHY?

Why do I hate Cr?

> Chromium's electron configuration is *[Ar] $4s^1$ $3d^5$* ~~because it's awful and I hate it~~ because apparently it prefers having all its orbitals with 1 electron each if possible.
> I don't know why.

Why do I hate Cu?

> Copper's electron configuration is *[Ar] $4s^1$ $3d^{10}$* because it's awful, terrible, and Chromium set a bad example.

WHAT ARE VALENCE ELECTRONS?

When atoms are reacting and forming bonds, it seems to usually involve the ***valence electrons***.
Valence electrons are the electrons in the **outermost shell**. If an element only has maybe one lonely electron in its outermost shell, then it's likely to be very reactive. Sodium and lithium are good examples of this.
Likewise, if it's got a full set of electrons in its outermost shell, then it's got a pretty good equilibrium going, and is unlikely to want to react with anything. Neon is a good example of an unreactive noble gas.

HOW CAN OUR TINY HUMAN BRAINS UNDERSTAND ALL THIS?

We can't easily visualize the places where the electrons are in each atom, because it usually looks like a mess. It's just a bunch of slightly overlapping blobs.

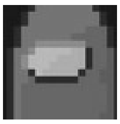
Instead of that, we can use **fancy notation** to get all the important bits.

WHY ARE NOBLE GASES COOL AND GOOD?

Noble gases always have a comfortable full shell of electrons. Kinda. This means they are great for example purposes.
Helium: Completed 1st shell
-> $\mathbf{1s^2}$
-> *s* sub-shell
-> two electrons total
Neon: Completed 2nd and 1st shells
-> $1s^2$ $\mathbf{2s^2}$ $\mathbf{2p^6}$

WHY ARE NOBLE GASES COOL AND GOOD? (cont)

-> *s, p* sub-shells
-> 10 electrons total
Argon: Completed 3rd, 2nd and 1st shells
-> $1s^2$ $2s^2$ $2p^6$ $\mathbf{3s^2}$ $\mathbf{3p^6}$
-> *s, p* sub-shells
-> 18 electrons total
Krypton: Completed 4th, 3rd, 2nd and 1st shells
-> $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $\mathbf{4s^2}$ $\mathbf{3d^{10}}$ $\mathbf{4p^6}$
-> *s, p, d* sub-shells
-> 36 electrons total
Why the hell did Krypton's electrons dip back into the 3rd shell to fill in the *d* sub-shell?!
When adding electrons, it turns out that the electrons would first rather fit into the nice simple *s* subshell, which is basically just a big sphere around the atom.
If they really have to fit in even more, they'd rather squeeze into the empty space in the 3rd shell than try to go straight to the huge *4p* subshell.
The *4p* is the *p* subshell in the 4th shell overall. This means in order to fit, it has to be way bigger than *3p*, and *3p* has to be way bigger than *2p*.
Rather than occupy these big shells immediately, it's easier to just squeeze into the gaps left in the 3rd shell.



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WHAT IS ALL THIS FANCY NOTATION?

What are electron shells?

Electrons are organized in shells. These shells behave like 'layers'. Usually, when you add more electrons, it sticks to the outermost shell. If there are gaps, it will fill into the inner shells instead.

What are electron sub-shells?

Each shell contains at least one sub-shell. These sub-shells have been given random letters to distinguish them from each other. The main sub-shells are named *s*, *p*, *d* or *f*.

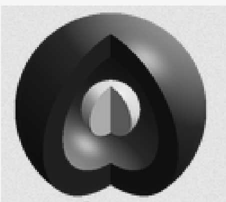
What are electron orbitals?

Each sub-shell contains some number of orbitals.
The *s* sub-shell contains a single orbital.
The *p* sub-shell contains 3 orbitals.
The *d* sub-shell contains 5 orbitals.
The *f* sub-shell contains 7 orbitals.

How many electrons in each orbital?

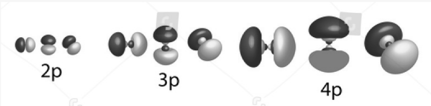
There are two electrons in each orbital.
There can only be two electrons per orbital because of the ***Pauli exclusion principle***.
The reason it's two per orbital is because nature likes symmetry, and there is something complicated about 'spin'.

HOW DO ALL THESE SHELLS AND SUBSHELLS FIT?!



This diagram depicts a very big blue *2s* subshell around a much smaller yellow *1s* subshell.

HOW DO THE p SUBSHELLS FIT?!

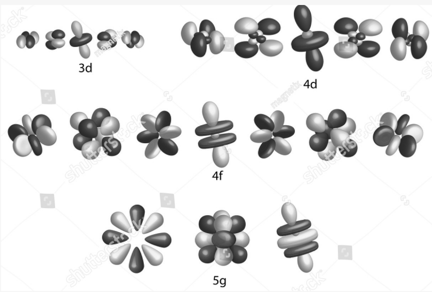


This picture shows a series of *p* subshells from each shell, gradually moving further and further out.

You can see in *3p* for instance, that there is a smaller *2p* subshell nested all cozy inside the larger one. Looking at this image, it becomes clear that there is a lot of empty space in the middle (close to the nucleus) for electrons to fit before they try going straight to the higher *4p* subshell.

This explains why Krypton is such a nuisance.

WHAT ABOUT 3d, 4d, 4f AND 5g?



Anyway, like I said, it's probably not worth trying to visualize how all these shells fit together. This is why we're using the notation instead.

Check out that symmetry though!!!