The periodic table and atoms

Shape is more than meets the eye

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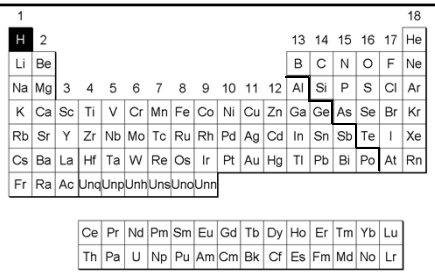

What are the features of the periodic table?

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Features

- Vertical columns are called groups or families
  - Special groups
    - Group IA ⇒ Alkali metals
    - Group IIA ⇒ Alkaline Earth metals
    - Group VIIA ⇒ Halogens
    - Group VIIIA ⇒ Noble Gases
- Horizontal rows are called periods
- "Stair-step" line separates the metals on the left from the non-metals on the right. It's bordered by the metalloids or the semi-metals.

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Periodic Law

- Discovered independently by Dimitri Mendeleev and Lothar Meyer in the mid-1800s
- States that when the atoms are arranged in order of atomic number there is a periodicity of properties (chemical and physical)

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Why does the periodic law work?

- Let's look at the periodic table to find out why.

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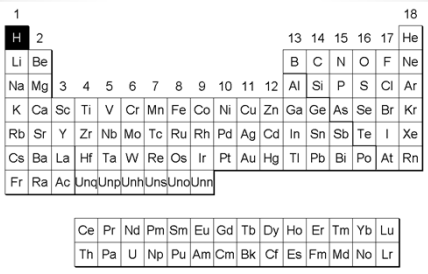
What is it about this shape that explains the law?



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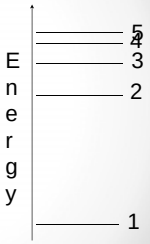
Let's look at the electrons

- **Electrons are allowed only certain energies. They are numbered from 1 on.**
- **The electrons will stay in the lowest energy, or "ground state," until they receive enough energy to move to a higher level.**
- **Electrons cannot be between energy levels**
- **The energy levels get closer together as we move up in energy.**



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- The electrons are not only in energy levels but also in sublevels. The number of sublevels is equal to the energy level number. (Level 1 has 1 sublevel and so on).
  - First sublevel is "s"
  - Second sublevel is "p"
  - Third sublevel is "d"
  - Fourth sublevel is "f"
- The sublevels are divided into orbitals, each of which can hold, at most, 2 electrons. The orbitals have the same name as the sublevel.

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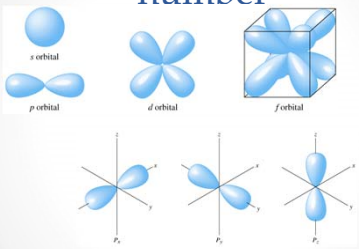
Orbital shapes and number



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Where are the electrons then?

- Electron configuration tells us this.
- We can find electron configurations from the periodic table with only one map.

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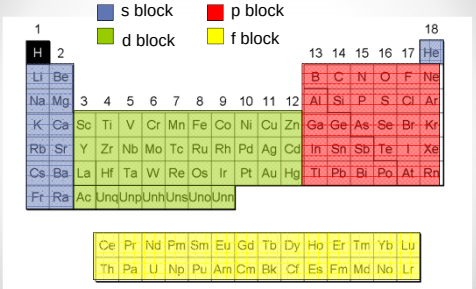
What is it about this shape that explains the law?



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Electron configurations

- The row number corresponds, for the most part, with the energy level.
- The block corresponds with the sublevel.
- The column within the block corresponds to which electron in that sublevel.

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Examples

- Carbon:
  $1s^2\ 2s^2\ 2p^2$
- Iron:
  $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$
- Uranium:
  $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6\ 7s^2\ 6d^1\ 5f^3$

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Is there an easier way for larger atoms?

- There is. Let's look at uranium again:

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6\ 7s^2\ 6d^1\ 5f^3$

- Now let's look at Radon:

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6$

- They are the same except for the last few bits.

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Noble gas shorthand: the easier way

- Look at the element in question. Find the noble gas that comes immediately before it.
- Write the symbol for that noble gas in square brackets.
- Finish the rest of the configuration. For Uranium this would be:

[Rn] $7s^2\ 6d^1\ 5f^3$

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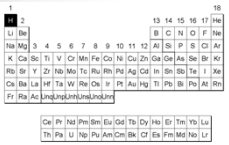
An explanation



Similar electron configurations means that the atoms will react in a similar fashion, the periodic law.

This shape is because of where the electrons are in the atom.

The periodic law is there because elements in the same column have similar electron configurations.

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Now a finer look

- Electron configurations give us the neighborhood in which the electron lives.
- What about having a street address? We can know that someone lives in Studio City or Van Nuys, but if we don't know that they live on say Kittridge, it doesn't say much. To find this for an electron we need to look at another property of electrons, spin.

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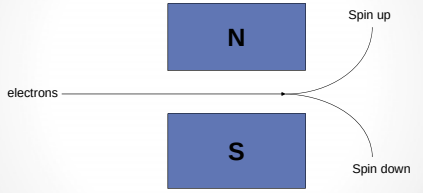
Spin



These are the only two possibilities!

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Spin

- Spin is reason why only two electrons can be in each orbital.
- We can now show the orbitals with their electrons, but we have to follow a couple of rules.
  - No more than two electrons per orbital
  - The electrons in an orbital must have opposite spins
  - When there is more than one orbital with the same energy, one electron per orbital first, until all the orbitals have one, then pair up with opposite spins.

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Orbital Diagrams

We need the electron configuration first.
Let's look at Carbon:

$1s^2\ 2s^2\ 2p^2$

What does the orbital diagram look like?

1s 2s 2p

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Write electron configurations and orbital diagrams for:

- Tungsten
- Tellurium
- Plutonium

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- Tungsten: [Xe] $6s^2\ 5d^4\ 4f^{14}$

[Xe] 6s 5d 4f

- Tellurium: [Kr] $5s^2\ 4d^{10}\ 5p^4$

[Kr] 5s 4d 5p

- Plutonium: [Rn] $7s^2\ 6d^1\ 5f^5$

[Rn] 7s 6d 5f

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Trends in the periodic table

- Atomic radius:
  - Increases as we move down a group
  - Decreases as we move across a period
- Metallic Character
  - Increases as we move down a group
  - Decreases as we move across a period

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Explanation of periodic trends

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