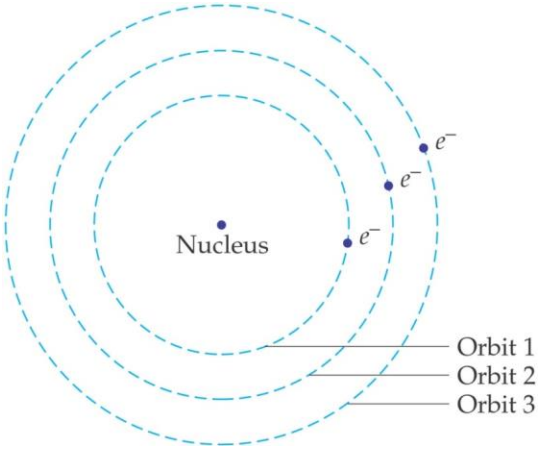
Levels, Sublevels, Orbitals, and Electrons!!!

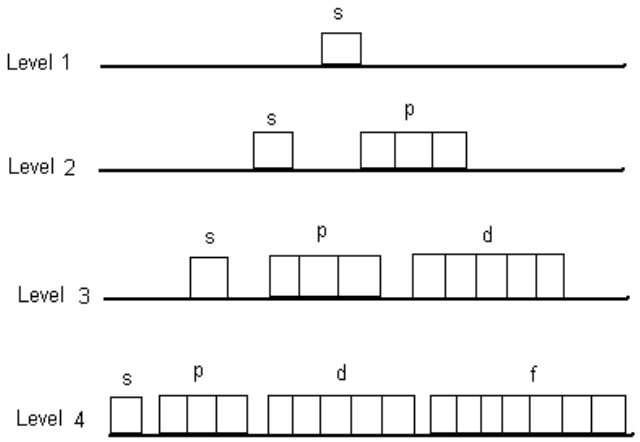
Electrons exist around the nucleus of an atom in discrete, specific orbits. Electrons can not just exist at any distance from the nucleus. These orbits are called **levels** and we number them 1, 2, 3, 4, and so forth with the 1st level being the orbit closest to the nucleus. See the figure to the right.



The levels can be broken down into **sublevels**. We have s, p, d, and f sublevels. Level one has one sublevel – an s. Level 2 has 2 sublevels - s and p. Level 3 has 3 sublevels - s, p, and d. Level 4 has 4 sublevels - s, p, d, and f. These are pictured below.

The sublevels contain **orbitals**. Orbitals are spaces that have a high probability of containing an electron. In other words, an orbital is an area where the electrons live. There can be two **electrons** in one orbital maximum. The s sublevel has just one orbital, so can contain 2 electrons max. The p sublevel has 3 orbitals, so can contain 6 electrons max. The d sublevel has 5 orbitals, so can contain 10 electrons max. And the 4 sublevel has 7 orbitals, so can contain 14 electrons max. In the picture below, the orbitals are represented by the boxes. You can put two electrons in each box.

Some things to notice. Level 1 does not have a p or d or f sublevel, only an s sublevel. So there is no such thing as 1p or 1d or 1f. To distinguish between the different s sublevels, we call them 1s, 2s, 3s, and 4s. The p sublevels are called 2p, 3p, and 4p. There is no d sublevel until the 3rd level. The d sublevels are called 3d and 4d. The only f sublevel we study is the 4f.

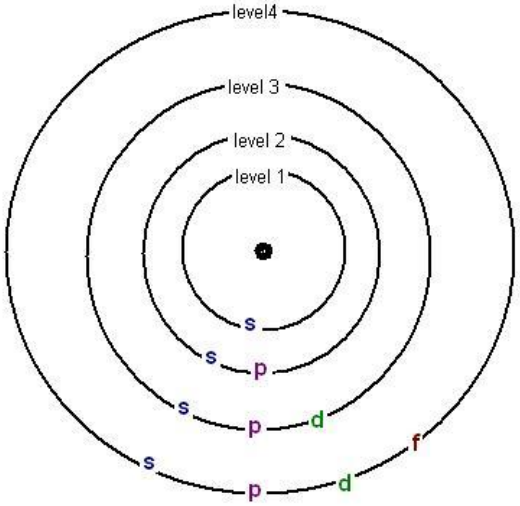


When we fill electrons into an atom, we start with the 1st level because it is closer to the nucleus and thus lower in energy. Then we fill in the second level, and so forth in general.

Putting Electons into Orbitals – an Analogy

Let's pretend we are moving students into campus housing. The housing is on 1st, 2nd, 3rd and 4th street (the levels). There are houses on these streets. The houses are called s, p, d and f houses. The s house has 1 bedroom, the p house has 3 bedrooms, and d house has 5 bedrooms, and the f house has 7 bedrooms. In each bedroom there is a bunk bed, so two students can sleep in a bedroom. Answer the questions:

1. How many houses on 4th street? 4
2. How many students can live on 3rd street? 18
3. How many bedrooms on 2nd street? 4
4. How many students can live in a p house? 6
5. How many bedrooms in a p house? 3
6. How many bedrooms in an f house? 7
7. How many students can live in an f house? 14
8. How many students can live on 1st street? 2
9. How many students can live on 2nd street? 8



In this analogy streets are levels, houses are sublevels, bedrooms are orbitals, and students are electrons. Answer the same nine questions in chemistry terms:

1. How many sublevels on the 4th level?
2. How many electrons can fit on the 3rd level?
3. How many orbitals on the 2nd level?
4. How many electrons can fit in a p sublevel?
5. How many orbitals in a p sublevel?
6. How many orbitals in an f sublevel?
7. How many electrons can fit in an f sublevel?
8. How many electrons can fit on the 1st level?
9. How many electrons can fit on the 2nd level?

Electron Configuration – shorthand notation for showing what sublevels are filled

We fill in electrons according to lowest energy sublevels first. So we basically go in order: 1s, 2s, 2p, 3s, 3p now next is 3d BUT the d orbitals are complex and rather high in energy, so actually 4s is lower in energy. So we fill in 4s next then go back to 3d and so forth. So the order is 1s, 2s, 2p, 3s, 3p, 4s. We will not fill in more than 20 electrons so don't worry about what comes next after 4s. Remember for neutral atoms, the number of protons equals the number of electrons. So for each atom note how many electrons you have and fill them in! Remember s sublevels can only hold 2 electrons, and p 6 electrons. Examples:

1. Carbon atom has 6 electrons – $1s^2 2s^2 2p^2$ because 2+2+2=6
2. Silicon atom has 14 electrons – $1s^2 2s^2 2p^6 3s^2 3p^2$ because 2+2+6+2+2=14

Practice Problems

1. The three subatomic particles are what? The center of an atom is called what?
2. What are the charges of the subatomic particles?
3. An atom's mass is the sum of what? The charge of an atom depends on what?

	^{41}K	^{3}H	^{133}Xe	^{14}C
# of protons				
# of neutrons				
# of electrons				
Mass				

4. What do you think is the most abundant isotope of Silicon? Potassium? Argon?
5. Which of the following would be an isotope of ^{17}O? ^{17}N ^{16}F ^{16}O ^{14}C
6. If wave A has longer wavelength than wave B, then which has higher frequency? Lower energy?
7. What type of wave has higher energy than radio and TV, but lower energy than IR?
8. How many electrons can fit in a p sublevel? In the 3rd level? In an f sublevel? In one orbital?
9. How many orbitals are in a p sublevel? In the 2nd level? In an f sublevel?
10. Give electron configurations for atoms of sodium, aluminum, argon, and boron.

STOP – Try to answer the questions above BEFORE looking at the answers below!!! ☺

Answers

1. Protons, neutrons, electrons. Nucleus
2. Protons are positive one, neutrons are neutral, and electrons are negative one.
3. Mass = # protons + # neutrons. Charge depends on protons and electrons.

	^{41}K	^{3}H	^{133}Xe	^{14}C
# of protons	19	1	54	6
# of neutrons	22	2	79	8
# of electrons	19	1	54	6
Mass	41	3	133	14

4. Silicon-28, potassium-39, argon-40
5. ^{16}O Isotopes have SAME # protons, thus same element, and different # neutrons, thus different masses.
6. Higher frequency is wave B and lower energy is wave A.
7. Microwave
8. 6 in a p sublevel, 18 in the 3rd level, 14 in an f sublevel, and 2 in one orbital
9. P sublevel has 3 orbitals. 2nd level has 4 orbitals. An f sublevel has 7 orbitals.
10. Na has 11 electrons so $1s^2 2s^2 2p^6 3s^1$
    Al has 13 electrons so $1s^2 2s^2 2p^6 3s^2 3p^1$
    Ar has 18 electrons so $1s^2 2s^2 2p^6 3s^2 3p^6$
    B has 5 electrons so $1s^2 2s^2 2p^1$