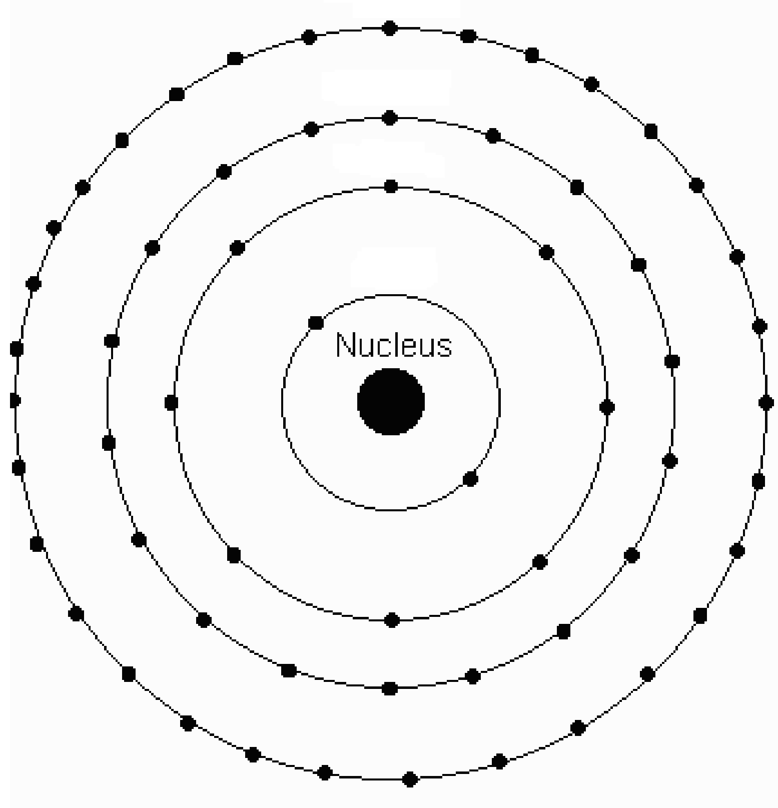
What is an Atom?

Chemistry
Unit 4
Module 4

Module Concepts

- Cloud Model Review
- Electron Configurations
  - Neutral Atoms
  - Long Form vs. Short Form
  - Time permitting: Ions
- Valence Electrons
- The Octet Rule
- Noble gases

- The electrons for an atom orbit its nucleus in energy levels, rings, or shells.
  - Each level has a maximum number of electrons that it can hold.
  - The smallest energy level (the one closest to the nucleus, the first) can hold 2 electrons.
  - The second energy level, slightly larger and farther away from the nucleus, can accommodate 8 electrons.
  - The third energy level, even larger and farther away from the nucleus, can hold up to 18 electrons.
  - Where do these numbers come from?

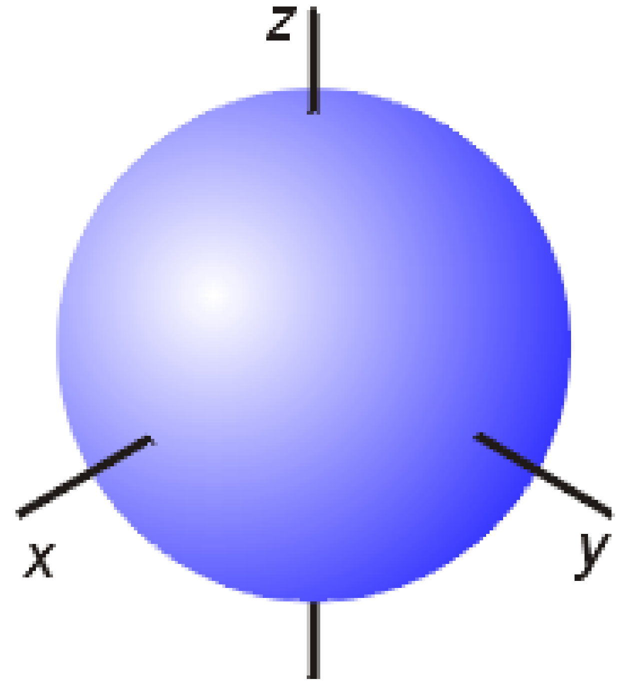


Orbitals

- Rather than thinking of electrons as simply residing in permanent shells (aka energy levels or rings) with well-defined borders, it was found that there were *regions of high probability where a given electron would be found based on its energy.* These became known as *orbitals* and gave rise to the *electron cloud model* of the atom.
- Orbitals come in four different shapes, or ***sublevels*** that can be found within each energy level, shell, or ring. These sublevels are represented with letters.

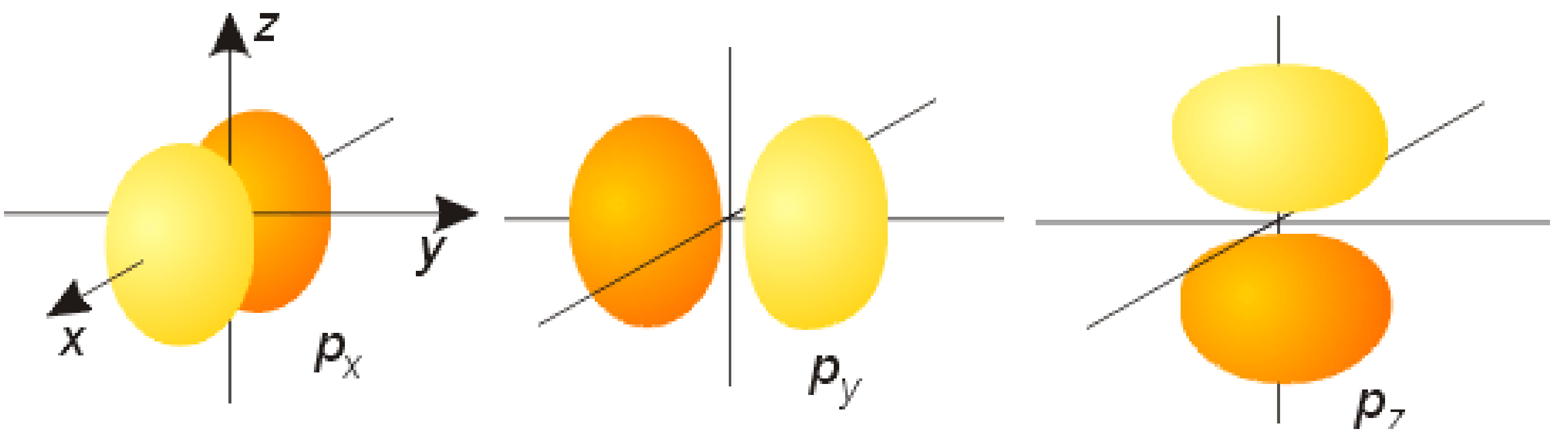
s-orbitals

- *s*-orbitals, the lowest energy orbitals or sublevels, are spherically shaped and can hold a maximum of 2 electrons.



p-orbitals

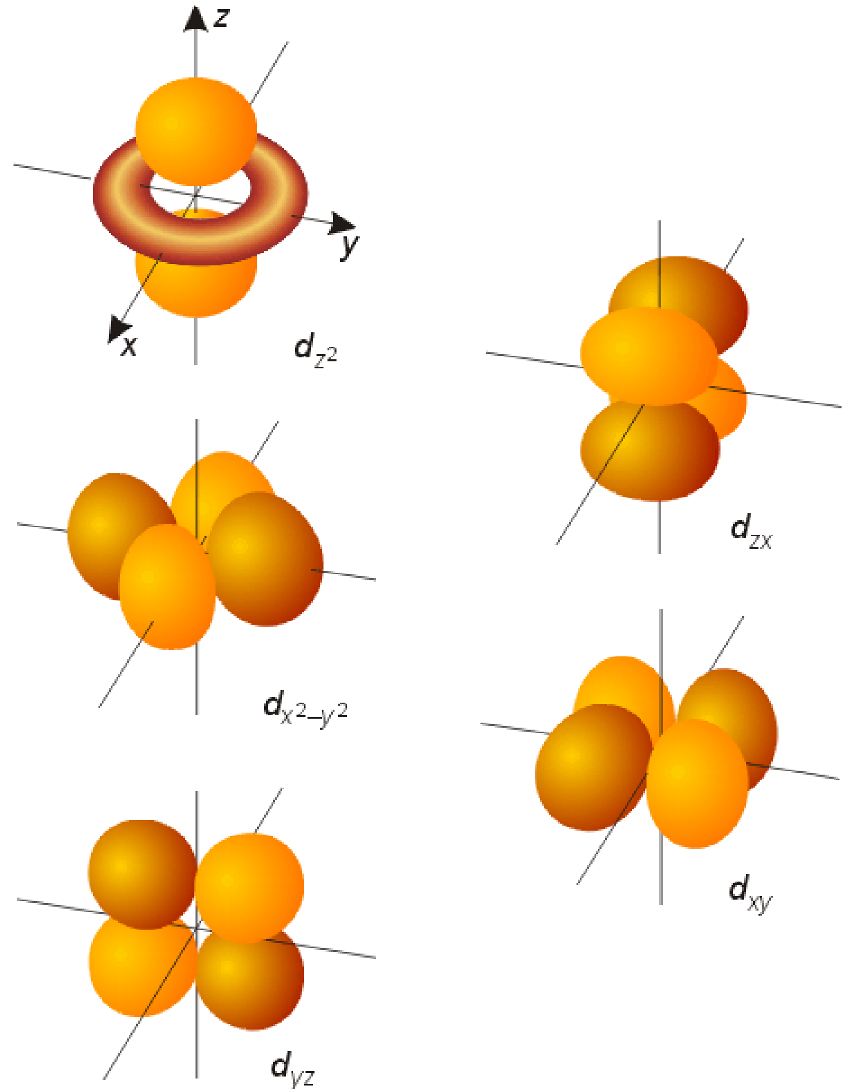
- *p*-orbitals, higher in energy than *s*-orbitals, are shaped like peanuts and are situated on each of the three axes in a 3-D graph (x, y, z).
- A maximum of 2 electrons can fit in each of the three p-orbitals for a total of 6 electrons



http://www.chemistry.uvic.ca/chem222/Notes/lect3v1.htm

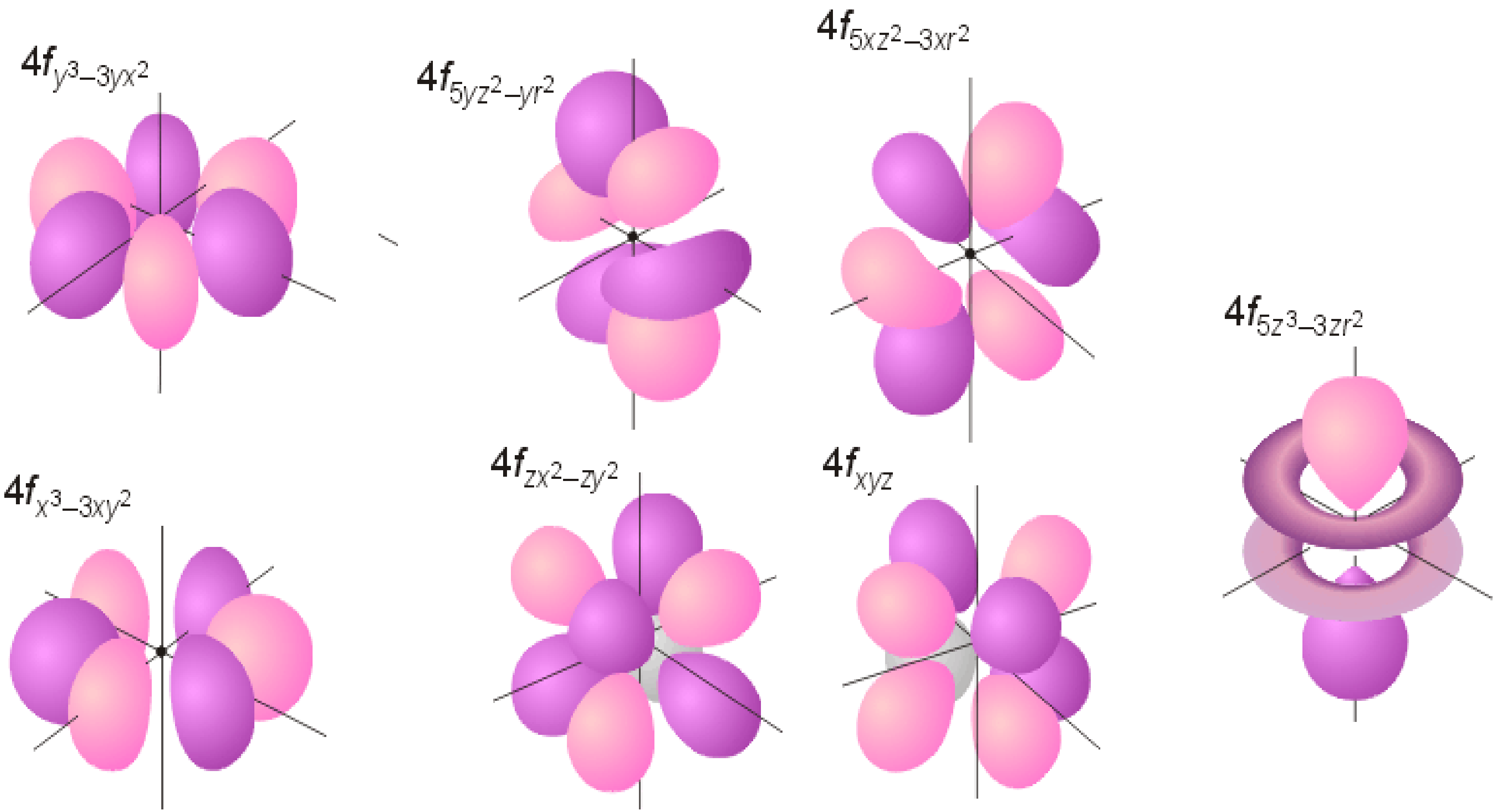
d-orbitals

- *d*-orbitals, higher in energy than p-orbitals, come in 5 axis arrangements, known as spatial orientations, holding a maximum of 10 electrons, 2 in each orientation.



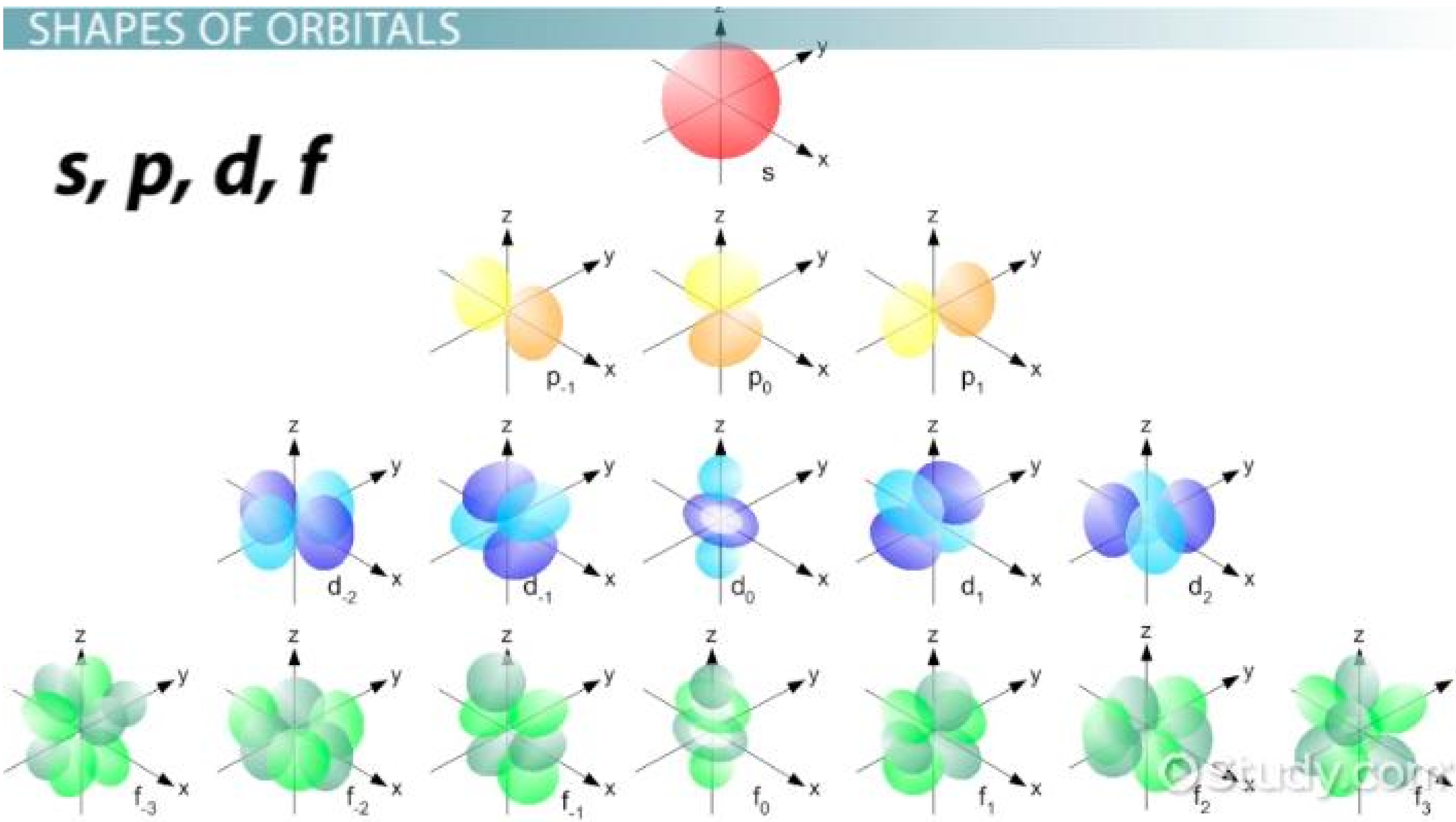
f-orbitals

- *f*-orbitals, the highest energy orbitals for electrons of atoms in the ground state, have seven possible arrangements; each atomic orbital may hold 2 electrons for a maximum of 14 electrons that can fit in the *f*-orbitals.


4f_{y3–3yx2}
4f_{5yz2–yr2}
4f_{5xz2–3xr2}
4f_{5z3–3zr2}
4f_{x3–3xy2}
4f_{zx2–zy2}
4f_{xyz}

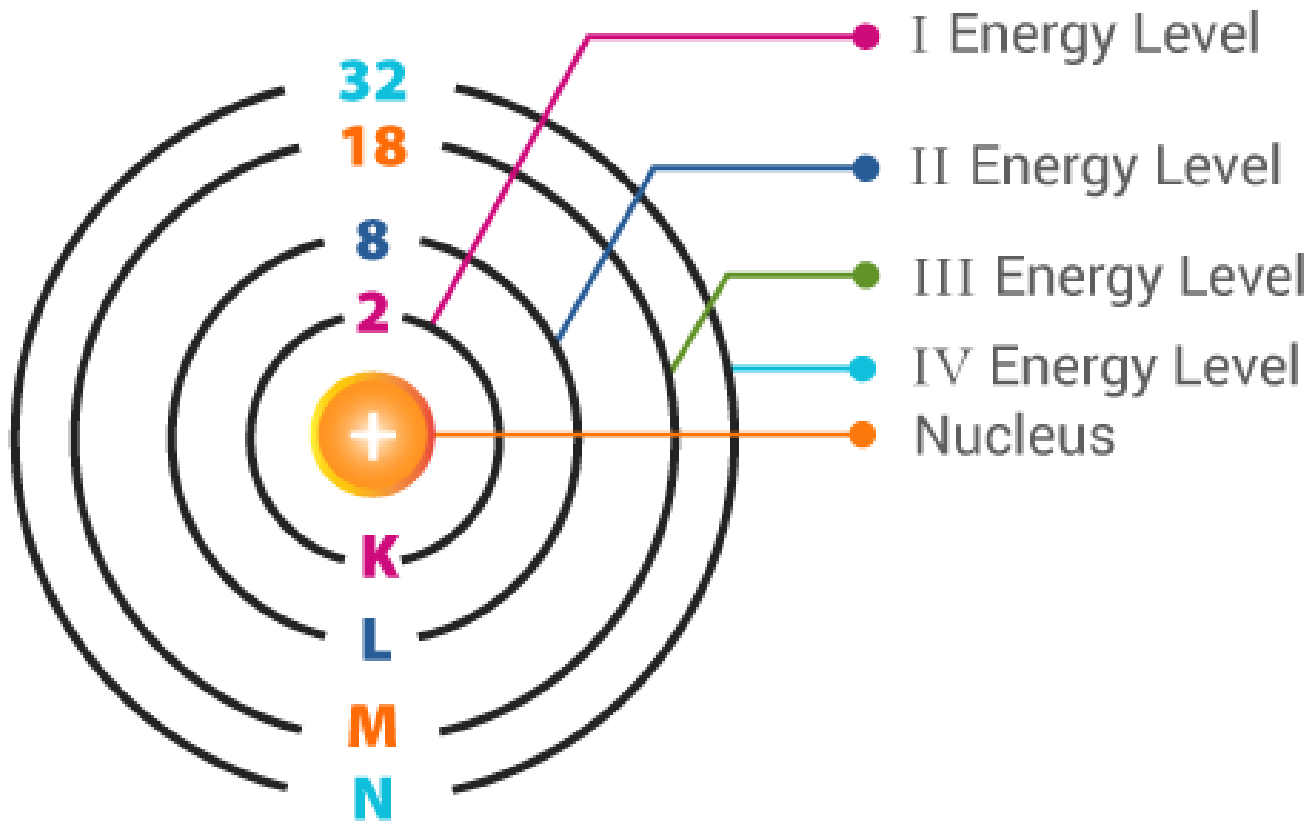
SHAPES OF ORBITALS

_s, p, d, f_

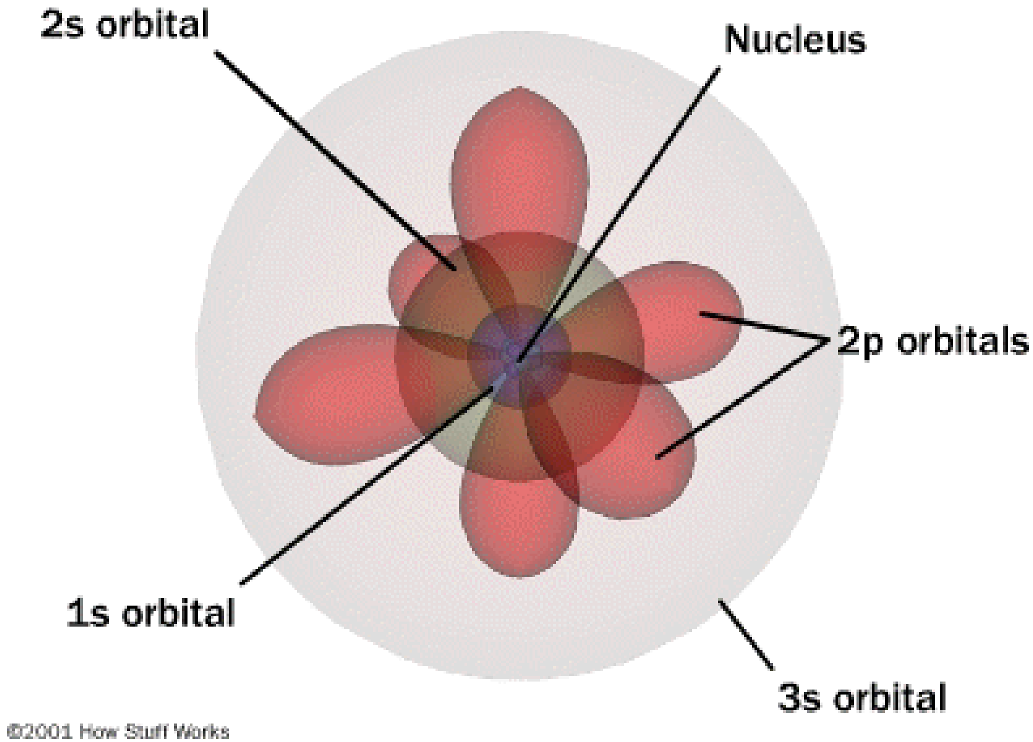


Orbital Shapes – Listed in order of Increasing Energy

Orbital Shape	# Spatial Orientations	Maximum # Electrons
s	1	2
p	3	6
d	5	10
f	7	14


32
18
8
2
K
L
M
N
I Energy Level
II Energy Level
III Energy Level
IV Energy Level
Nucleus

- In every atom, even if the shells are not full, the electron clouds still exist and overlap.



- Last class we learned how to write an electron configuration for elements 1-20 using the “boarding house” analogy and the “orbital diagram” model.
- These models that we looked at start to become less useful when we try to use them to write electron configurations for elements with atomic numbers higher than 21.
- Let’s learn how to use the Periodic Table, the ultimate cheat sheet you’ll ever be allowed to use, to write the electron configurations for elements.

Prepare your Periodic Table – Step 1!

1. Put your name on the PT sheet.
2. Choose 4 colors to represent 4 different *blocks* of the periodic table (*s,p,d,f*). Make sure the colors are dramatically different colors, not just shades of each other. You can use markers, colored pencils, highlighters, your choice.
3. Draw a legend, or key, to indicate which color will correspond to which letter. (Hint: I would save my FAVORITE color for either *p* or *d*!)

Periodic Table

Main groups | Transition metals | Main groups

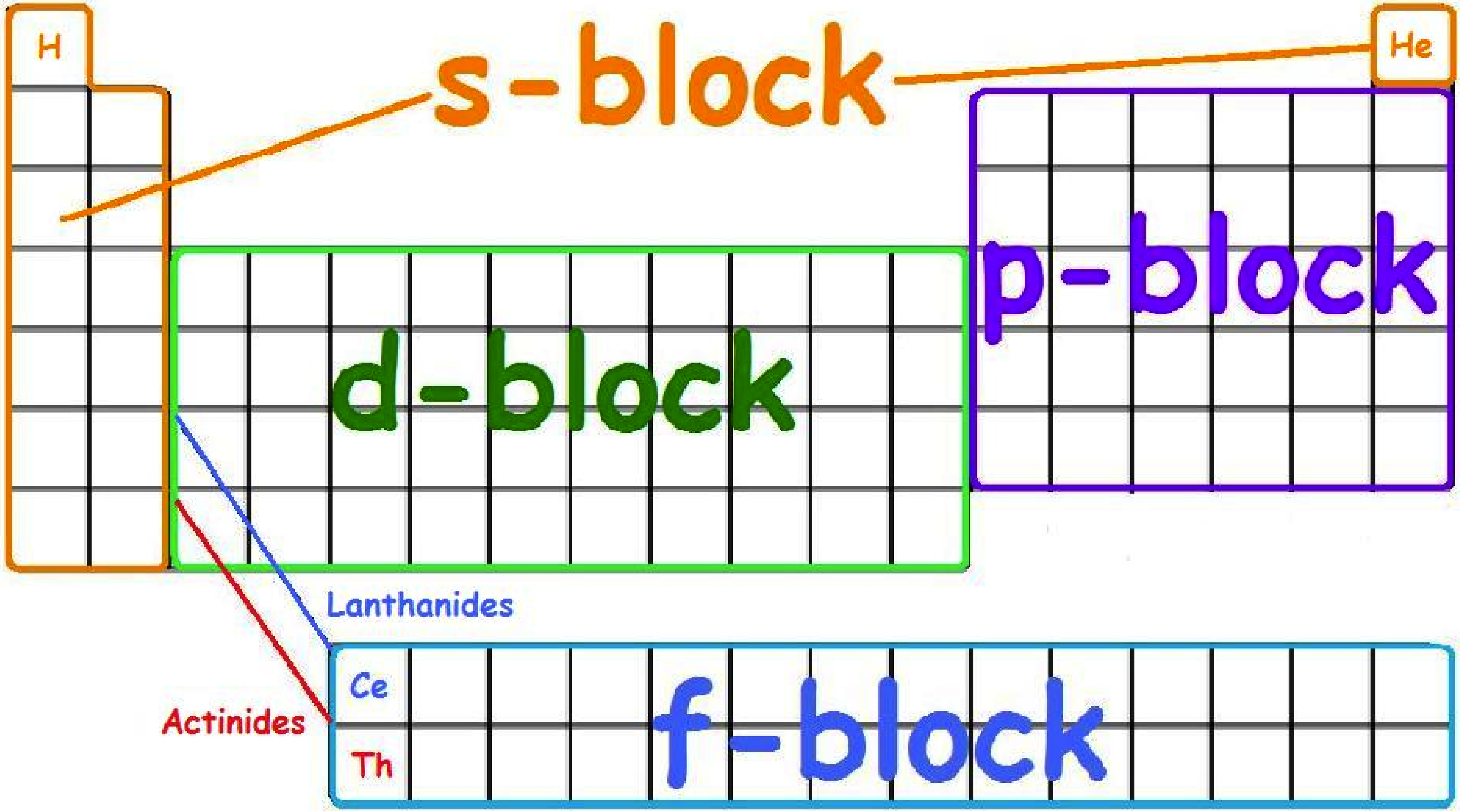
Period	1A[a] 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	1 **H** 1.00794																	2 **He** 4.00260
2	3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.811	6 **C** 12.0107	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.1797
3	11 **Na** 22.9898	12 **Mg** 24.3050											13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.065	17 **Cl** 35.453	18 **Ar** 39.948
4	19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.9559	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.9380	26 **Fe** 55.845	27 **Co** 58.9332	28 **Ni** 58.6934	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.64	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
5	37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** [98]	44 **Ru** 101.07	45 **Rh** 102.9055	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.760	52 **Te** 127.60	53 **I** 126.9045	54 **Xe** 131.293
6	55 **Cs** 132.9055	56 **Ba** 137.327	71 **Lu** 174.967	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.078	79 **Au** 196.9666	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.9804	84 **Po** [208.98]	85 **At** [209.99]	86 **Rn** [222.02]
7	87 **Fr** [223.02]	88 **Ra** [226.03]	103 **Lr** [262.11]	104 **Rf** [261.11]	105 **Db** [262.11]	106 **Sg** [266.12]	107 **Bh** [264.12]	108 **Hs** [269.13]	109 **Mt** [268.14]	110 **Ds** [271.15]	111 **Rg** [272.15]	112 **Cn** [277]	113 [284]	114 [289]	115 [288]	116 [292]		

Lanthanide series	57 **La** 138.9055	58 **Ce** 140.116	59 **Pr** 140.9077	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.964	64 **Gd** 157.25	65 **Tb** 158.9253	66 **Dy** 162.50	67 **Ho** 164.9303	68 **Er** 167.259	69 **Tm** 168.9342	70 **Yb** 173.04
Actinide series	89 **Ac** [227.03]	90 **Th** 232.0381	91 **Pa** 231.0359	92 **U** 238.0289	93 **Np** [237.05]	94 **Pu** [244.06]	95 **Am** [243.06]	96 **Cm** [247.07]	97 **Bk** [247.07]	98 **Cf** [251.08]	99 **Es** [252.08]	100 **Fm** [257.10]	101 **Md** [258.10]	102 **No** [259.10]

[a]The labels on top (1A, 2A, etc.) are common American usage. The labels below these (1, 2, etc.) are those recommended by the International Union of Pure and Applied Chemistry (IUPAC).

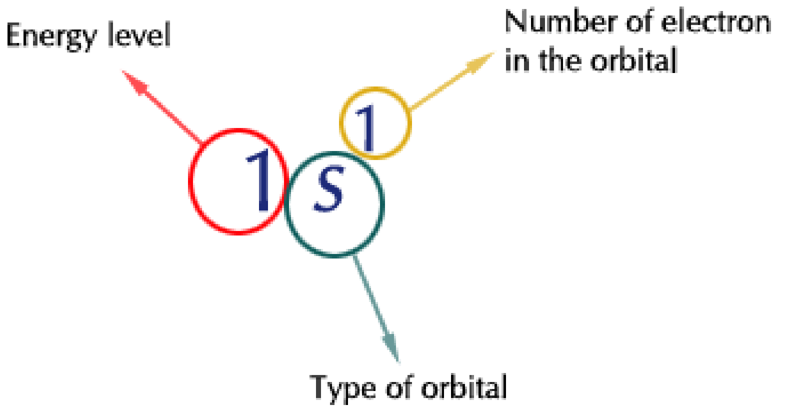
Prepare your Periodic Table – Step 2!

- Now, color your Periodic Table to reflect the s, p, d, and f blocks!
- s block is all squares in vertical columns 1 and 2 *plus* He
- p block is all squares in vertical columns 13 – 18 *minus* He
- d block is all squares in vertical columns 3 – 12 (the bridge between s and p blocks)
- f block is all squares in the 2 horizontal rows at the bottom, off by themselves


H
s-block
He
p-block
d-block
Lanthanides
Ce
Actinides
Th
f-block

Electron Configurations – The Basics

- An electron configuration gives an account for ALL of the electrons in an element. There are three parts to an electron configuration: the coefficient represents the energy level that the electron resides in ***(which corresponds to the horizontal row number on the PT)***, a letter (s,p,d,f) that indicates the type of orbital/sublevel the electron resides in ***(which corresponds to the block from the PT)***, and a superscript ***(which corresponds to the number of electrons in the orbital).***



Rules for writing an electron configuration!

- The start position is always in front of H, atomic #1.
- Element squares = steps! (Like spaces on a board game!)
- Follow the atomic numbers; don’t skip spaces!
- Every time you enter a *new block or new horizontal row*, start recounting your steps (from the number 1) to figure out the superscript that goes with the letter.
- The superscript for s cannot exceed 2
- The superscript for p cannot exceed 6
- The superscript for d cannot exceed 10
- The superscript for f cannot exceed 14

Rules to Follow – Cont'd

- When crossing over the *s* and *p* blocks, the coefficient (energy level number) is equal to the horizontal row (i.e. period) number.
- When crossing over the *d* block, the coefficient (energy level number) is equal to the *row number minus one*.
- When crossing over the *f* block, the coefficient (energy level number) is equal to the *row number minus two.*
- FOLLOW THE ATOMIC NUMBERS IN ORDER TO WRITE ELECTRON CONFIGURATIONS PROPERLY!
- Let's practice together as a class!
- *Valence electrons are the electrons in the highest energy LEVEL of an element. Core electrons are the electrons in the LOWER energy levels of an element.*

	Long form	Noble gas abbreviation	# Valence Electrons
Hydrogen			
Helium			
Lithium			
Beryllium			
Boron			
Carbon			
Nitrogen			
Oxygen			
Fluorine			
Neon			
Iron			
Cadmium			
Zirconium			
Bromine			
Antimony			

Man, that gets long!

- Electron configurations can get very long, as you can see in the table.
  - A shortened form of the electron configuration can be written for most elements. This shortened form is often referred to as the *noble gas abbreviated* electron configuration, or the *short form*.
  - To write the noble gas configuration, find the last *noble gas* (i.e. member of *vertical column 18* of the PT) that was crossed over *on the way to your element*. This noble gas symbol is placed in square brackets, creating a new start position for writing the remainder of the electron configuration. Let’s finish filling in that table!

Electron Configurations for Ions

- Electron configurations can also be given for ions (when neutral elements lose or gain electrons). Just find the number of electrons the ion has, and write the electron configuration to that atomic number, rather the atomic number of the neutral atom. Example: Na^{+1} has 10 electrons. Write the electron configuration to an atomic number of 10 (i.e. stop at Neon) rather than going all the way to atomic number 11, the atomic number of sodium. Now, give the electron configurations for the ions in your notes packet.

Have you noticed a trend?

- Notice that when elements gain or lose electrons to form ions (anions and cations), they seek to achieve a noble gas configuration (i.e. 8 electrons in the outer shell, or a stable octet).
  - Based on this pattern, we can predict the charge of ions of elements in the s and p blocks. All you need to know is that elements are LAZY. Elements will take the *shortest path available* to a noble gas configuration.

Example - Sodium

- The electron configuration for sodium is $1s^2 2s^2 2p^6 3s^1$.
- Sodium has 1 valence electron. A noble gas has 8 valence electrons. Sodium has the option of moving 1 step backward (i.e. lose 1 electron) to the Neon noble gas configuration or 7 steps forward (i.e. gain 7 electrons) to the Argon noble gas configuration.
- Sodium is lazy. The shortest path to the noble gas configuration is to lose 1 electron. Hence, sodium will form an ion with a 1+ charge by losing 1 electron.

Element	#Valence electrons	Gain or Lose?	Ion Charge
Magnesium			
Fluorine			
Aluminum			
Nitrogen			
Sulfur			
Potassium			