Chemistry 6A Fall 2007

Dr. J. A. Mack

Wednerdsday

9/26/07

I put a boat-load of extra credit OWL exercises for you to work on this week!

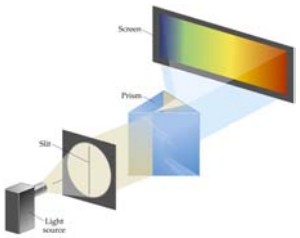
And I've decided that you can earn up to 125% of the maximum HW points with the extra credit!

So if the HW is worth 50 points, you can earn up to 62.5 points!

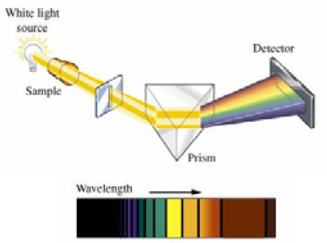
Beware… HW points alone will not ensure passing, you must do well on exams and quizzes!

Line Spectra and the Bohr Model

1860: Robert Wilhelm Bunsen and Gustav Kirchoff noted the presence of dark lines arising from absorption of light when observing the spectrum of a bright light source through the flame seeded with alkali metals.



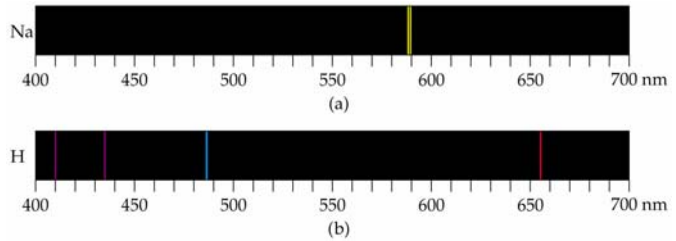
Normal spectrum of white light.



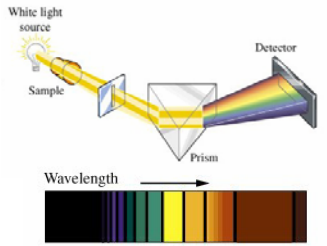
Gaps due to absorption by atoms in the flame

Atomic Line Spectra

Each element has a unique line spectrum.

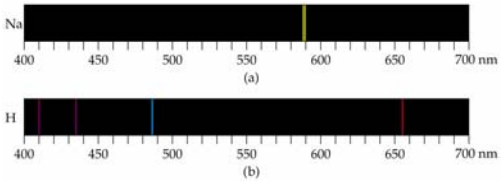


- The lines indicate that the electrons can only make "jumps" between allowed energy levels.
- Knowing the color (wavelength) on can determine the magnitude of the energy gape using Planck's Law.



Gaps due to absorption by atoms in the flame.
Electrons are moving to higher energy levels from lower energy levels.

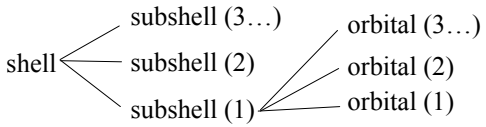
Lines are due to emission by atoms in the flame. Electrons are moving from higher energy levels to lower energy levels.



THE QUANTUM MECHANICAL MODEL OF ELECTRON BEHAVIOR IN ATOMS

- According to the quantum mechanical model of electron behavior, the precise paths of electrons moving around the nucleus cannot be determined accurately.
- Instead of circular orbits, the location and energy of electrons moving around the nucleus is specified using the three terms **shell, subshell** and **orbital**.

Each ***shell*** is broken up into ***subshells*** and each ***subshell*** is divided into orbitals



and so on…

The Bohr Model: *A new quantum leap in atomic structure*

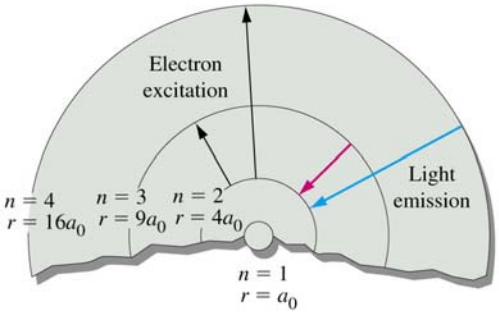
Bohr asserted that line spectra of elements indicated that the electrons were confined to specific energy states. These he called orbits.

The lines (colors) corresponded to "jumps" or transitions between the levels.

The Bohr Model:

$r_n = n^2 a_o$

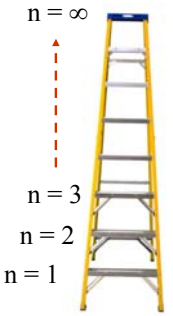
n = 1, 2, 3, 4…



SHELL

- The location of electrons in a shell is indicated by assigning a number *n* to the shell and all electrons located in the shell.
- The value of *n* can be 1, 2, 3, 4, etc.
- The higher the *n* value, the higher is the energy of the shell and the contained electrons.

Each ***shell*** can be thought of as a step on a ladder



SUBSHELL

- Each shell is made up of one or more subshells (l) that are designated by a letter from the group *s, p, d,* or *f*.
- The number of the shell to which a subshell belongs is combined with the letter of the subshell to clearly identify subshells.
- For example, a *p* subshell located in the third shell ($n = 4$) would be designated as a 4*p* subshell.

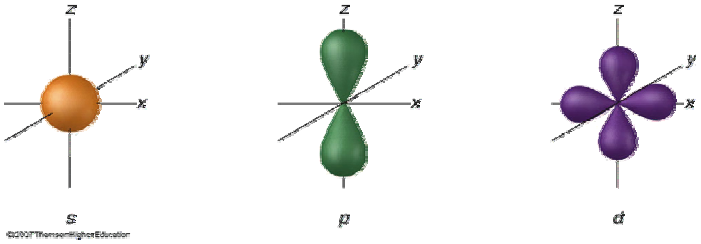
For a value of n, there are up to n subshells starting at $l = 0$ up to $l = n–1$.

if n = 4 there are 4 subshells

n = 4	$l = 3$	*f* subshell
	$l = 2$	*d* subshell
	$l = 1$	*p* subshell
	$l = 0$	*s* subshell

ATOMIC ORBITALS

- The description of the location and energy of an electron moving around a nucleus is completed in the quantum mechanical model by specifying an atomic orbital in which the electron is located.
- Each subshell consists of one or more atomic orbitals, which are specific volumes of space around the nucleus in which electrons move.

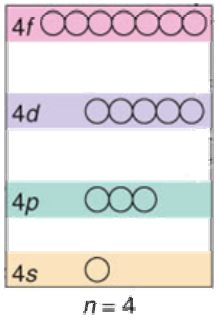


All *f* subshells consist of seven *f* orbitals.

All *d* subshells consist of five *d* orbitals.

All *p* subshells consist of three *p* orbitals.

All *s* subshells consist of a single *s* orbital.



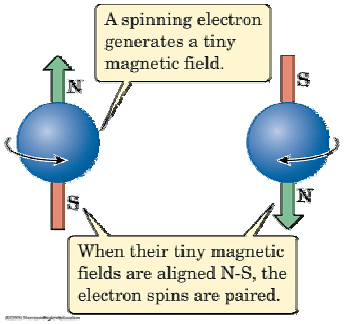
According to the quantum mechanical model, each atomic orbitals can hold a maximum of two electrons.

and so on….

p– subshell	three orbital	six electrons
s– subshell	one orbital	two electrons

THE PAULI EXCLUSION PRINCIPLE

- According to the *Pauli exclusion principle*, each orbital can accommodate only 2 electrons.
- These electrons must differ by their "intrinsic spin".
- One electron is spin up (↑) the other spin down (↓).

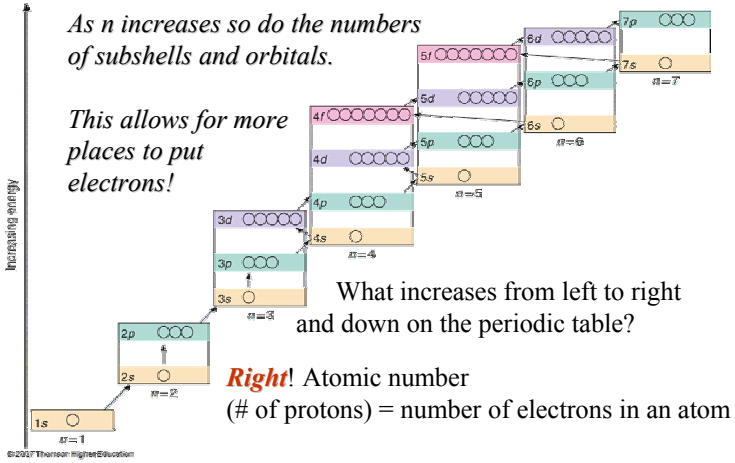


When the electrons pair up in an orbital, we don't know which is up or down, by convention we write the 1st on up and the second down.

THE ENERGY OF ELECTRONS IN ATOMS

As n increases so do the numbers of subshells and orbitals.

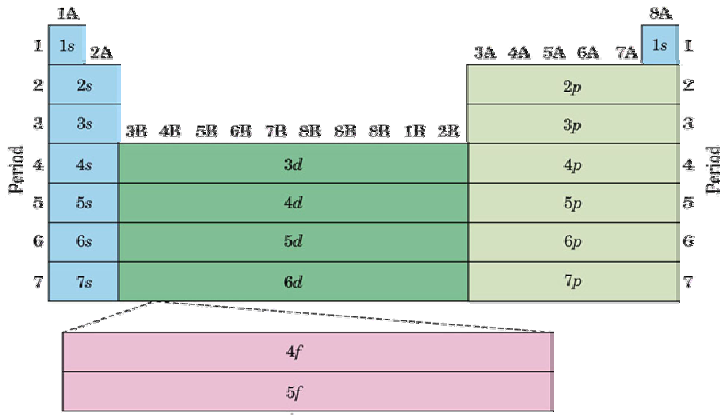
This allows for more places to put electrons!

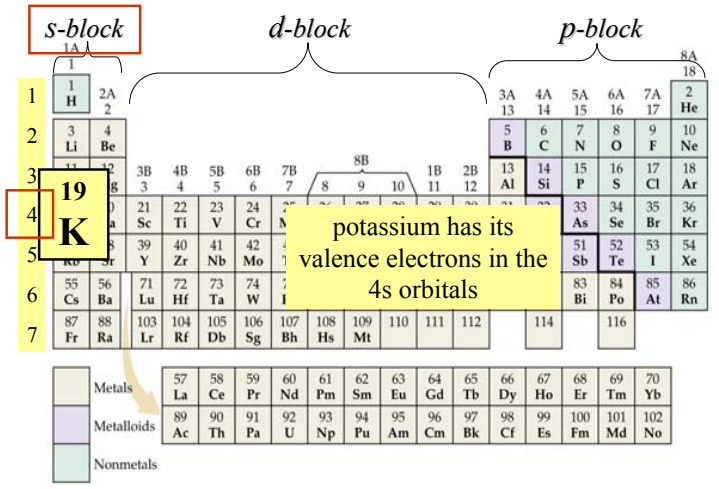


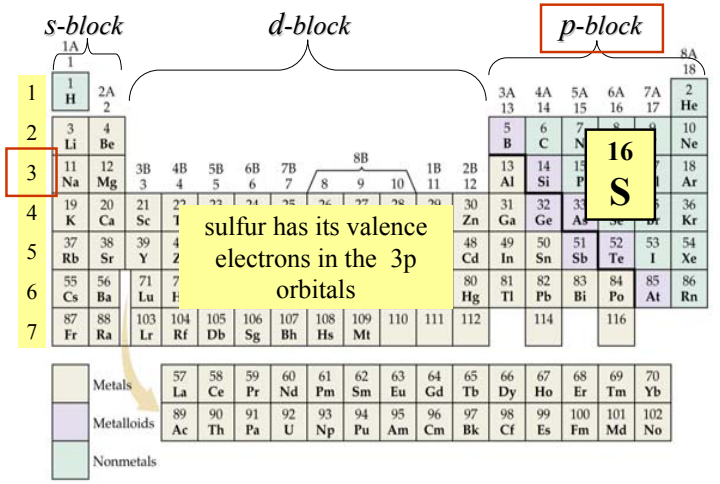
What increases from left to right and down on the periodic table?

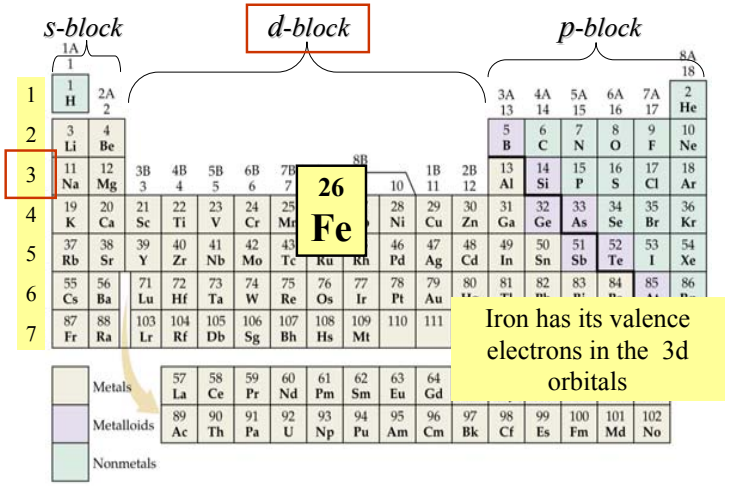
Right! Atomic number (# of protons) = number of electrons in an atom

The outermost electrons (valence) of an element are related to the elements position on the periodic table.









RELATIONSHIPS BETWEEN SHELLS, SUBSHELLS, ORBITALS AND ELECTRONS

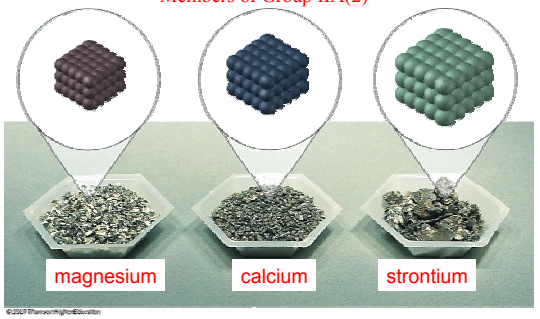
TABLE 3.1 Relationships between shells, subshells, orbitals, and electrons

Shell number (n)	Number of subshells in shell	Subshell designation	Number of orbitals in subshell	Orbital designation	Maximum number of electrons in subshell	Maximum number of electrons in shell
1	1	1*s*	1	1*s*	2	2
2	2	2*s*	1	2*s*	2	
		2*p*	3	2*p*	6	8
3	3	3*s*	1	3*s*	2	
		3*p*	3	3*p*	6	
		3*d*	5	3*d*	10	18
4	4	4*s*	1	4*s*	2	
		4*p*	3	4*p*	6	
		4*d*	5	4*d*	10	
		4*f*	7	4*f*	14	32

ELECTRONS AND CHEMICAL PROPERTIES

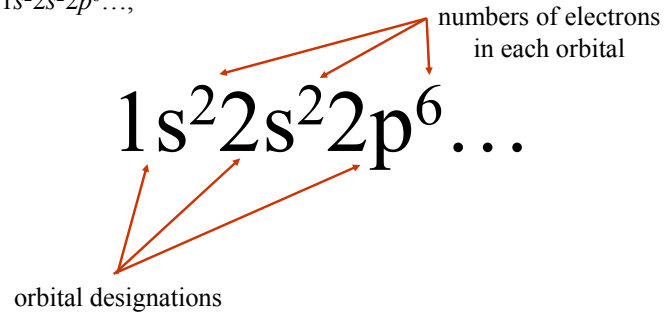
- The valence shell of an atom is the shell that contains electrons with the highest n value.
- Atoms with the same number of electrons in the valence shell have similar chemical properties.

Members of Group IIA(2)

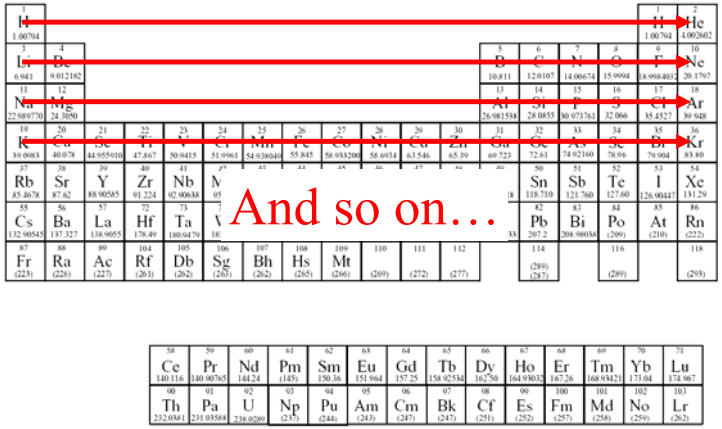


ELECTRONIC CONFIGURATIONS

- Electronic configurations give details of the arrangements of electrons in atoms.
- The notation used to represent electronic configurations is $1s^2 2s^2 2p^6 \ldots$,



Electrons fill orbitals on the periodic table across then down"



Orbital Filling: The Aufbau Principle and Hund's rule.

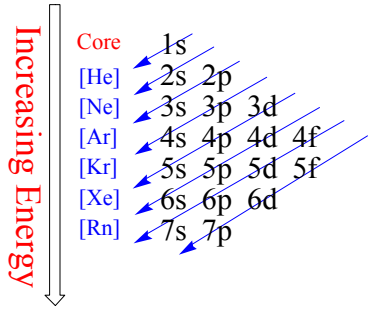
Aufbau Principle:
Lower energy orbitals fill first.

Hund's Rule.

Degenerate orbitals are filled with electrons until all are half filled before pairing up of electrons can occur.

Individual orbitals only hold two electrons, and each should have different spin.

"Pauli exclusion principle"



"s" orbitals can hold 2 electrons

3 "p" orbitals hold up to 6 electrons

5 "d" orbitals can hold up to 10 electrons