Atoms & Elements

Major Goals of our Atom & Elements Module:

1. Finding the exact location (home) for the electron in an atom
2. Discuss physical and chemical experimental evidence which supports
   a) electronic structure &
   b) the periodic trends in the properties of atoms.

This powerpoint reviews key topics for atom & elements

- Electromagnetic Radiation
- Atomic Spectra & Energy Levels
- Energy Levels (shells), Sublevel(subshell) & Orbitals
- Writing Orbital Diagrams & Electron Configurations
- Electron Configurations & the Periodic Table
- Periodic Trends of the Elements

Handout "All about e-" (click here)

"It's all about e^-"

Properties for an Electron in an Atom

1. **light weight particle; 1/2000th an atomic mass unit (amu)**
2. **(-) negatively charged particle**
3. **loosely bound; American Heritage Dictionary defines loose as**
   - **not fastened; unbound**
4. **attracted to (+) positively charged particles**
5. **repelled by other negatively charged particles**
6. **dynamic not static; I'd would like to move about or jump around**
7. **at home within an electron shell shown by Bohr's model**
8. **a traveler and would love to travel but never far from home**
9. **easily excitable**

Point 7 is in red because some textbooks do not discuss Bohr's model directly, only indirectly when discussing Atom & Elements basics.

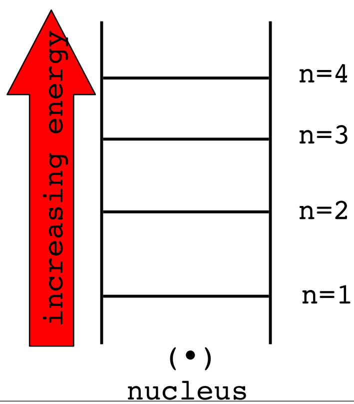
Supplemental packet page 44

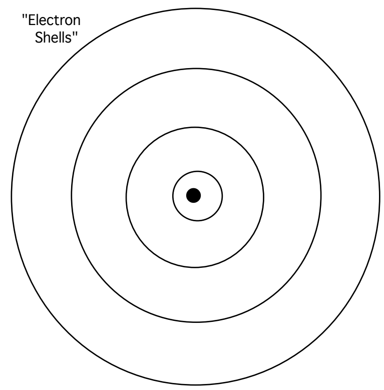
Atomic Spectra & Energy Levels

Point 7 is in <u>red</u> because some textbooks do not discuss Bohr's model directly, only indirectly when discussing Atom & Elements basics.

The ladder and the concentric circles below are visuals for Bohr's model.

Bohr's Model Playlist (click here)





<u>Bohr discovered that</u>

Electrons have a home in a discrete "quantized" shell

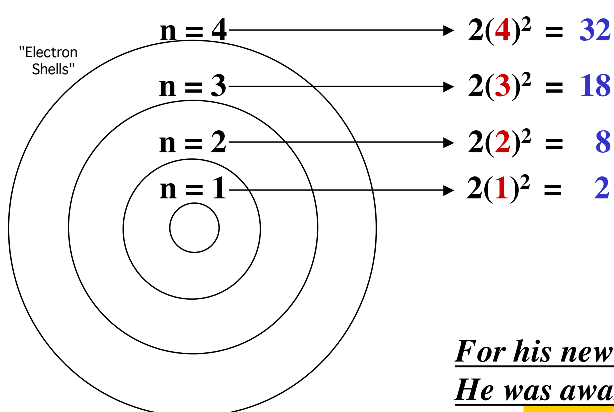
quantized = discrete

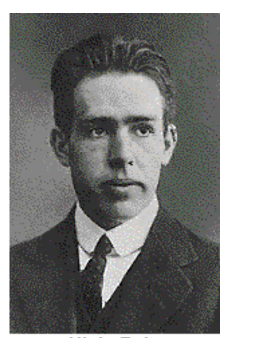
Bohr's Model for atoms

<u>Where</u>

Supplemental packet page 44

The <u>maximum</u> number of electrons per <u>shell</u> is given by $2(n)^2$





Niels Bohr
Culver Pictures, Inc.

<u>For his new discovery,</u>
<u>He was awarded the</u>

Nobel Prize in physics 1922

You don't have to be smart to be awarded a Nobel Prize. You just have to discover something new which revolutionizes the way society views the world around us.

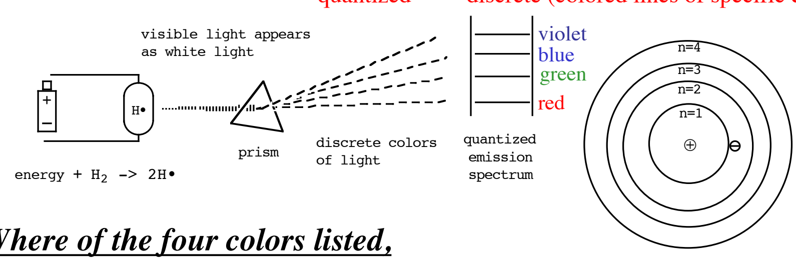
Supplemental packet page 44

<u>Bohr based his discovery on the emission spectrum for hydrogen</u>

F. 1913 Neils Bohr

1. The HYDROGEN atom has played a major role in the development of models of electronic structure.
2. In a hydrogen discharge tube, individual atoms of hydrogen emit visible light.
3. When the light is passed through a prism, refraction occurs, and a quantized emission spectrum appears.

quantized = discrete (colored lines of specific energy)



<u>Where of the four colors listed,</u>

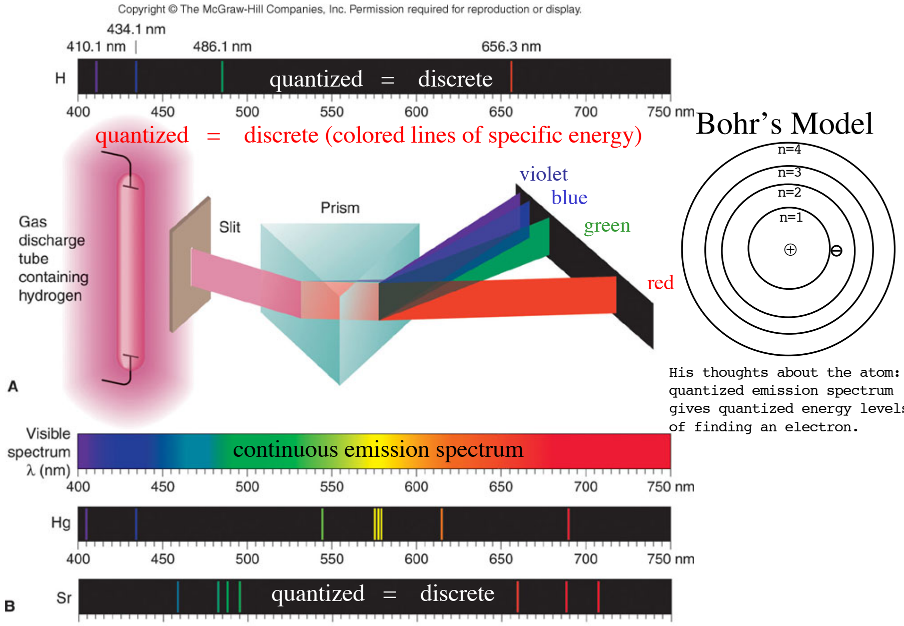
<u>violet color (visible light) is highest in energy</u>

<u>Red color (visible light) is lowest in energy</u>

<u>Visible light is an example of electromagnetic radiation</u>

His thoughts about the atom:
quantized emission spectrum
gives quantized energy levels
of finding an electron.

Emission Spectra that support Bohr's discrete energy levels

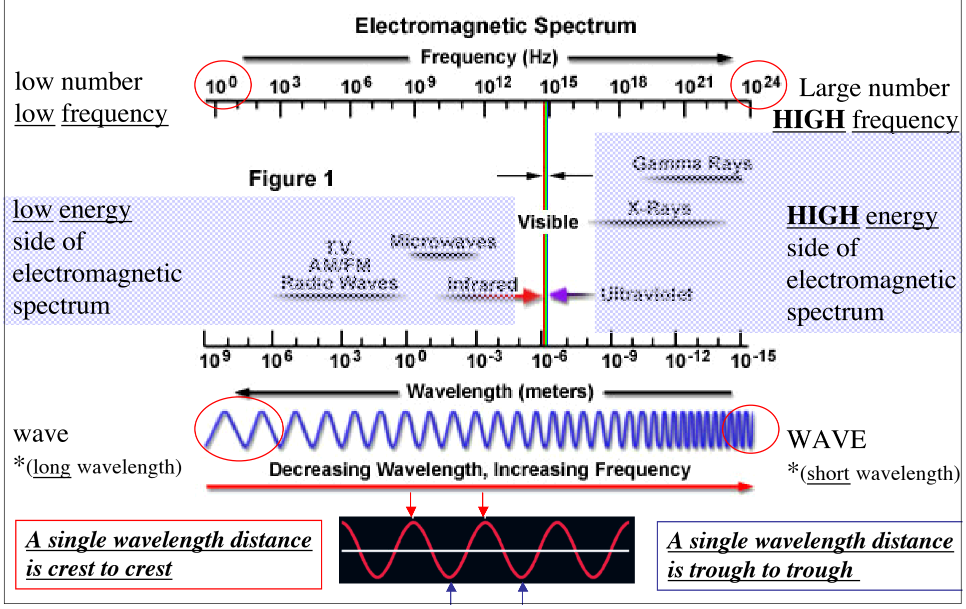


quantized = discrete (colored lines of specific energy)

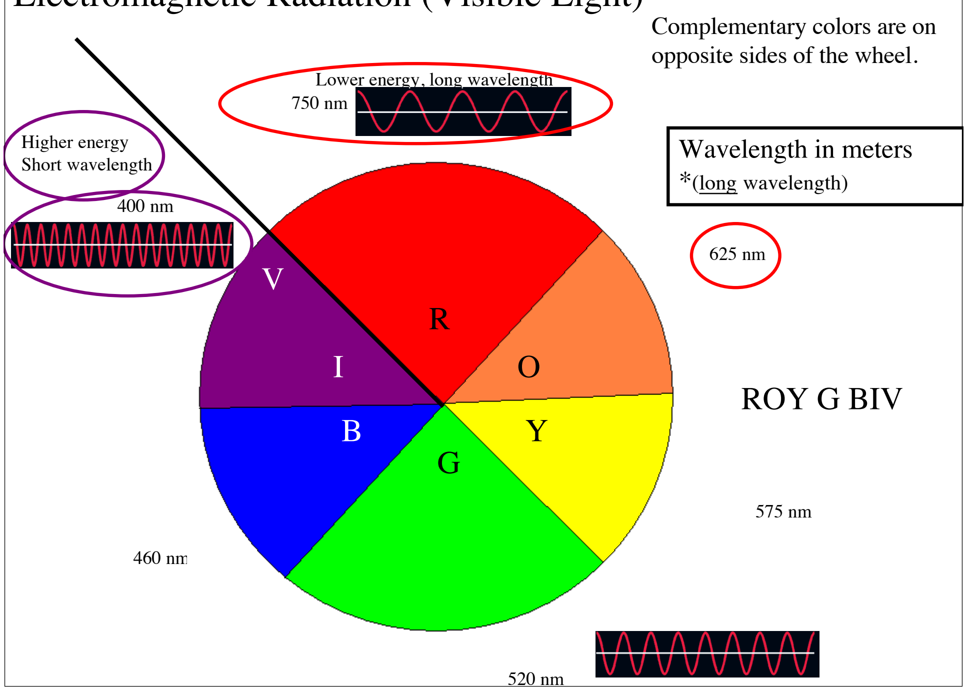
Electromagnetic Radiation

Supplemental packet page 45 & 46

Study all the basic information on this page



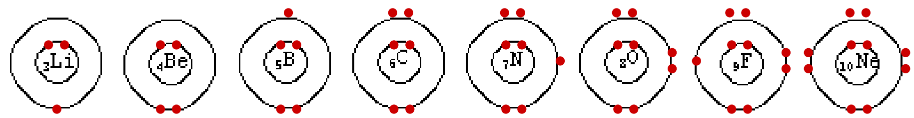
Electromagnetic Radiation (Visible Light)



Record into your notes opposite page 48

A. Valence electrons - Valence (outermost) electrons are in the principle energy shell furthest from the nucleus (the highest energy shell).

a. Draw Bohr electron dot structures for the elements of period (row) 2.



b. Draw Lewis electron dot structures or the elements of period (row) 2.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8

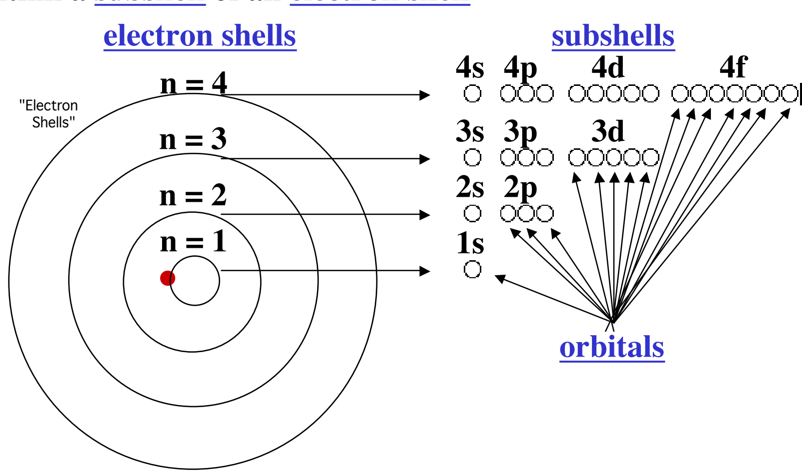
<u>Lewis Dot Structure</u> only show outermost electrons (valence electrons)

- the group number equals the number of valence electrons for representative elements
- only show the valence electrons as dots about the atom in a Lewis dot

Summary: Row number = number of shells in Bohr's Model
Group number = number of valence electrons in Lewis dot

Energy Levels (shells), Sublevel(subshell), Orbitals

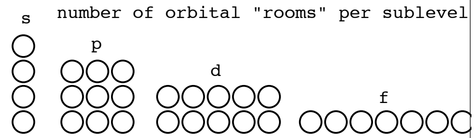
In today's world, <u>quantum physics</u> gives a better theoretical model for where an electron is located. Electrons resided in an <u>orbital</u> within a <u>subshell</u> of an <u>electron shell</u>



What is the exact address for the location of a hydrogen electron?

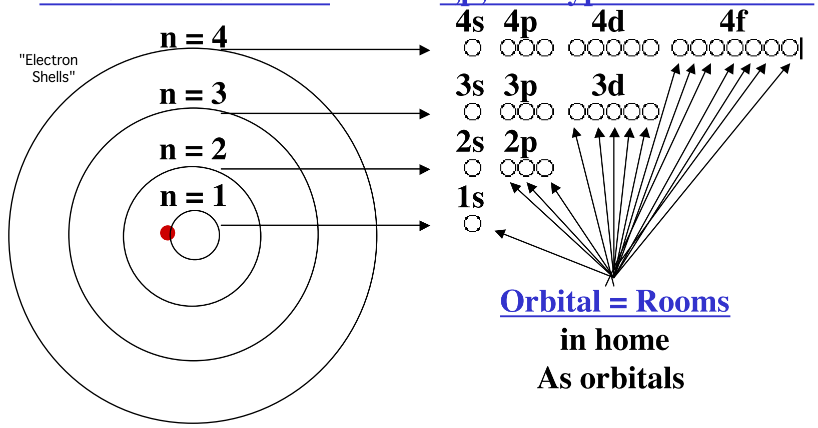
On ‘all about e,’ know the ordering, location, shape, & and spatial orientation of orbitals

Shell level	subshell sublevel	orbital	number of orbital "rooms" per sublevel
1	one	s	
2	two	s, p,	
3	three	s, p, d	
4	four	s, p, d, f	



Perhaps a good illustration for finding an electron address would be

n = Number of Street   **s,p,d f = type of track home**



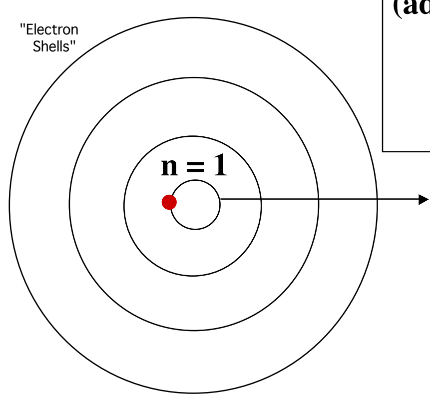
Orbital = Rooms
in home
As orbitals

Writing Orbital Diagrams & Electron Configurations

Our current model: the location (the home address) for an electron

What is the exact address for the location of a hydrogen electron?

For the hydrogen atom



The excact location is: (address) $1s^1$ ← **Total number of electrons in sublevel**

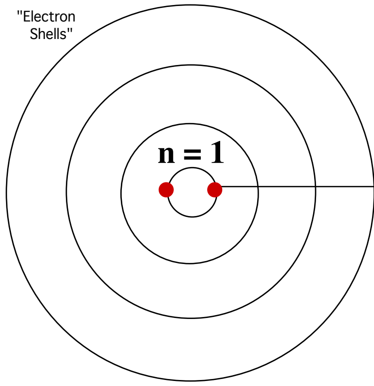
shell subshell

electron shell	subshell	orbital
1	s	↿

Writing Orbital Diagrams & Electron Configurations

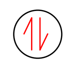
Our current model: the location (the home address) for an electron

For the helium atom



$1s^2$ ← **Total number of electrons in sublevel**

↑ **shell** ↑ **subshell**

electron shell	**subshell**	**orbital**
1	**s**	

Putting it all together

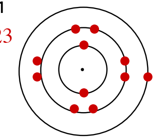
Element	Atomic Number	nucleus	Bohr Model n shells			Wave Mechanical Model Electron Configuration principal shell & subshell number	
Supplemental page 48 & 53							
H	1	1+	e				first row elements
He	2	2+	e e				
Li	3	3+	e e	e			
Be	4	4+	e e	e e			
B	5	5+	e e	e e e			
C	6	6+	e e	e e e e		valence shell	second row elements
N	7	7+	e e	e e e e e			
O	8	8+	e e	e e e e e e			
F	9	9+	e e	e e e e e e e			
Ne	10	10+	e e	e e e e e e e e			
Na	11	11+	e e	e e e e e e e e	e		third row elements

Element	Atomic Number	nucleus	Bohr Model n shells			Wave Mechanical Model Electron Configuration principal shell & subshell number	1s 2s 2p 3s 3p 4s 3d 4p 5s 4d……
Supplemental page 48 & 53							
H	1	1+	e			$1s^1$	first row elements
He	2	2+	e e			$1s^2$	
Li	3	3+	e e	e		$1s^2\ 2s^1$	
Be	4	4+	e e	e e		$1s^2\ 2s^2$	
B	5	5+	e e	e e e		$1s^2\ 2s^2\ 2p^1$	valence shell
C	6	6+	e e	e e e e		$1s^2\ 2s^2\ 2p^2$	second row elements
N	7	7+	e e	e e e e e		$1s^2\ 2s^2\ 2p^3$	
O	8	8+	e e	e e e e e e		$1s^2\ 2s^2\ 2p^4$	
F	9	9+	e e	e e e e e e e		$1s^2\ 2s^2\ 2p^5$	
Ne	10	10+	e e	e e e e e e e e		$1s^2\ 2s^2\ 2p^6$	
Na	11	11+	e e	e e e e e e e e	e	$1s^2\ 2s^2\ 2p^6\ 3s^1$	third row elements

Supplemental packet page 49

Atomic Structure

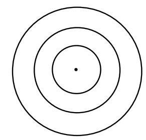
Atomic Number: 11
Name: sodium-23
Symbol: $^{23}_{11}Na$



mass # 23
p __11__
n __12__
e __11__
Electronic Configuration: $1s^2\ 2s^2\ 2p^6\ 3s^1$

Physical Properties: soft metal, conducts e-
Chemical Properties: reacts w/ H_2O
Lewis Dot: Na•

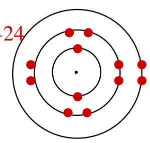
Atomic Number: 17
Name:
Symbol:



mass # 35
p ______
n ______
e ______
Electronic Configuration:

Physical Properties:
Chemical Properties:
Lewis Dot:

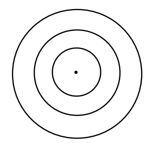
Atomic Number: 12
Name: magnesium-24
Symbol: $^{24}_{12}Mg$



mass # 24
p __12__
n __12__
e __12__
Electronic Configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2$

Physical Properties: ductile metal, conducts e-
Chemical Properties: burns in O_2
Lewis Dot: • Mg•

Atomic Number: 8
Name:
Symbol:



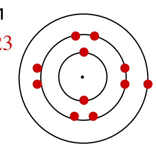
mass # 16
p ______
n ______
e ______
Electronic Configuration:

Physical Properties:
Chemical Properties:
Lewis Dot:

Supplemental packet page 49

Atomic Structure

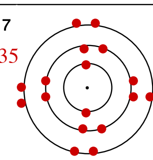
Atomic Number: 11
Name: sodium-23
Symbol: $^{23}_{11}Na$



mass # 23
p __11__
n __12__
e __11__
Electronic Configuration: $1s^2\ 2s^2\ 2p^6\ 3s^1$

Physical Properties: soft metal, conducts e-
Chemical Properties: reacts w/ H_2O
Lewis Dot: Na•

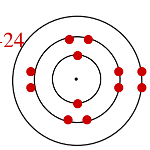
Atomic Number: 17
Name: chlorine-35
Symbol: $^{35}_{17}Cl$



mass # 35
p __17__
n __18__
e __17__
Electronic Configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

Physical Properties: yellow gas, nonconductor
Chemical Properties: reacts w/ Na(s)
Lewis Dot: :Cl• (7 dots)

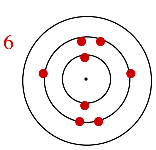
Atomic Number: 12
Name: magnesium-24
Symbol: $^{24}_{12}Mg$



mass # 24
p __12__
n __12__
e __12__
Electronic Configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2$

Physical Properties: ductile metal, conducts e-
Chemical Properties: burns in O_2
Lewis Dot: • Mg •

Atomic Number: 8
Name: oxygen-16
Symbol: $^{16}_{8}O$



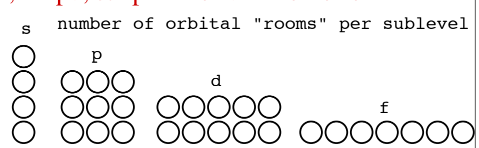
mass # 16
p __8__
n __8__
e __8__
Electronic Configuration: $1s^2\ 2s^2\ 2p^4$

Physical Properties: colorless gas, nonconductor
Chemical Properties: supports combustion
Lewis Dot: •O• (6 dots)

Mathematical Descriptions of Orbitals & Their Spatial Locations

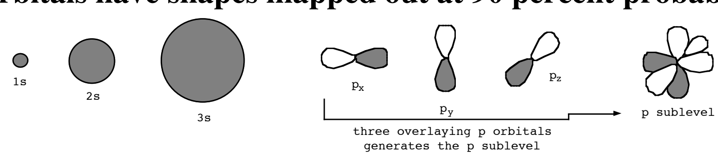
On 'all about e,' know the ordering, location, shape, & spatial orientation of orbitals

Shell level	subshell sublevel	orbital
1	one	s
2	two	s, p,
3	three	s, p, d
4	four	s, p, d, f



Supplement packet page 56

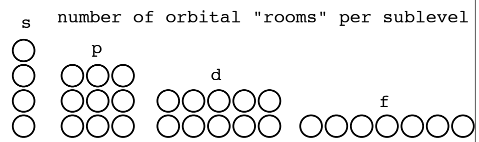
- **Orbitals have shapes mapped out at 90 percent probability :**



- **Orbitals are regions of greatest probability within a subshell for finding an electron; two electrons <u>MAXIMUM</u> per orbital.**
- **Heisenburg Uncertainty Principle - (Werner von Heisenberg) Nobel prize in physics 1932**
- **The Schrödinger equation maps the orbital regions mathematically at 90% probability. (Erwin Schrödinger) Nobel prize in physics 1939; productive forms of atomic theory**

Writing Orbital Diagrams & Electron Configurations

Shell level	subshell sublevel	orbital
1	one	s
2	two	s, p,
3	three	s, p, d
4	four	s, p, d, f



What will be the arrangement of subshells in an atom?

Supplemental packet page 51
Textbook

- **These subshells are arranged from lowest to highest energy values outwards from the nucleus of the atom**

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d……

n (row) number   subshell letter

- **This electron directory is called an "electron configuration"**

Electron Configurations and the Periodic Table

- **These subshells are arranged from lowest to highest energy values outwards from the nucleus of the atom**

Textbook

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d……

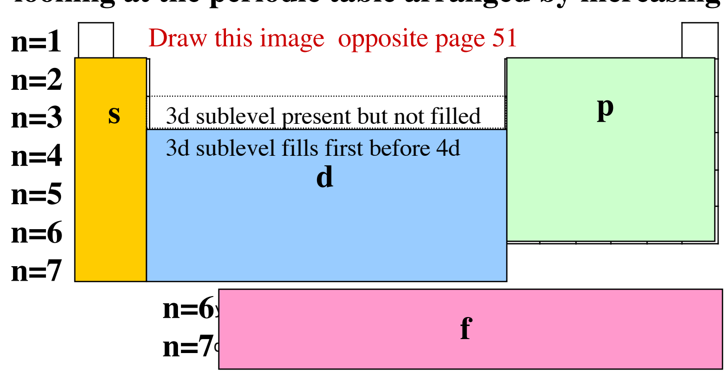
n (row) number   subshell letter

- **This electron directory is called an "electron configuration"**

Bottom right corner of supplemental packet page 51

- **The "electron configuration" filling order can be learned by looking at the periodic table arranged by increasing atomic #**

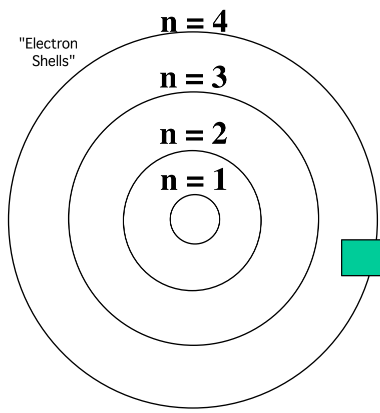
Draw this image opposite page 51



Supplemental packet page 51 - Bohr's Model versus the current Schrodinger Model

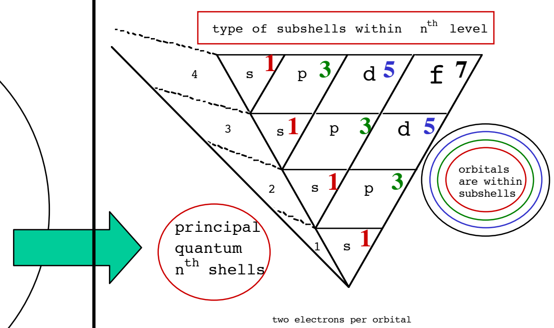
Electron shells

Bohr's Model for Hydrogen



Electron shell, subshell, orbitals

Quantum Wave Mechanical Model (Schrodinger)



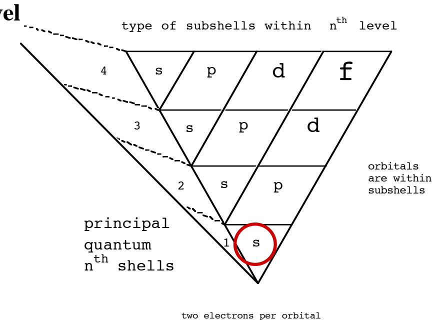
Electron configuration
1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p....

Where is hydrogen's <u>one</u> electron located??????

$1s^1$ ← Total number of electrons in sublevel

↑ shell ↑ subshell

Quantum Wave Mechanical Model (Schrodinger)



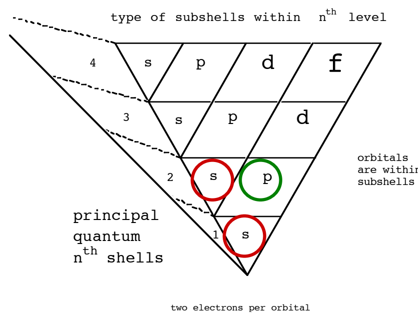
Electron configuration
1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p....

Where are the six electrons for carbon located???????

$_6C$ $1s^2 2s^2 2p^2$

Maximum number in
s sublevel is 2 electron
p sublevel is 6 electrons
d sublevel is 10 electrons
f sublevel is 14 electrons

Quantum Wave Mechanical Model (Schrodinger)



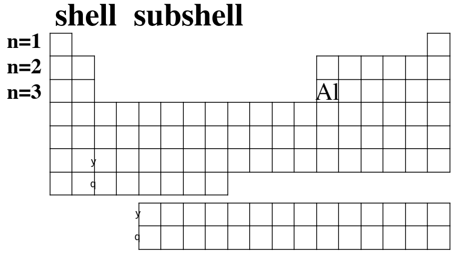
An electron directory is called "electron configuration"
It is begins starting from the lowest energy orbital, the 1s

Electron configuration
1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p....

Where is the last electron to fill for aluminum located??????

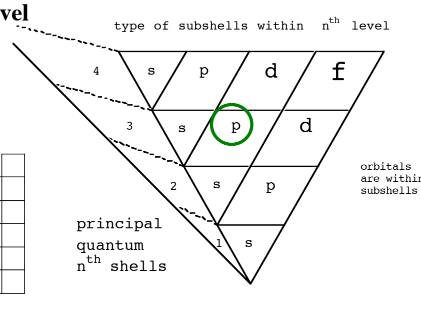
3p^1 ← **Total number of electrons in sublevel**

shell subshell



1s 2s 2p 3s 3p

n (row) number   subshell letter



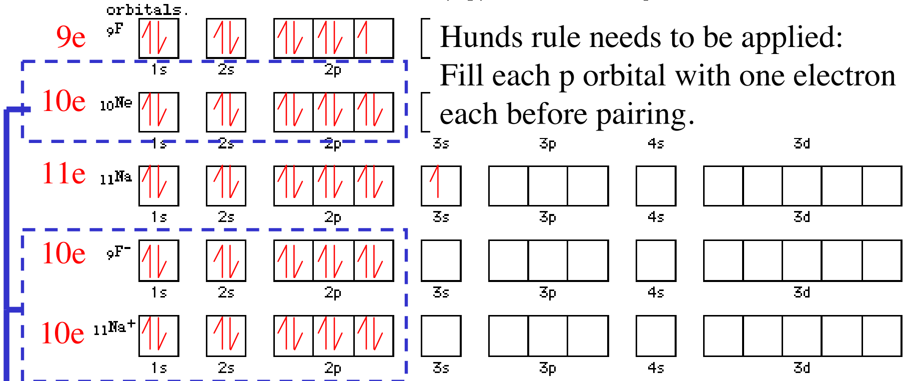
Electron configuration
1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p....

Supplemental packet page 53

Electron Orbital Filling

Wave Mechanical Atomic Orbital Structure

Construct orbital diagrams showing electron arrangements for atoms of F, Ne, Na, F^-, and Na^+ and O^{2-}. Each subshell s, p, d has been expanded to show individual orbitals.



Hunds rule needs to be applied: Fill each p orbital with one electron each before pairing.

F^- and Na^+ are **isoelectronic** (the same electronically) with Ne

All elements lose or gain electrons to achieve noble gas e- configuration

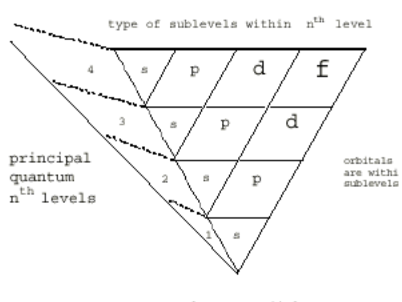
Supplemental packet pages 52 & 57

Complete:

1. The 1st level has __1__ sublevel named __s__.
   The 2nd level has __2__ sublevels named __s, p__
   The 3rd level has __3__ sublevels named __s,p,d__
   The 4th level has __4__ sublevels named __s,p,d,f__

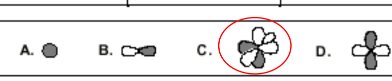
2. A s sublevel has __1__ orbitals and can hold a maximum of __2__ electrons.
   A p sublevel has __3__ orbitals and can hold a maximum of __6__ electrons.
   A d sublevel has __5__ orbitals and can hold a maximum of __10__ electrons.
   A f sublevel has __7__ orbitals and can hold a maximum of __14__ electrons.

3. The first level can hold a maximum of __2__ electrons.
   The second level can hold a maximum of __8__ electrons.
   The third level can hold a maximum of __18__ electrons.
   The fourth level can hold a maximum of __32__ electrons.

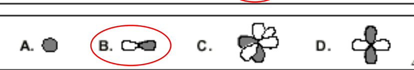


4. For the following pairs of orbitals, indicate which is lower in energy.	(3p) or 4p	(2s) or 3d	(4s) or 4d	(3s) or 4f
5. Give the number of orbitals in:	the principle level n = 3: 9(s,p,d)	a 4d sublevel: 5 orbitals	an f sublevel: 7 orbitals	
6. Give the maximum number of electrons in each:	the principle level n = 3: 18	a 4d sublevel: 10	an f sublevel: 14	

7. A p sublevel has the following shape:



8. A p orbital has the following shape:

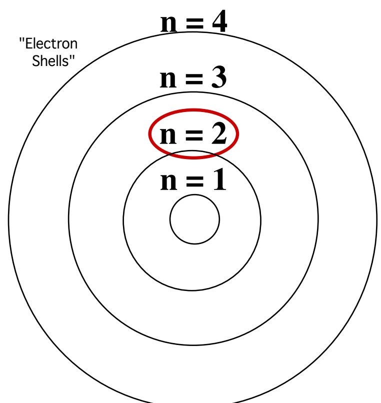


Where would a $2s^1$ electron be located?
In subshell located within a shell.

$2s^1$ ← **Total number of electrons**

Second shell

The letter represents A "s" sublevel; Both the shell & "s" subshell are described mathematically by <u>Quantum Mechanics</u>



The shell (principal quantum level)
Is the most important locator for an electron

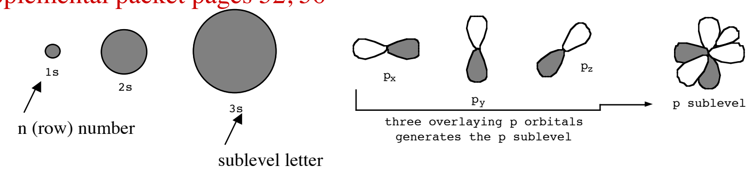
More on orbital shapes and volumes

- **The subshells are arranged from lowest to highest energy values**

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d……

n (row) number   sublevel letter

Supplemental packet pages 52, 56



Know the <u>shape</u> (volume) and spatial orientation (distance from the nucleus) for the subshells and for the orbitals

- **lower "n" values mean the electron is closer to the nucleus**
- **subshells increase in energy in the following order   s < p < d < f**
- **lower "n" values means smaller size and volume for the atom**