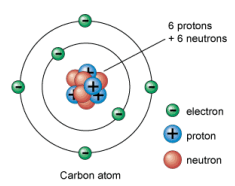


Unit 3 (Electron Cloud)
The Electron Cloud

Quantum Mechanics

1913 **Niels Bohr** Danish Physicist

Theorized that electrons circle the nucleus only in allowed fixed paths (**orbits**).



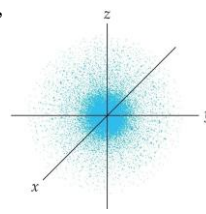
Each orbit had a **specific amount of energy**

Quantum Mechanics

1926 **Heisenberg** German Physicist
 Schrödinger Austrian Physicist

Electrons exist in **ORBITALS**, a 3-D space around the nucleus.

Electrons occupied a **general region** based on **energy**.



Learning Target 1
 Use Quantum Numbers to locate electrons within orbitals


Quantum Numbers (Orbitals)

Quantum Numbers

It's all about...

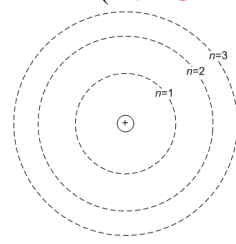
ENERGY and **ELECTRON REPULSION**

92% Accurate...



Principle Quantum Number (n)

Distance from the Nucleus.
 (**ENERGY LEVEL** or **SHELL**)




Bohr Model helps illustrate

n = 1 Close to the Nucleus
n = 2
n = 3
n = ...7 Far from the Nucleus





Orbital Quantum Number (ℓ)

Shape of the Orbital

(ENERGY SUBLEVEL or SUBSHELL)

Orbital	Shape	
(s)	“Sphere”	Low Energy  High Energy
(p)	“Peanut”	
(d)	“Double Peanut”	
(f)	“Flower”	

Orbital Shapes (ℓ)

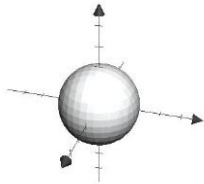
Shape	Spherical	Dumb bell	Double-dumb bell	Complex
Structure				
	S orbital	P Orbital	d Orbital	f-Orbital

LARGER orbitals can hold more electrons = More Energy

Magnetic Quantum Number (m_ℓ)

3-D LOCATION

(Referred to as **ORIENTATION**)



Orbital	Location
(s)	One orientation
(p)	Three orientations
(d)	Five orientations
(f)	Seven orientations

THE spdf ORBITALS

(An artistic rendition)

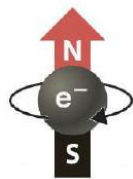
Joel M Williams ©2013
JW
TSC

TYPE	SET	INDIVIDUAL ORBITALS					COLLECTIVE
f	Cubic						
	General						
d	Common						
	“Tri-torus”						
p							
s							

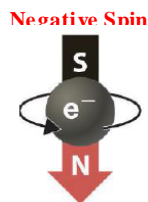
Spin Quantum Number (m_s)

Positive or Negative Spin

(Electrons spin to generate a magnetic field)



Positive Spin



Negative Spin

Quantum Mechanics Review

Principle Quantum (n) **Distance** from Nucleus
 $n = 1, 2, 3, \dots$

Orbital Quantum (ℓ) **Orbital Shape**

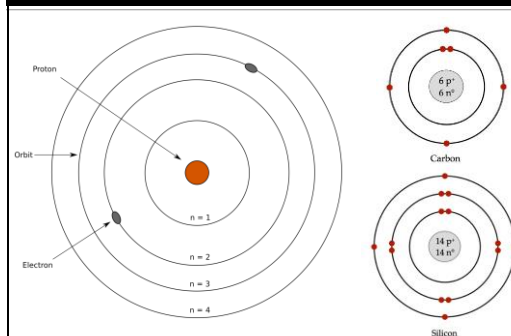
Magnetic Quantum (m_ℓ) **3-D Location**

Spin Quantum (m_s) **\uparrow or \downarrow Spin**

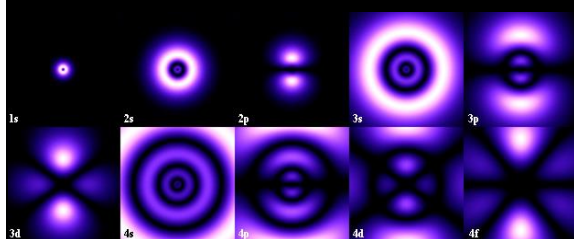
Learning Target 1
Use Quantum Numbers to locate electrons within orbitals

Orbital Notation

Basic Model of the Atom



Quantum Model of the Atom



Scanning Microscope

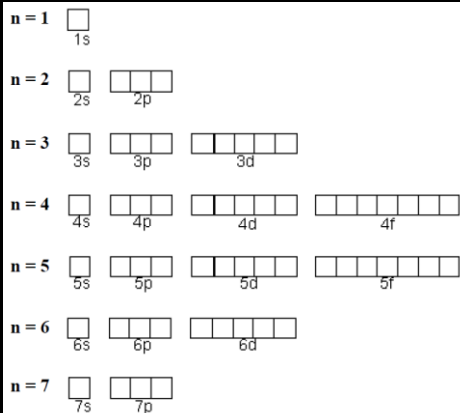
Quantum Mechanics Review

Principle Quantum (n) **Distance** from Nucleus
 $n = 1, 2, 3, \dots, 7$

Orbital Quantum (ℓ) **Orbital Shape**

Magnetic Quantum (m_ℓ) **3-D Location**

Spin Quantum (m_s) **\uparrow or \downarrow Spin**



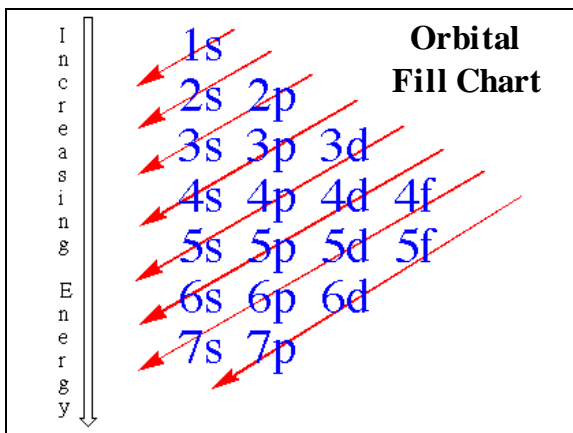
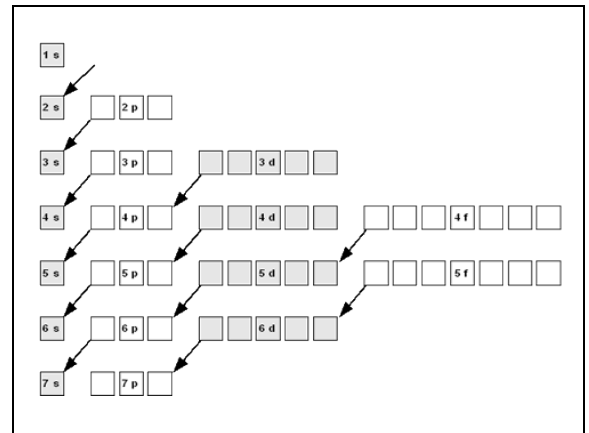
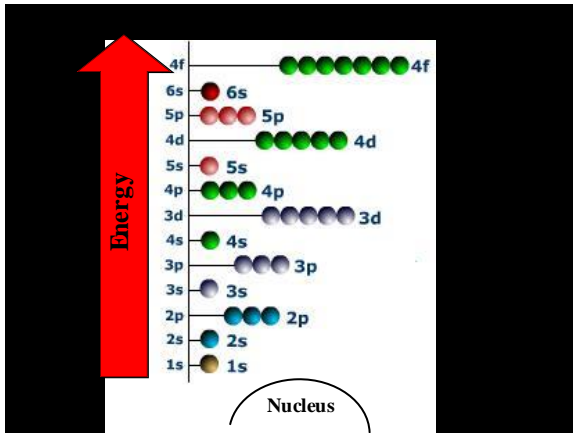
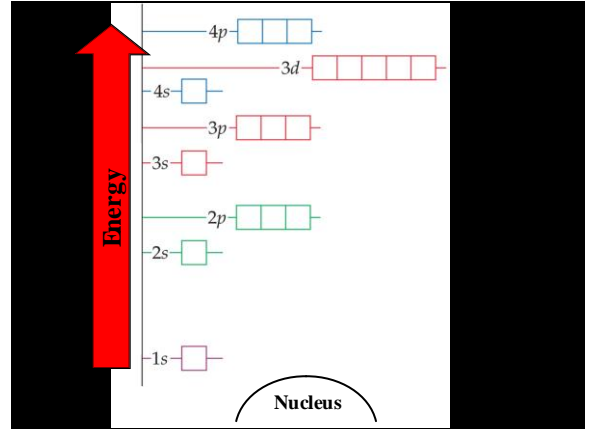
How Many Electrons?

Each orientation can hold
TWO ELECTRONS

Orbital	Orientation	2 Electrons	Max Total
(s)	1 orientation	(1) ($2e^-$)	= 2 electrons
(p)	3 orientations	(3) ($2e^-$)	= 6 electrons
(d)	5 orientations	(5) ($2e^-$)	= 10 electrons
(f)	7 orientations	(7) ($2e^-$)	= 14 electrons

Quantum Numbers

Principle (n)	Orbital (l)	Magnetic (m)	Orbital Electrons	Total Electrons
n = 1	s	2	2	2
n = 2	s	2	2	8
	p	2 2 2	6	
n = 3	s	2	2	18
	p	2 2 2	6	
	d	2 2 2 2 2	10	
n = 4	s	2	2	32
	p	2 2 2	6	
	d	2 2 2 2 2	10	
	f	2 2 2 2 2 2 2	14	



Configuration Rules

Aufbau Principle
Electrons must fill up **LOWEST** energy first.

Hund's Rule
Each orientation must have **one electron** before electrons can be **paired up**.

Pauli Exclusion Principle
Paired electrons must have **opposite spins**.

Magnesium Orbital Notation

12	Increasing Energy ↓	1s
Mg		2s 2p
		3s 3p 3d
Magnesium 24.31		4s 4p 4d 4f
	5s 5p 5d 5f	
	6s 6p 6d	
	7s 7p	

Phosphorous Orbital Notation

15	Increasing Energy ↓	1s
P		2s 2p
		3s 3p 3d
Phosphorous 30.97		4s 4p 4d 4f
		5s 5p 5d 5f
		6s 6p 6d
		7s 7p

Orbital Notation HOMEWORK

1. Beryllium **Be**

2. Carbon **C**

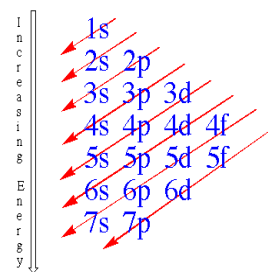
3. Argon **Ar**

Orbital Notation HOMEWORK

Aufbau Principle
LOWEST energy first.

Hund's Rule
**One electron before
paired up.**

**Pauli Exclusion
Principle**
**Paired electrons have
opposite spins.**



Learning Target 2
Use configuration notation to illustrate the electron cloud

Configuration Notation

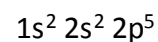
Representing Electron Configuration

Electron Configuration Notation [ECN]

a. eliminates ____ and ↑↓

b. Number of electrons in sublevels shown
by superscripts on orbital quantum number

Ex: Fluorine (F) $\frac{\uparrow\downarrow}{1s} \frac{\uparrow\downarrow}{2s^2} \frac{\uparrow\downarrow}{2p^5}$



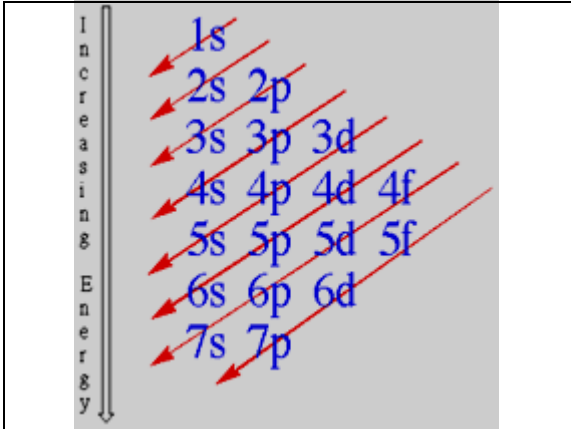
Learning Target 2 Use Electron Configurations to illustrate the electron cloud.

How to use the Periodic Table to write Electron Configurations

Electron Configuration Notation

Write the Configuration Notations:

1. Carbon (C)
2. Magnesium (Mg)
3. Chlorine (Cl)
4. Potassium (K)
5. Bromine (Br)



O = 8e⁻ 1s² 2s² 2p⁴

Al = 13e⁻ 1s² 2s² 2p⁶ 3s² 3p¹

Fe = 26e⁻ 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d⁶

As = 33e⁻ 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d¹⁰ 4p³

Ba = 56e⁻ 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d¹⁰ 4p⁶
5s² 4d¹⁰ 5p⁶ 6s²

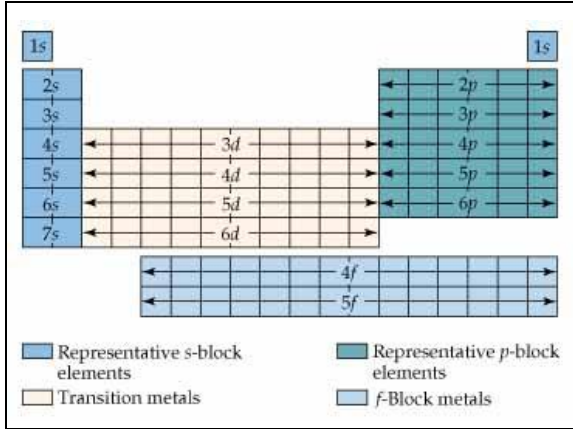
I = 53e⁻ 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d¹⁰ 4p⁶
5s² 4d¹⁰ 5p⁵

Electron Configurations in the Periodic Table

TABLE 6.3 • Electron Configurations of Several Lighter Elements

Element	Total Electrons	Orbital Diagram				Electron Configuration	
		1s	2s	2p	3s		
Li	3	↑↓	↑	□	□	1s ² 2s ¹	
Be	4	↑↓	↑↓	□	□	1s ² 2s ²	
B	5	↑↓	↑↓	↑	□	1s ² 2s ² 2p ¹	
C	6	↑↓	↑↓	↑	↑	1s ² 2s ² 2p ²	
N	7	↑↓	↑↓	↑	↑	↑	1s ² 2s ² 2p ³
Ne	10	↑↓	↑↓	↑↓	↑↓	↑↓	1s ² 2s ² 2p ⁶
Na	11	↑↓	↑↓	↑↓	↑↓	↑	1s ² 2s ² 2p ⁶ 3s ¹

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Monday Nov 4 Bell Ringer

Write the CONFIGURATION NOTATION for each of element using only the PERIODIC TABLE

1. Magnesium Mg
2. Sulfur S
3. Titanium Ti
4. Selenium Se
5. Gold Au

ELECTRON(IC) BATTLESHIP

Attacking: **CONFIGURATION NOTATION**

Mr. Hemmingsen calls "**3p⁴**"

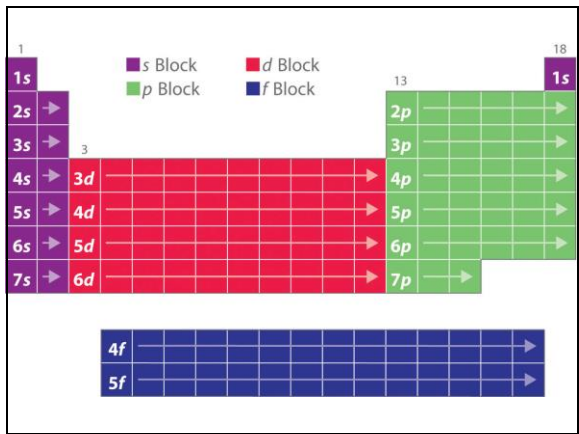
Responding: **ELEMENT NAME**

Johnny responds "**Sulfur**" with **HIT** or **MISS**.

ELECTRON(IC) BATTLESHIP

Key		Average Atomic Mass																	
Atomic Number	Element Symbol	Element Name																	
1	H	2	He	3	Li	4	Be	5	B	6	C	7	N	8	O	9	F	10	Ne
11	Na	12	Mg	13	Al	14	Si	15	P	16	S	17	Cl	18	Ar	19	K	20	Ca
21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn
31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr	37	Rb	38	Sr	39	Y	40	Zr
41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn
51	Sb	52	Te	53	I	54	Xe	55	Cs	56	Ba	57	La	58	Ce	59	Pr	60	Nd
61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb
71	Lu	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg
81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn	87	Fr	88	Ra	89	Ac	90	Th
91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm
101	Md	102	No	103	Lr	104	Rf	105	Db	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds
111	Cn	112	Nh	113	Fl	114	Mc	115	Lv	116	Ts	117	Og	118	Xg	119	Uu	120	Uub
121	Uut	122	Uuq	123	Uup	124	Uuq	125	Uup	126	Uuq	127	Uup	128	Uuq	129	Uup	130	Uuq
131	Uuq	132	Uup	133	Uuq	134	Uup	135	Uuq	136	Uup	137	Uuq	138	Uup	139	Uuq	140	Uup
141	Uuq	142	Uup	143	Uuq	144	Uup	145	Uuq	146	Uup	147	Uuq	148	Uup	149	Uuq	150	Uup
151	Uuq	152	Uup	153	Uuq	154	Uup	155	Uuq	156	Uup	157	Uuq	158	Uup	159	Uuq	160	Uup
161	Uuq	162	Uup	163	Uuq	164	Uup	165	Uuq	166	Uup	167	Uuq	168	Uup	169	Uuq	170	Uup
171	Uuq	172	Uup	173	Uuq	174	Uup	175	Uuq	176	Uup	177	Uuq	178	Uup	179	Uuq	180	Uup

Modified Fall 2014 Raymond Prentiss School District



Gen Chem Bell Ringer

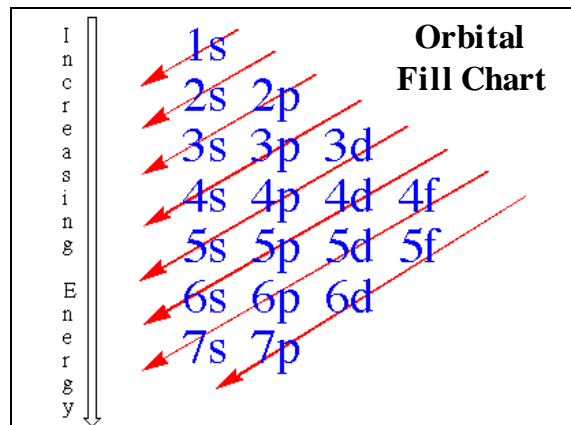
Prepare Yourself! QUIZ

Quantum Numbers (**n, l, m_l, m_s**)

Orbital Notation (**arrows**)

Configuration Notation (**superscripts**)

Orbital Fill Rules (**Aufbau, Hund, Pauli**)



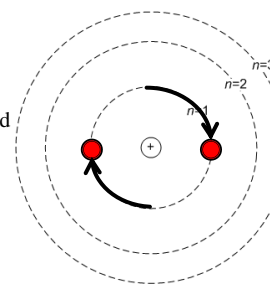
Learning Target 3
Relate wavelength and frequency to the energy in an electron

Light Duality

Electrons Review

Niels Bohr

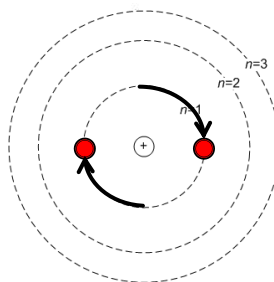
Theorized that the electrons moved around the nucleus just like how the planets orbit around the sun.



Electrons Review

Electrons have energy to orbit the nucleus.

**The more energy,
the higher the orbit.**



Learning Target 3
Relate wavelength and frequency to the energy in an electron

Light as a Wave

Light as a WAVE

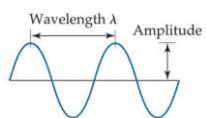
ELECTROMAGNETIC WAVES

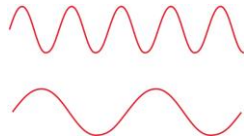
Energy that shows "wave-like" behavior traveling through space.

Wavelength (λ)

Frequency (ν)

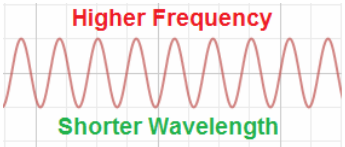
Energy (**E**)





Light as a WAVE

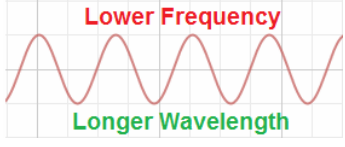
Higher Frequency



Shorter Wavelength

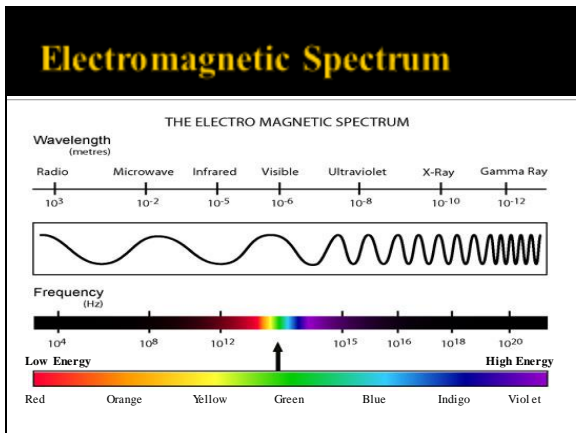
= **Higher Energy**

Lower Frequency

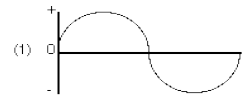


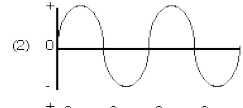
Longer Wavelength

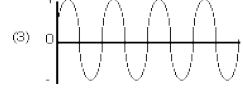
= **Lower Energy**



Light as a Wave Quiz

(1) 

(2) 

(3) 


Which wave has the most amount of energy?

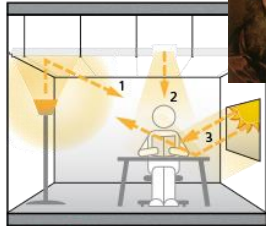
Write the relationship between...
WAVELENGTH
FREQUENCY and
ENERGY

Learning Target 3
Relate wavelength and frequency to the energy in an electron


Light as a PARTICLE

Light as a Particle






No light diffusion



Good light diffusion



1. Indirect lighting
2. Direct lighting
3. Combination of direct and indirect lighting

Light as a PARTICLE

Max Planck **Quantum Theory**

Light also acts like a **PARTICLE**.

Objects gain or lose energy in small specific amounts.

Max Planck QUANTUM Gained or Lost Energy by an atom.	Albert Einstein PHOTON LIGHT energy given off.
---	---

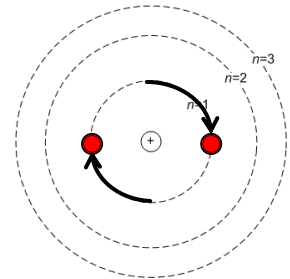
Light as a PARTICLE

Electrons have ENERGY, while in orbit...

GROUND STATE:

Lowest energy level.

Closest to the nucleus.



Light as a PARTICLE

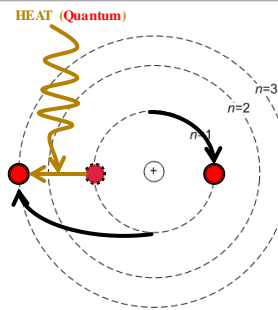
Electrons gain ENERGY, from adding HEAT.

EXCITED STATE:

Higher energy level.

Electrons jump levels.

GAIN Energy.



Light as a PARTICLE

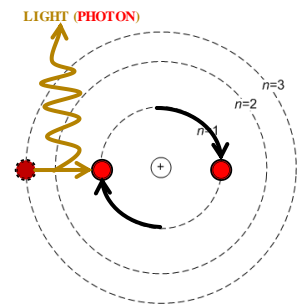
Electron returns to Ground State.

GROUND STATE:

Energy is RELEASED.

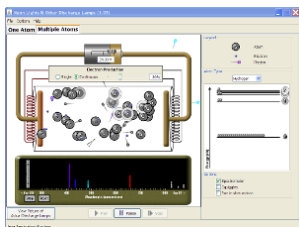
Electrons back down.

Energy = Light!



pHet Simulation (Neon Lamp)

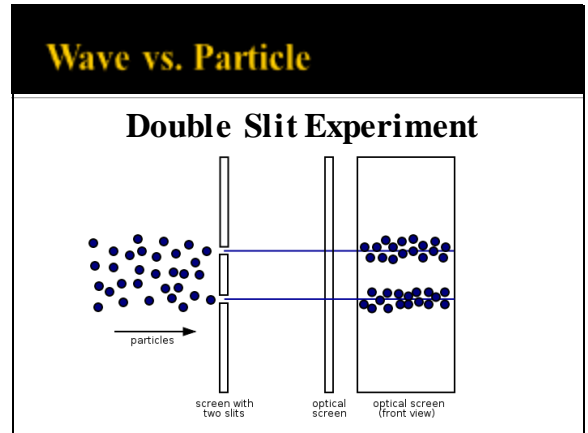
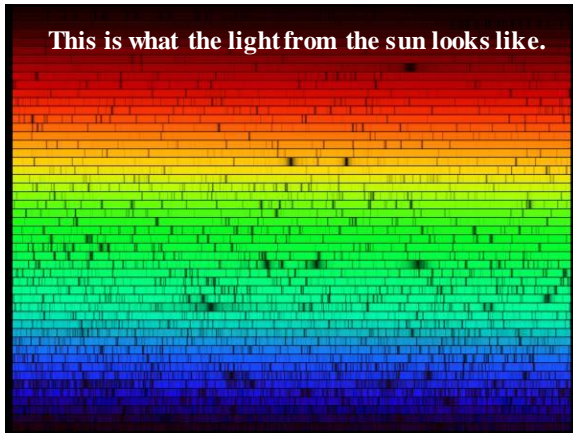
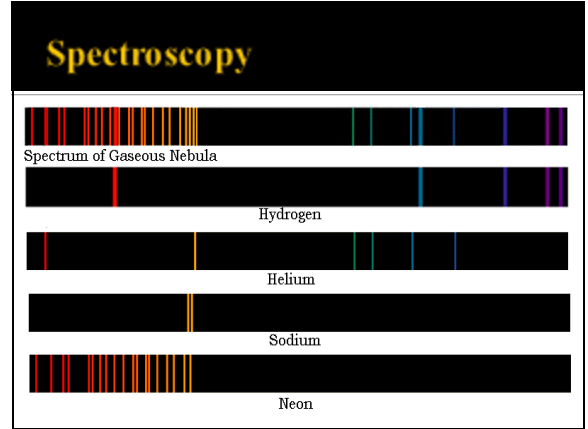
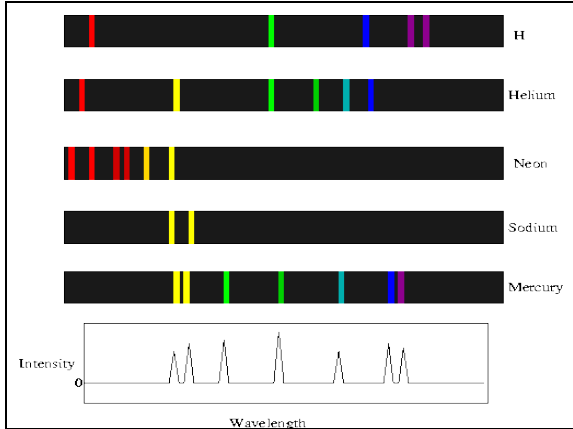
<http://phet.colorado.edu/en/simulation/discharge-lamps>



Spectroscopy

Energy is absorbed by electrons...
they become excited...
and then go back to their ground state...

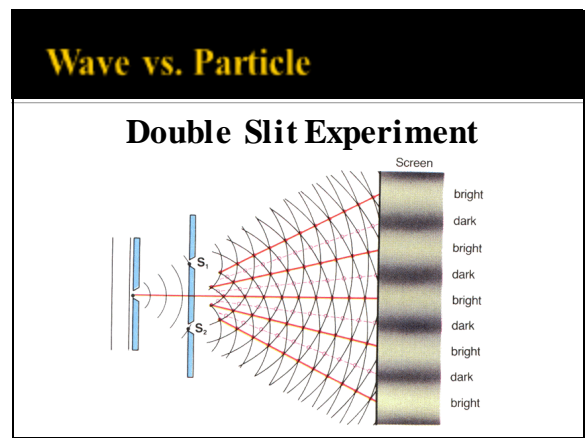
1. Releasing wavelengths that are characteristic for that substance.
2. As distinct as fingerprints.



Light Duality

Veritasium
an element of truth

[Veritasium – Light \(Double Slit Experiment\)](http://www.youtube.com/watch?v=luv6hY6zsd0)
<http://www.youtube.com/watch?v=luv6hY6zsd0>



Light Duality

LIGHT IS A
WAVE!

Gen Chem November 10

PREPARE YOURSELF!

One Day Exam
(MCQ + FRQ)

