



Unit 2

The Periodic Table & Quantum Theory

Mendeleev's Periodic Table – THE FIRST



Arranged the elements in his periodic table in order of increasing atomic mass



Also arranged using properties of the elements



The periodic table can be used to predict the properties of undiscovered elements.



1869

An Early Version of Mendeleev's Periodic Table

но въ ней, мнѣ кажется, уже ясно выражается примѣнимость въ ставляемаго мною начала ко всей совокупности элементовъ, пай которыхъ извѣстенъ съ достовѣрностію. На этотъ разъ я и желалъ преимущественно найти общую систему элементовъ. Вотъ этотъ опытъ:

			Ti=50	Zr=90	?=180.
			V=51	Nb=94	Ta=182.
			Cr=52	Mo=96	W=186.
			Mn=55	Rh=104,4	Pt=197,4
			Fe=56	Ru=104,4	Ir=198.
		Ni=Co=59	Pt=106,4	Os=199.	
II=1		Cu=63,4	Ag=108	Hg=200.	
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?=68	Ur=116	Lu=197?
	C=12	Si=28	?=70	Su=118	
	N=14	P=31	As=75	Sb=122	Bi=210
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

A Song

Another Song

Periodic Law

When elements are arranged in order of increasing atomic number, a repeating pattern of properties can be seen.



www.LiveScience.com

Periodic Table of the Elements

Legend:

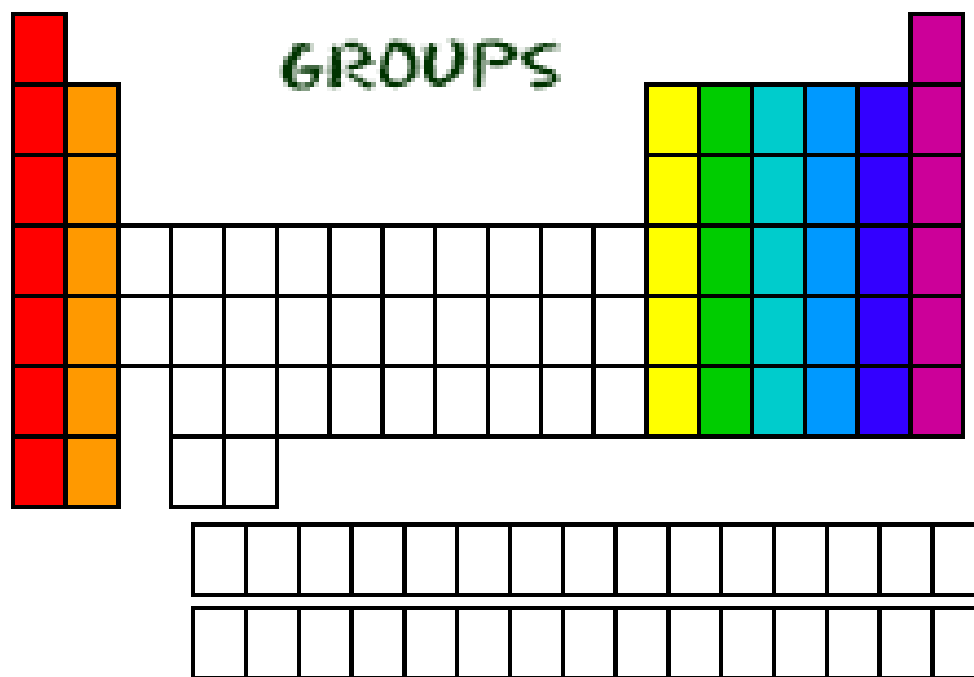
- Alkali metals (Yellow)
- Alkaline earth metals (Light Blue)
- Lanthanides (Dark Blue)
- Actinides (Red)
- Transition metals (Green)
- Unknown properties (White)
- Post-transition metals (Light Grey)
- Metalloids (Pink)
- Other nonmetals (Light Blue)
- Halogens (Cyan)
- Noble gases (Orange)

Element Data Legend:

- 11: Atomic number
- Na: Element symbol
- Sodium: Element name
- 22.990: Atomic weight

Group	1	2	3-10										11	12	13	14	15	16	17	18							
Period	1A	2A	3B	4B	5B	6B	7B	8	8B	10	11B	12B	3A	4A	5A	6A	7A	8A									
1	1 H Hydrogen 1.0078																		2 He Helium 4.0026								
2	3 Li Lithium 6.938	4 Be Beryllium 9.0122												5 B Boron 10.806	6 C Carbon 12.009	7 N Nitrogen 14.006	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180								
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.084	15 P Phosphorus 30.974	16 S Sulfur 32.059	17 Cl Chlorine 35.446	18 Ar Argon 39.948									
4	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798									
5	37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.96	43 Tc Technetium 98.9062	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29									
6	55 Cs Cesium 132.91	56 Ba Barium 137.33											81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)									
7	87 Fr Francium (223)	88 Ra Radium (226)											113 Uut Ununtrium (268)	114 Fl Flerovium (268)	115 Uup Ununpentium (268)	116 Lv Livermorium (268)	117 Uus Ununseptium (268)	118 Uuo Ununoctium (268)									
			Lanthanides										Actinides														
			57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97										
			89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)										

- Elements with similar properties are grouped in a columns (up and down)
- Called groups or FAMILIES



- The Group 1A elements are called **alkali metals**.

Alkali Metal Reactions

- The Group 2A elements are called **alkaline earth metals**.

Alkaline Earth Metal Reactions

The nonmetals of Group 7A are called **halogens**.

[Halogen Video](#)

Group 8A – noble gases

[Noble Gases](#)

Organizing the Elements >

1 H [1.00784; 1.00811] HYDROGEN																	2 He 4.0026 HELIUM								
3 Li [6.938; 6.997] LITHIUM	4 Be 9.0122 BERYLLIUM	METALS										METALLOIDS				NONMETALS				5 B [10.806; 10.821] BORON	6 C [12.0096; 12.0116] CARBON	7 N [14.00643; 14.00728] NITROGEN	8 O [15.99903; 15.99977] OXYGEN	9 F 18.998 FLUORINE	10 Ne 20.180 NEON
11 Na 22.990 SODIUM	12 Mg 24.305 MAGNESIUM																	13 Al 26.982 ALUMINUM	14 Si [28.084; 28.086] SILICON	15 P 30.974 PHOSPHORUS	16 S [32.059; 32.076] SULFUR	17 Cl [35.446; 35.457] CHLORINE	18 Ar 39.948 ARGON		
19 K 39.098 POTASSIUM	20 Ca 40.078 CALCIUM	21 Sc 44.956 SCANDIUM	22 Ti 47.867 TITANIUM	23 V 50.942 VANADIUM	24 Cr 51.996 CHROMIUM	25 Mn 54.938 MANGANESE	26 Fe 55.845 IRON	27 Co 58.933 COBALT	28 Ni 58.693 NICKEL	29 Cu 63.546 COPPER	30 Zn 65.392 ZINC	31 Ga 69.723 GALLIUM	32 Ge 69.723 GERMANIUM	33 As 74.922 ARSENIC	34 Se 78.963 SELENIUM	35 Br 79.904 BROMINE	36 Kr 83.801 KRYPTON								
37 Rb 85.468 RUBIDIUM	38 Sr 87.62 STRONTIUM	39 Y 88.906 YTTRIUM	40 Zr 91.224 ZIRCONIUM	41 Nb 92.906 NIObIUM	42 Mo 95.94 MOLYBDENUM	43 Tc 97.907 TECHNETIUM	44 Ru 101.07 RUTHENIUM	45 Rh 102.906 RHODIUM	46 Pd 106.42 PALLADIUM	47 Ag 107.868 SILVER	48 Cd 112.411 CADMIUM	49 In 114.818 INDIUM	50 Sn 114.818 TIN	51 Sb 121.760 ANTIMONY	52 Te 127.603 TELLURIUM	53 I 126.904 IODINE	54 Xe 131.292 XENON								
55 Cs 132.905 CESIUM	56 Ba 137.327 BARIUM	57-71 La-Lu LANTHANIDES	72 Hf 178.49 HAFNIUM	73 Ta 180.95 TANTALUM	74 W 183.84 TUNGSTEN	75 Re 186.207 RHENIUM	76 Os 190.233 OSMIUM	77 Ir 192.217 IRIDIUM	78 Pt 195.084 PLATINUM	79 Au 196.967 GOLD	80 Hg 200.59 MERCURY	81 Tl [204.382; 204.385] THALLIUM	82 Pb 204.383 LEAD	83 Bi 208.980 BISMUTH	84 Po 208.982 POLONIUM	85 At 209.987 ASTATINE	86 Rn 222.018 RADON								
87 Fr 223.020 FRANCIUM	88 Ra 226.0254 RADIUM	89-103 Ac-Lr ACTINIDES	104 Rf 263.113 RUTHERFORDIUM	105 Db 262.114 DUBNIUM	106 Sg 266.122 SEABORGIUM	107 Bh 264.125 BOHRIUM	108 Hs 269.134 HASSIUM	109 Mt 268.139 MEITNERIUM	110 Ds 272.146 DARMSTADIUM	111 Rg 272.154 ROENTGENIUM	112 Cn 277 COPERNICIUM	113 Uut 284 UNUNTRIUM	114 Uuq 284 UNUNQUADIUM	115 Uup 288 UNUNPENTIUM	116 Uuh 292 UNUNHEXIUM	117 Uus 294 UNUNSEPTIUM	118 Uuo 294 UNUNOCTIUM								
			57 La 138.905 LANTHANUM	58 Ce 140.116 CERIUM	59 Pr 140.908 PRASEODYMIUM	60 Nd 144.242 NEODYMIUM	61 Pm 144.913 PROMETHIUM	62 Sm 150.362 SAMARIUM	63 Eu 151.964 EUROPIUM	64 Gd 157.253 GADOLINIUM	65 Tb 158.925 TERBIUM	66 Dy 162.500 DYSPROSIUM	67 Ho 164.930 HOLMIUM	68 Er 167.259 ERBIUM	69 Tm 168.934 THULIUM	70 Yb 173.043 YTTERIUM	71 Lu 174.967 LUTETIUM								
			89 Ac 227.027 ACTINIUM	90 Th 232.038 THORIUM	91 Pa 231.036 PROTACTINIUM	92 U 238.029 URANIUM	93 Np 237.048 NEPTUNIUM	94 Pu 244.064 PLUTONIUM	95 Am 243.061 AMERICIUM	96 Cm 247.070 CURIUM	97 Bk 247.070 BERKELIUM	98 Cf 251.080 CALIFORNIUM	99 Es 252.083 EINSTEINIUM	100 Fm 257.095 FERMIUM	101 Md 258.098 MEDELEVIIUM	102 No 259.101 NOBELIUM	103 Lr 262.110 LAWRENCIUM								

Metals

- Most elements are metals
- High luster (shiny)
- Ductile (able to be pulled into a wire)
- Malleable (able to be bent)
- Good conductors of heat and electricity

Metalloids

A **metalloid** generally behaves kind of like a metal and kind of like a nonmetal.

Information about Metalloids

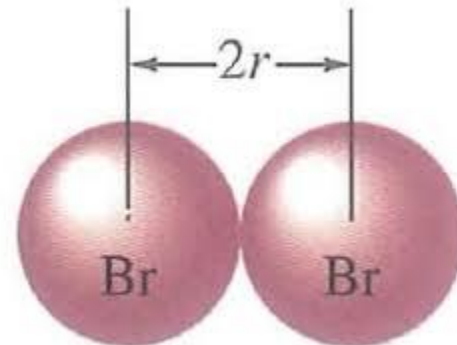
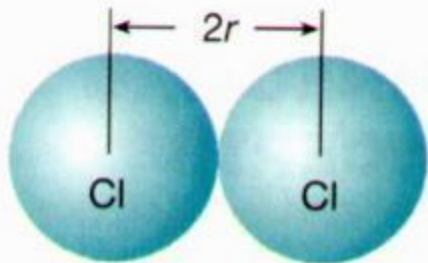
Nonmetals

- Most are gases at room temperature.
- Some are solids (sulfur and phosphorus & iodine)
- One nonmetal, bromine, is a dark-red liquid
- Poor conductors of heat and electricity

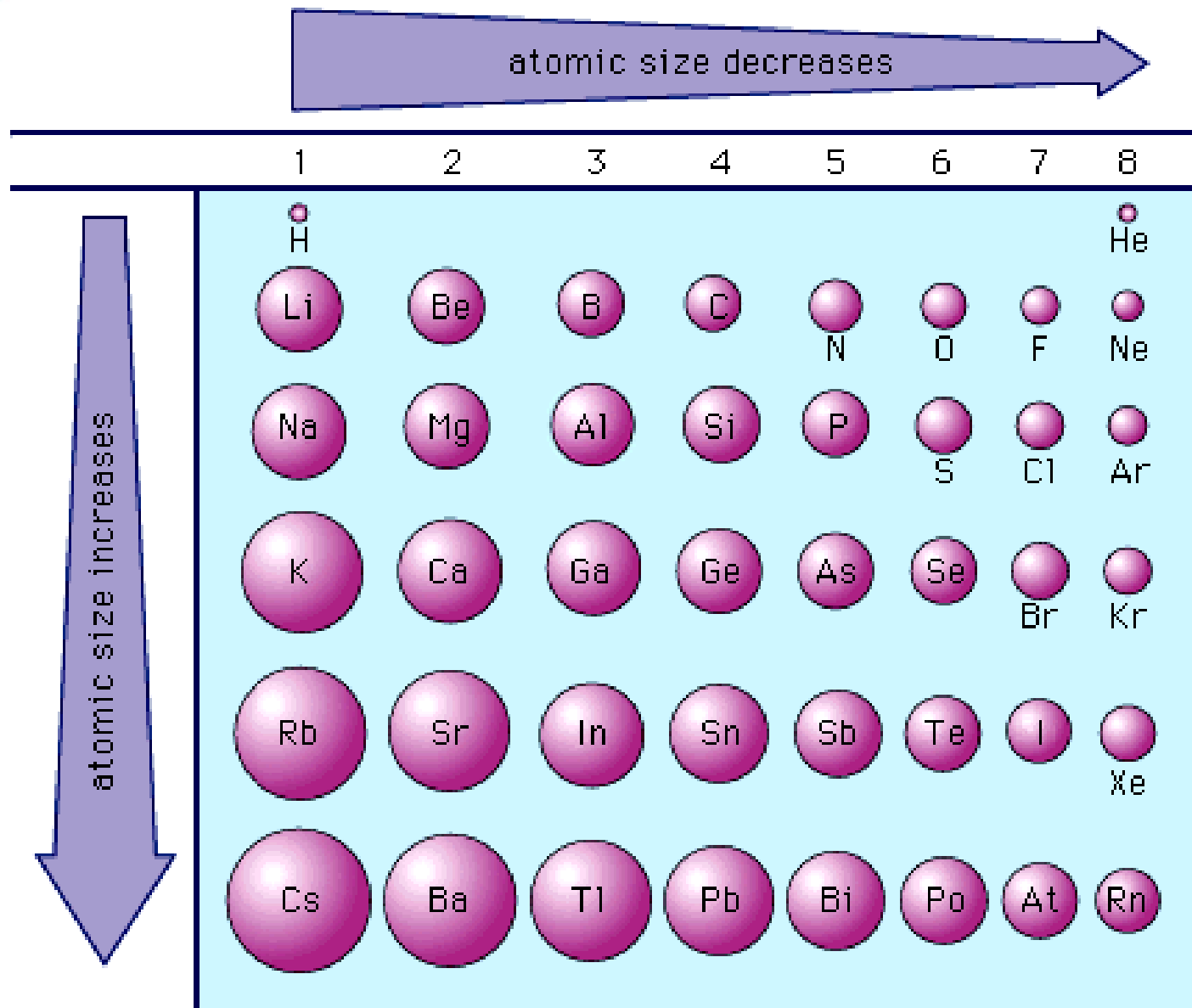
Periodic Trend – a repeating pattern in the periodic table when the atoms are arranged by atomic number.

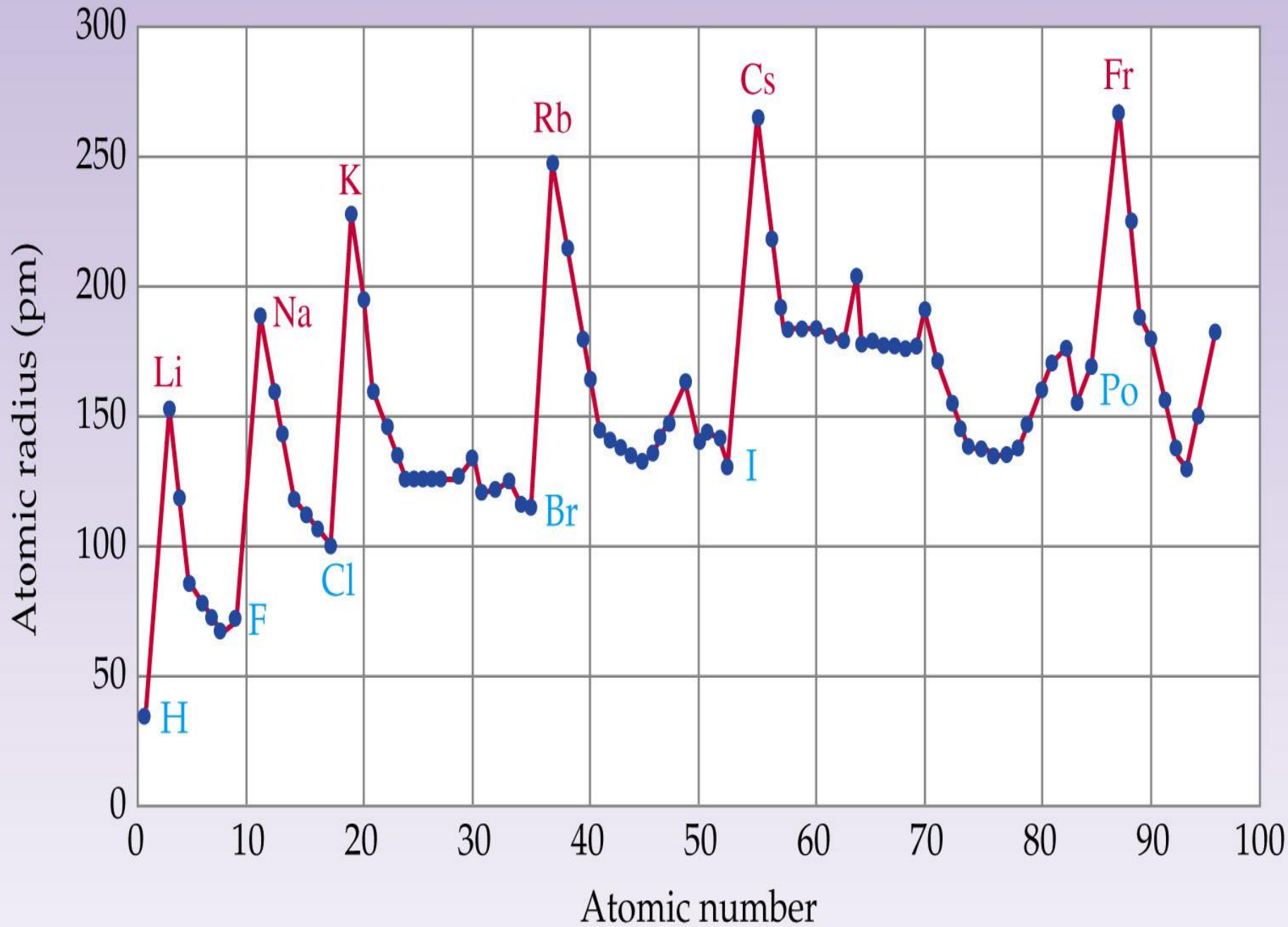
Atomic Radius

Distance from the nucleus to the edge of the electron cloud.



Organizing the Elements >

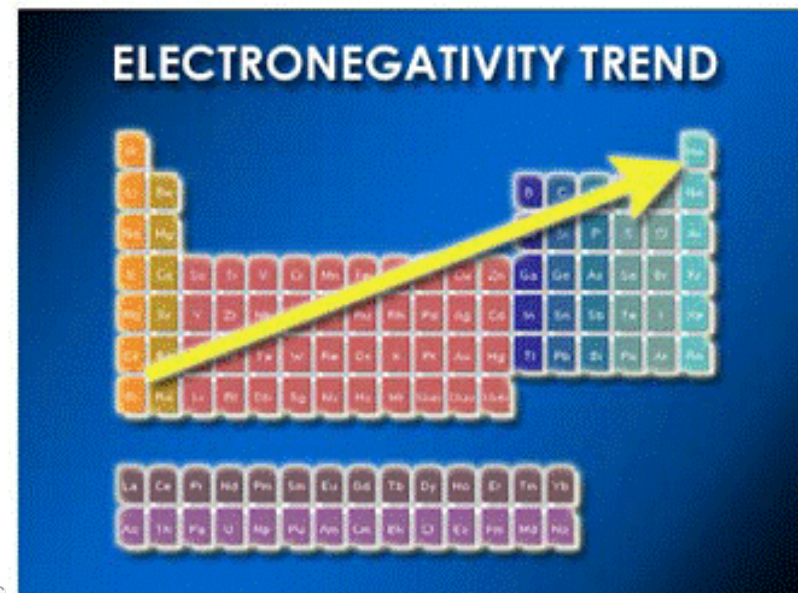




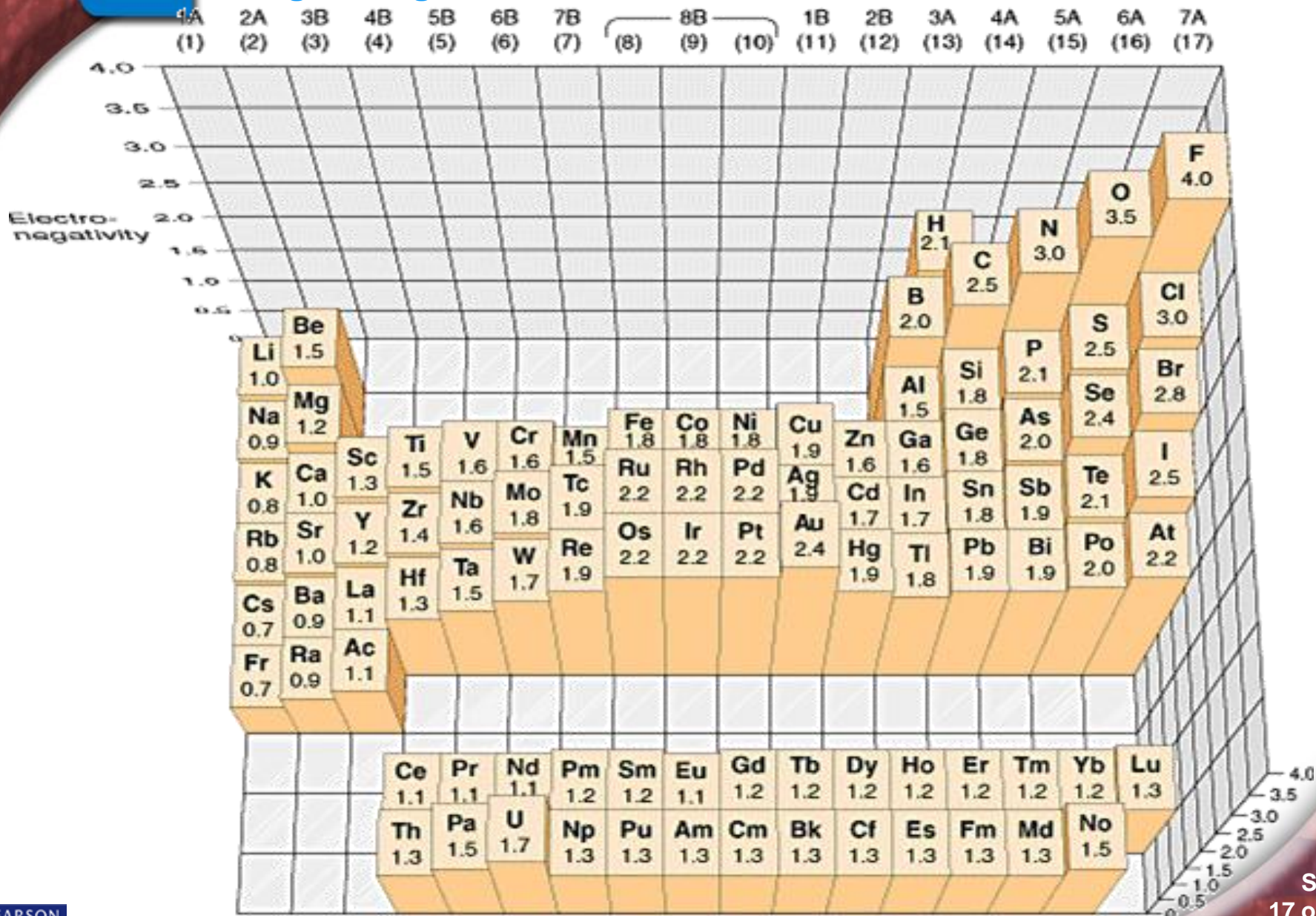
Periodic Trend - Electronegativity

Electronegativity is the power of an atom to attract an electron

Highest number is 4.0 - fluorine

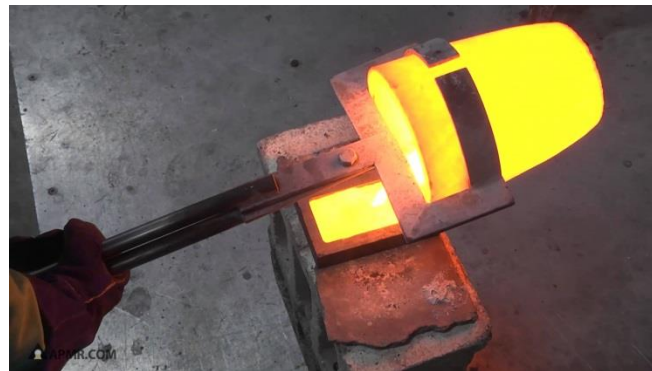


Organizing the Elements >

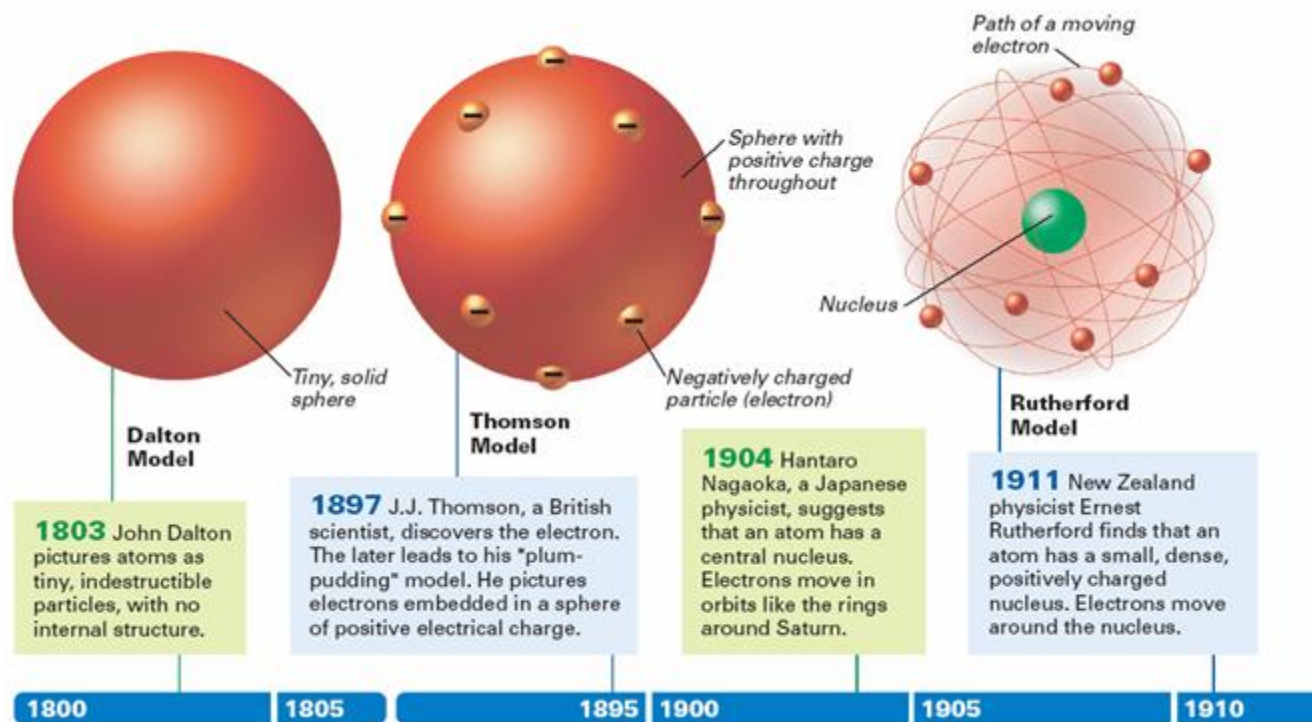


A NEW Question

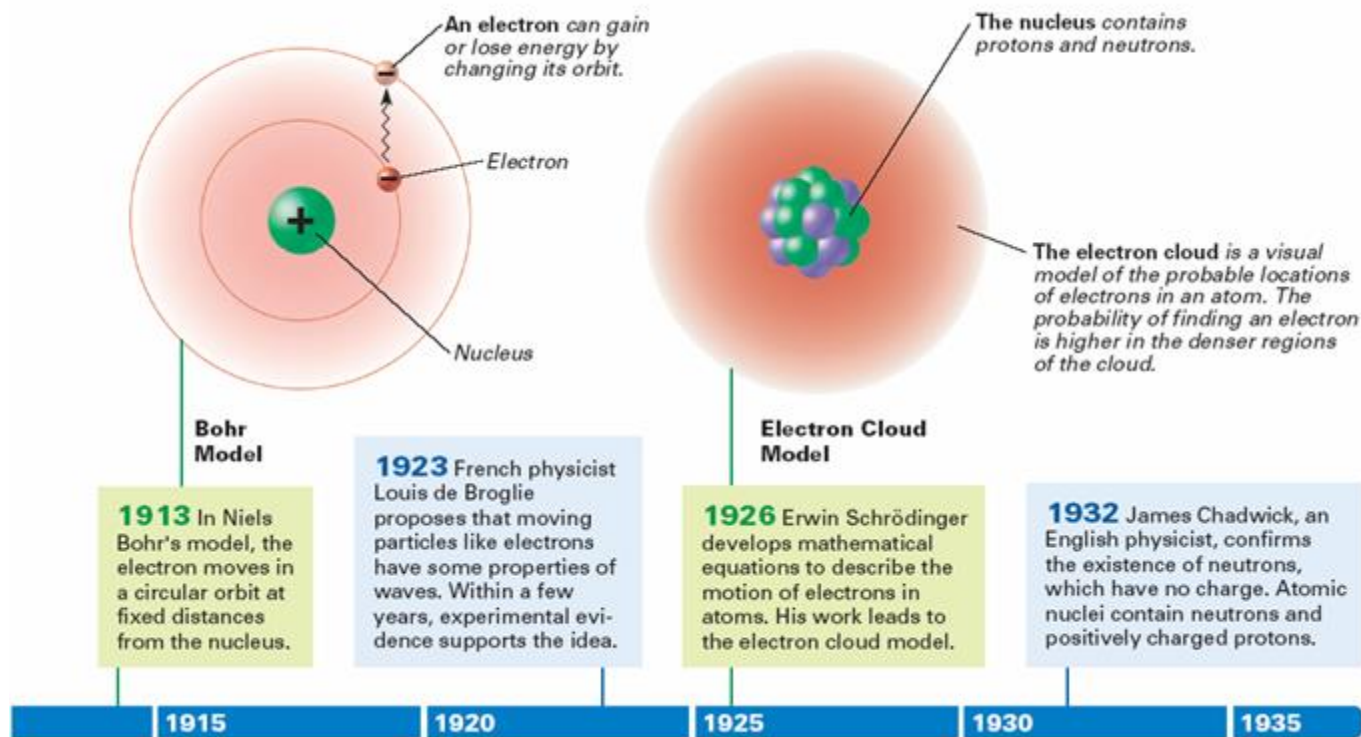
Rutherford's atomic model could not explain why objects change color when heated.



The timeline shows the development of atomic models from 1803 to 1911.



The timeline shows the development of atomic models from 1913 to 1932.



BOHR Findings

- **Electrons have fixed energy**
- **Fixed energies are called energy levels**
- **Quantum is the amount of energy required to move an electron from one energy level to another energy level.**

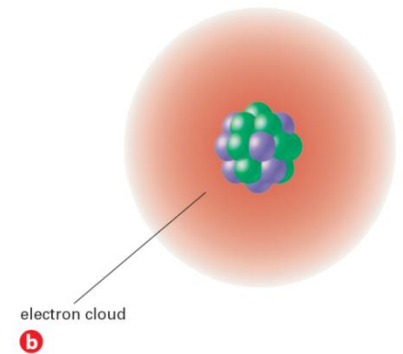
Energy Levels are Kind Of Like a Ladder Because...

- Energy levels are spaced out (not all equally)
- Ground State – close to the nucleus (low energy)
- Excited states – move away from lowest energy level – move up the ladder – higher energy

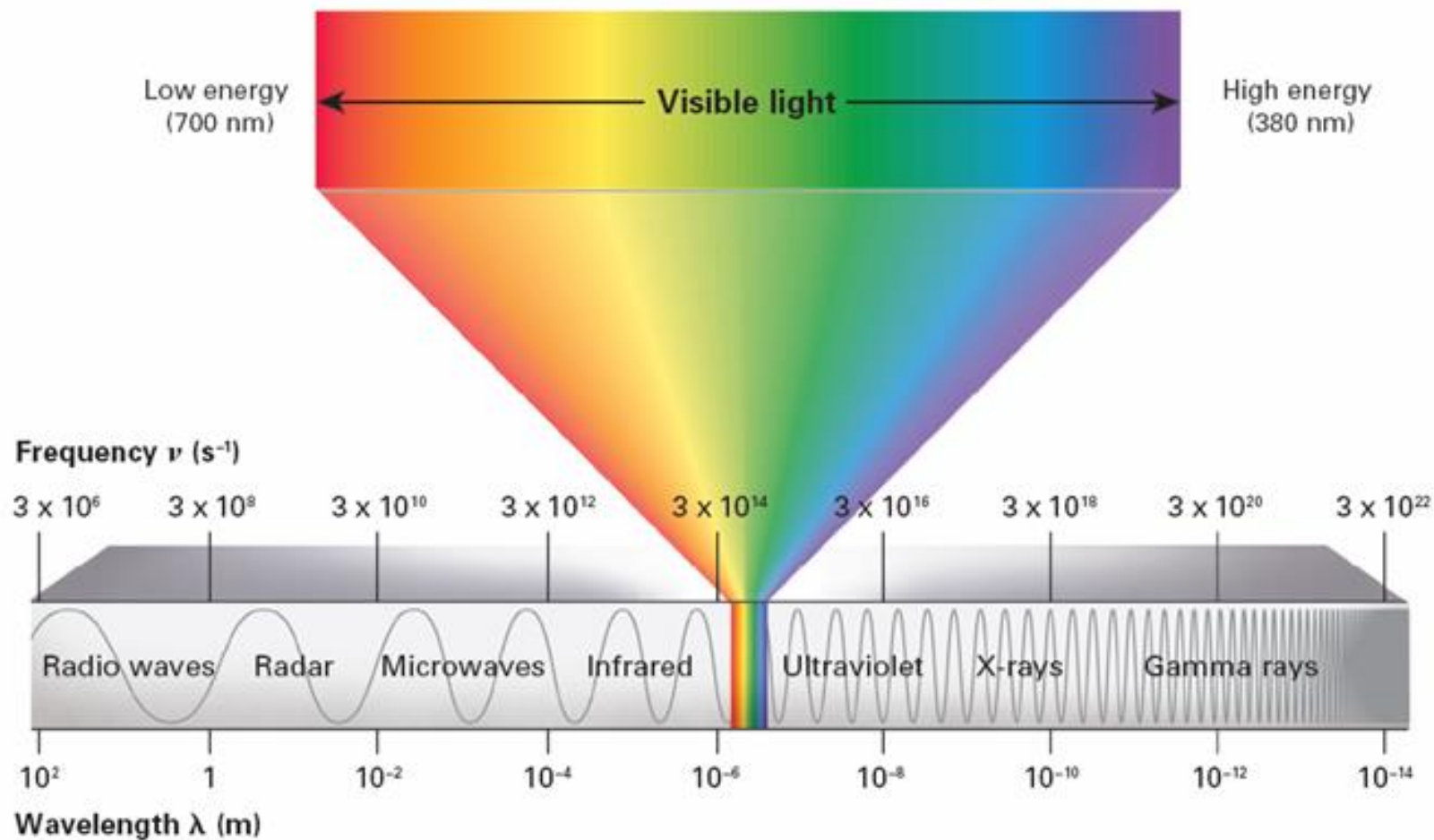


Erwin Schrödinger (1887–1961)

- Quantum mechanical model
- Mathematical proof
- Creates a “fuzzy” cloud of where electrons are likely to be found
- Give an address to location using quantum numbers.



The Electromagnetic Spectrum



ELECTROMAGNETIC SPECTRUM

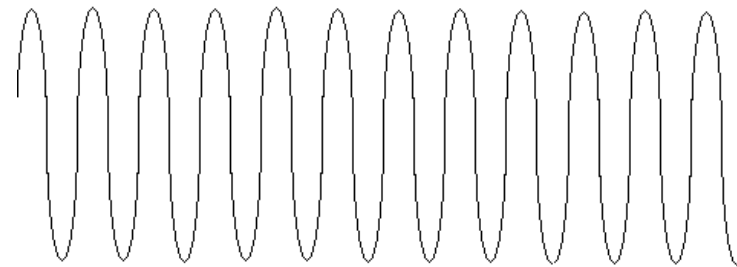
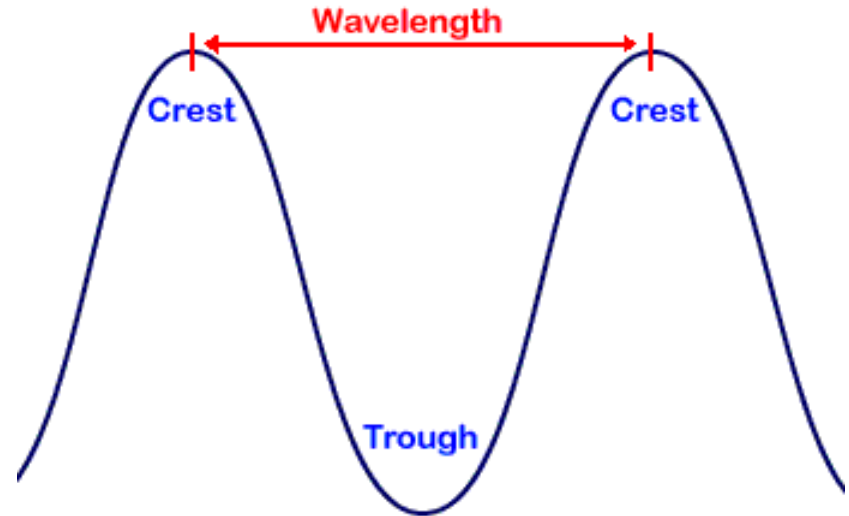
Important Words When Talking About Radiation

Wavelength

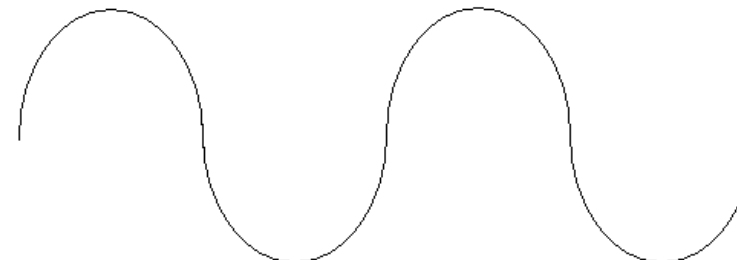
- is the distance between the crests
- Represented by greek letter λ
- Measures in meters, nanometers, centimeters

Frequency –

- is the number of wave cycles to pass a given point per unit of time (measured in Hertz or Hz)
- Represented by greek letter ν



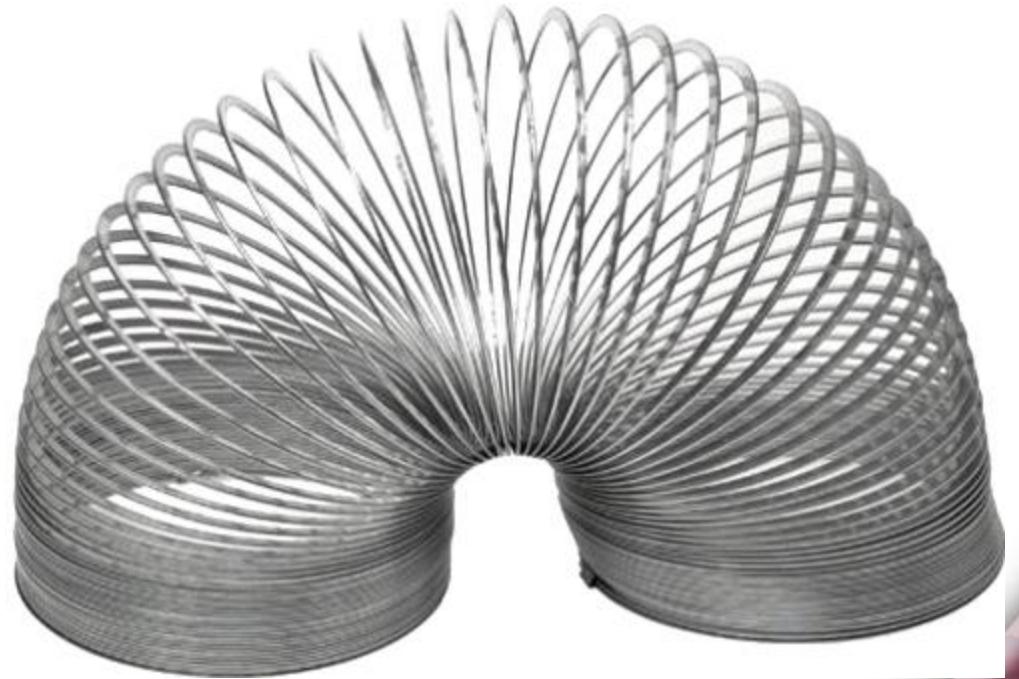
High frequency radio waves



Low frequency radio waves

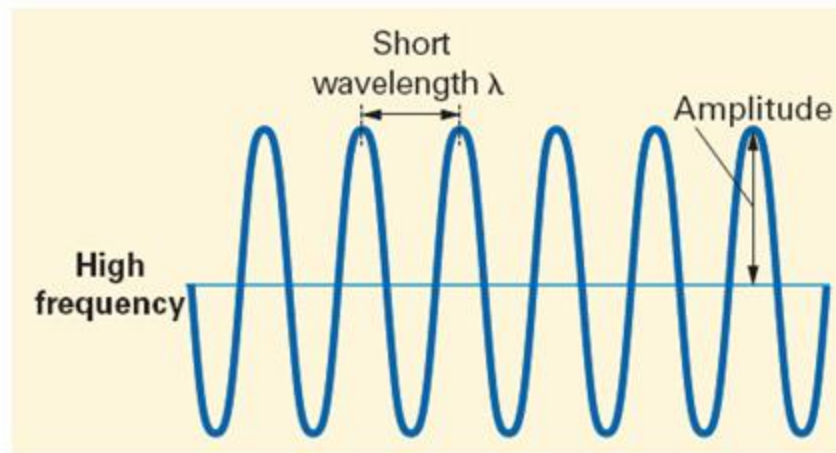
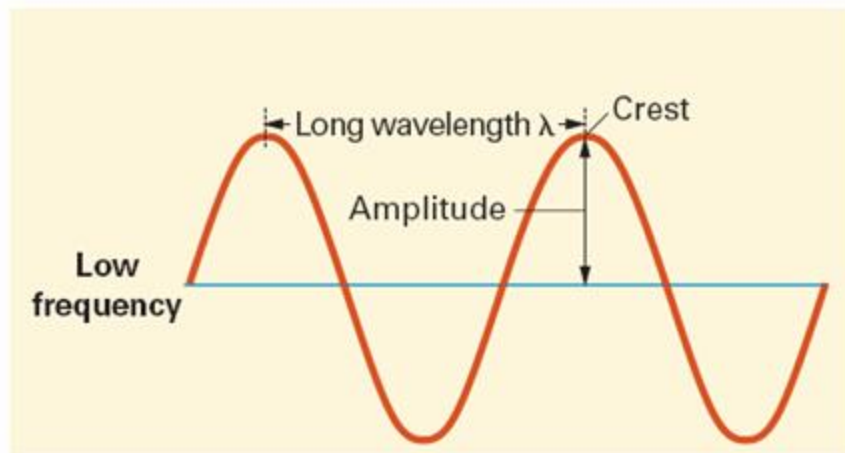
Slinky Demonstrations

What is the relationship between energy and wavelength and frequency?

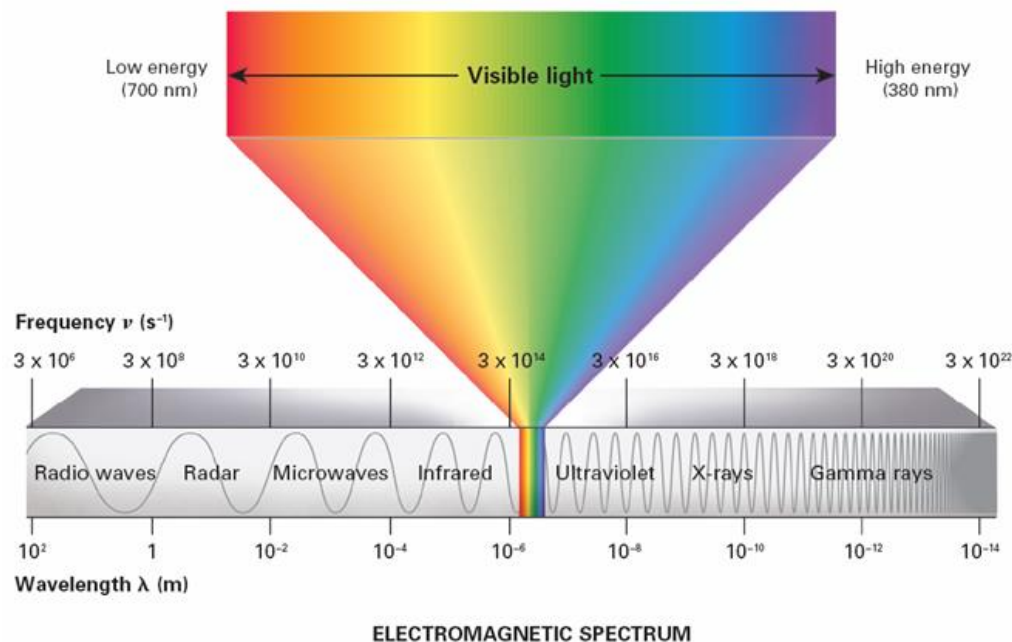




The wavelength and frequency of light are **inversely proportional** to each other.



Where is the HIGH ENERGY Radiation?



Describe the frequency and the wavelength of the high energy radiation.

Important Wave Information

Photon

- packet of energy

Speed of light

- how fast electromagnetic radiation travels in a vacuum
- Represented by letter “c”
- 3.0×10^8 meters/second

Organizing the Elements >

A diagram showing the equation $c = \lambda \nu$ with three red arrows pointing to its components. One arrow points from the text 'speed of light' to the variable c . Another arrow points from the text 'frequency (Greek letter, nu)' to the Greek letter ν . A third arrow points from the text 'wavelength' to the Greek letter λ .

speed of light

frequency
(Greek letter, nu)

$$c = \lambda \nu$$

wavelength

Calculate the wavelength of radiation with a frequency of 7.6×10^{13} Hz.

What is the **wavelength, in nanometers**, of light with a frequency of 7.1×10^{14} Hz?

Organizing the Elements >

energy gap between the
two energy levels in the
hydrogen atom

frequency of the light emitted

$$\Delta E = h\nu$$

Planck's constant

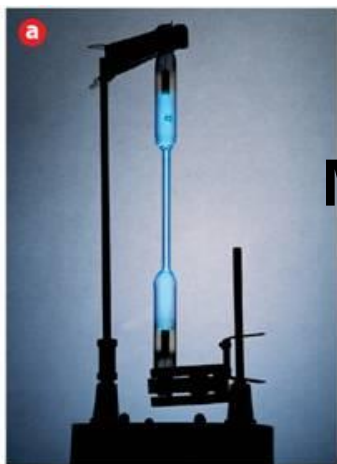
Calculate the energy of a photon of radiation with a frequency of $7.6 \times 10^{14}\text{Hz}$

A photon of light has a wavelength of 698 nm. How much **energy** does it have in Joules?

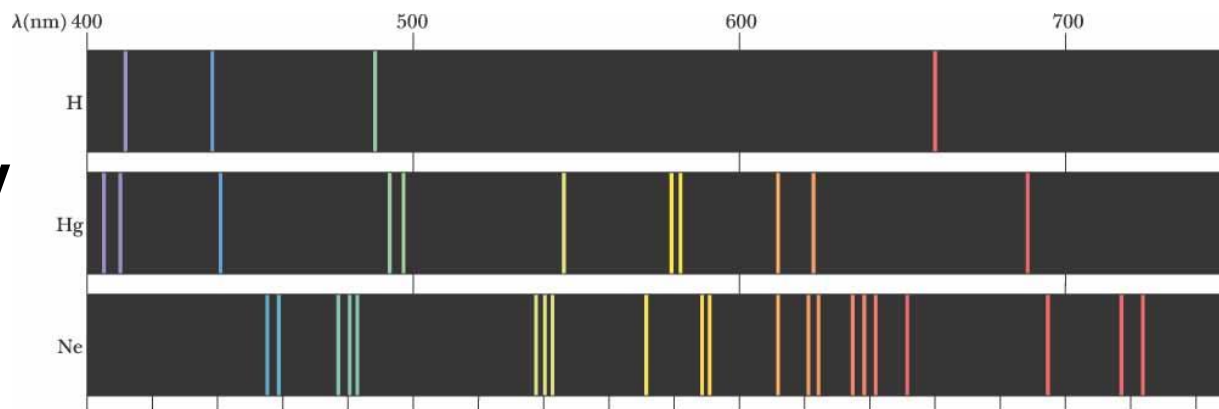
Atomic Spectra & How is it Created?

- 1) Atoms absorb energy
- 2) Electrons move into higher energy levels.
- 3) Electrons then lose energy by emitting light
- 4) Return to lower energy levels.

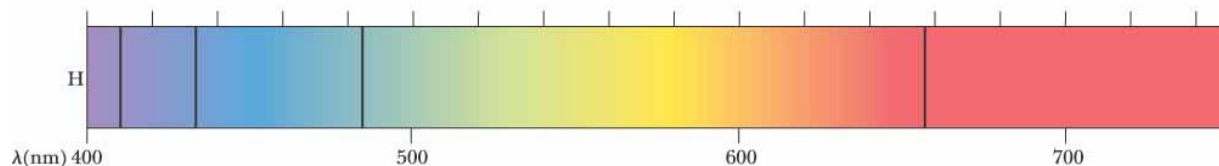
Each line in spectrum represents energy levels!



Mercury



(a)



(b)

©2004 Thomson - Brooks/Cole

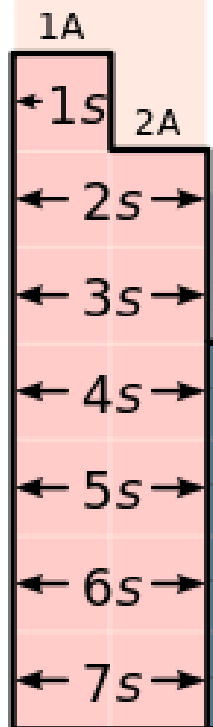
Flame Test Lab – Looking at Atomic Spectra

Electron Configurations

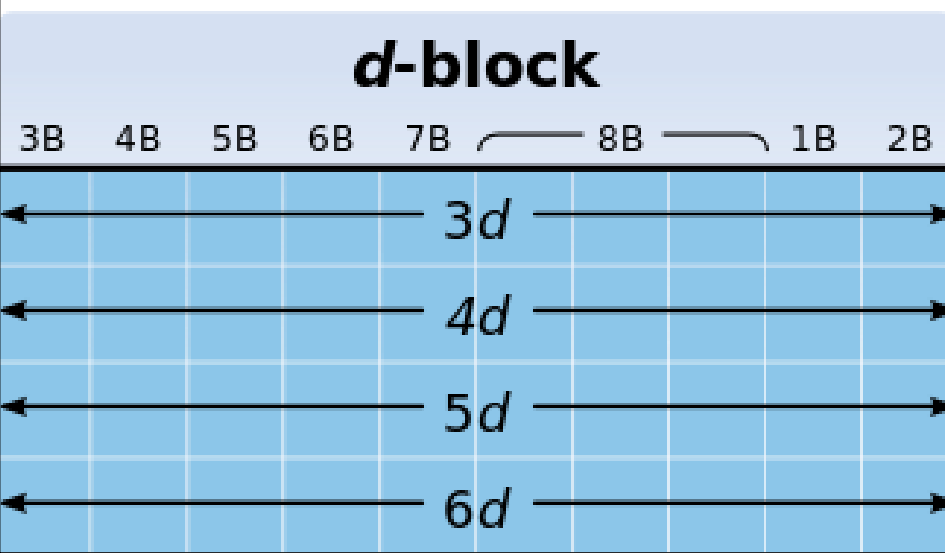
Give an address using quantum numbers describing where an electron lives

Organizing the Elements >

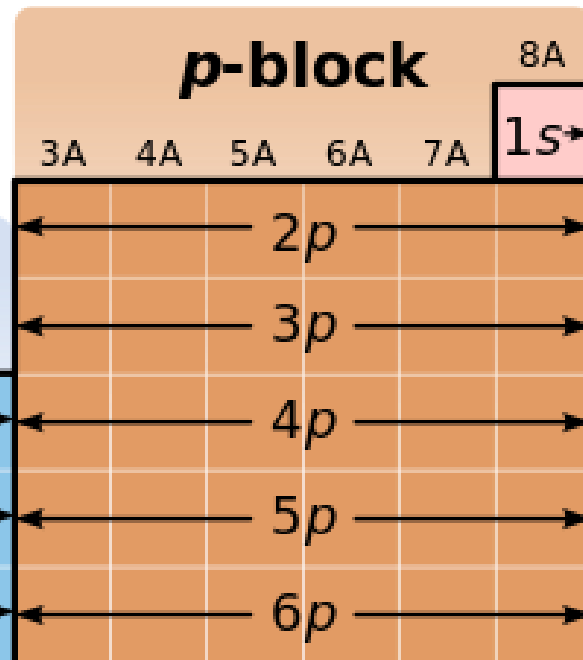
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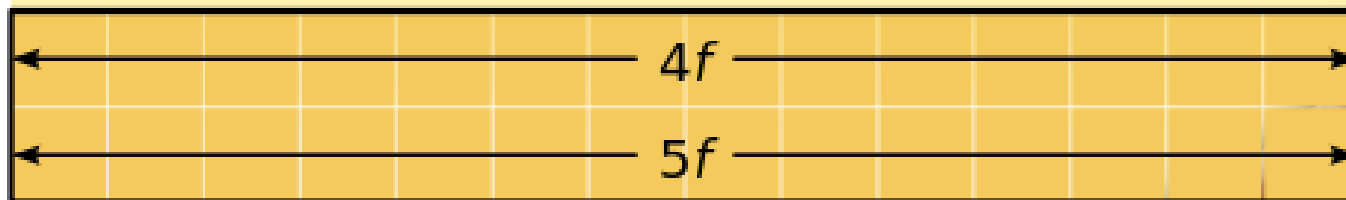
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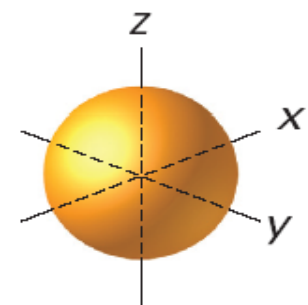
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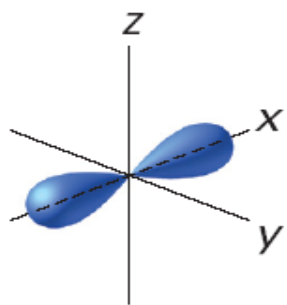
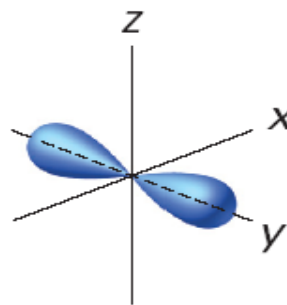
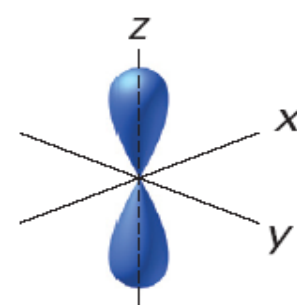
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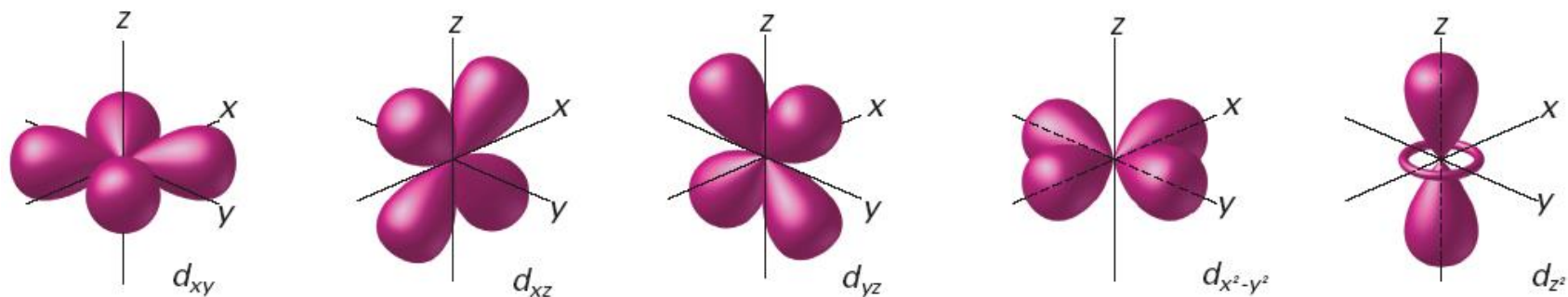
- Different atomic orbitals are denoted by different letters and numbers.
- Each orbital can hold two electrons
- Electrons will not pair up unless they have to!



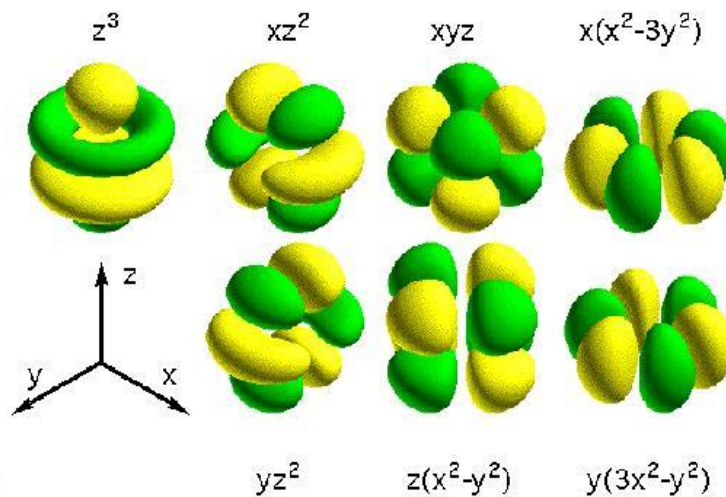
s orbital

 p_x orbital p_y orbital p_z orbital

d orbitals



f orbitals



Writing an Electron Configuration Using the Periodic

Li

C

Ar

Ca

Na

Br

Organizing the Elements >

Electron Configurations of Ions

Cations – positively charged – subtract electrons

Anions – negatively charged – add electrons

bromine ion

magnesium ion

Writing a Noble Gas Configuration

beryllium

carbon

phosphorus