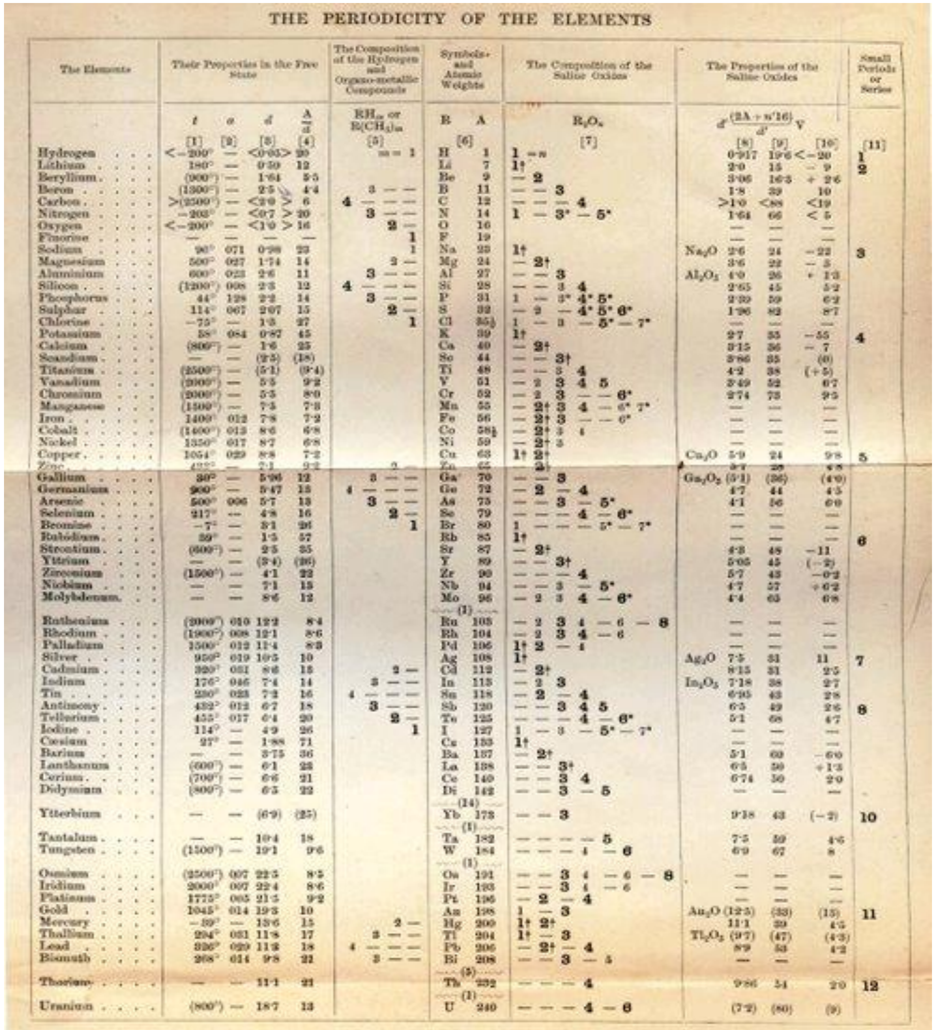
Unit 3 – The Periodic Table, Electron Configuration, &Periodic Trends

Chapters 4 & 5

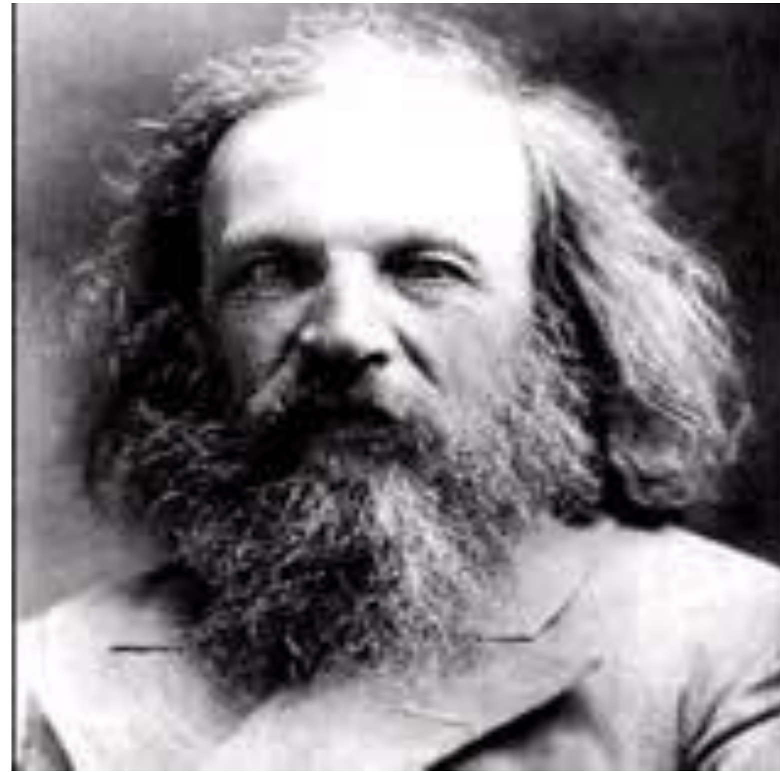
Creation of the Periodic Table

Mendeleev's Table



THE PERIODICITY OF THE ELEMENTS

The Elements	Symbols (B)	Atomic Weights (A)
Hydrogen	H	1
Lithium	Li	7
Beryllium	Be	9
Boron	B	11
Carbon	C	12
Nitrogen	N	14
Oxygen	O	16
Fluorine	F	19
Sodium	Na	23
Magnesium	Mg	24
Aluminium	Al	27
Silicon	Si	28
Phosphorus	P	31
Sulphur	S	32
Chlorine	Cl	35½
Potassium	K	39
Calcium	Ca	40
Scandium	Sc	44
Titanium	Ti	48
Vanadium	V	51
Chromium	Cr	52
Manganese	Mn	55
Iron	Fe	56
Cobalt	Co	58½
Nickel	Ni	59
Copper	Cu	63
Zinc	Zn	65
Gallium	Ga	70
Germanium	Ge	72
Arsenic	As	75
Selenium	Se	79
Bromine	Br	80
Rubidium	Rb	85
Strontium	Sr	87
Yttrium	Y	89
Zirconium	Zr	90
Niobium	Nb	94
Molybdenum	Mo	96
Ruthenium	Ru	103
Rhodium	Rh	104
Palladium	Pd	106
Silver	Ag	108
Cadmium	Cd	112
Indium	In	113
Tin	Sn	118
Antimony	Sb	120
Tellurium	Te	125
Iodine	I	127
Caesium	Cs	133
Barium	Ba	137
Lanthanum	La	138
Cerium	Ce	140
Didymium	Di	142
Ytterbium	Yb	173
Tantalum	Ta	182
Tungsten	W	184
Osmium	Os	191
Iridium	Ir	193
Platinum	Pt	196
Gold	Au	198
Mercury	Hg	200
Thallium	Tl	204
Lead	Pb	206
Bismuth	Bi	208
Thorium	Th	232
Uranium	U	240



Dmitry Mendeleev

He created the first periodic table based on the properties of the elements

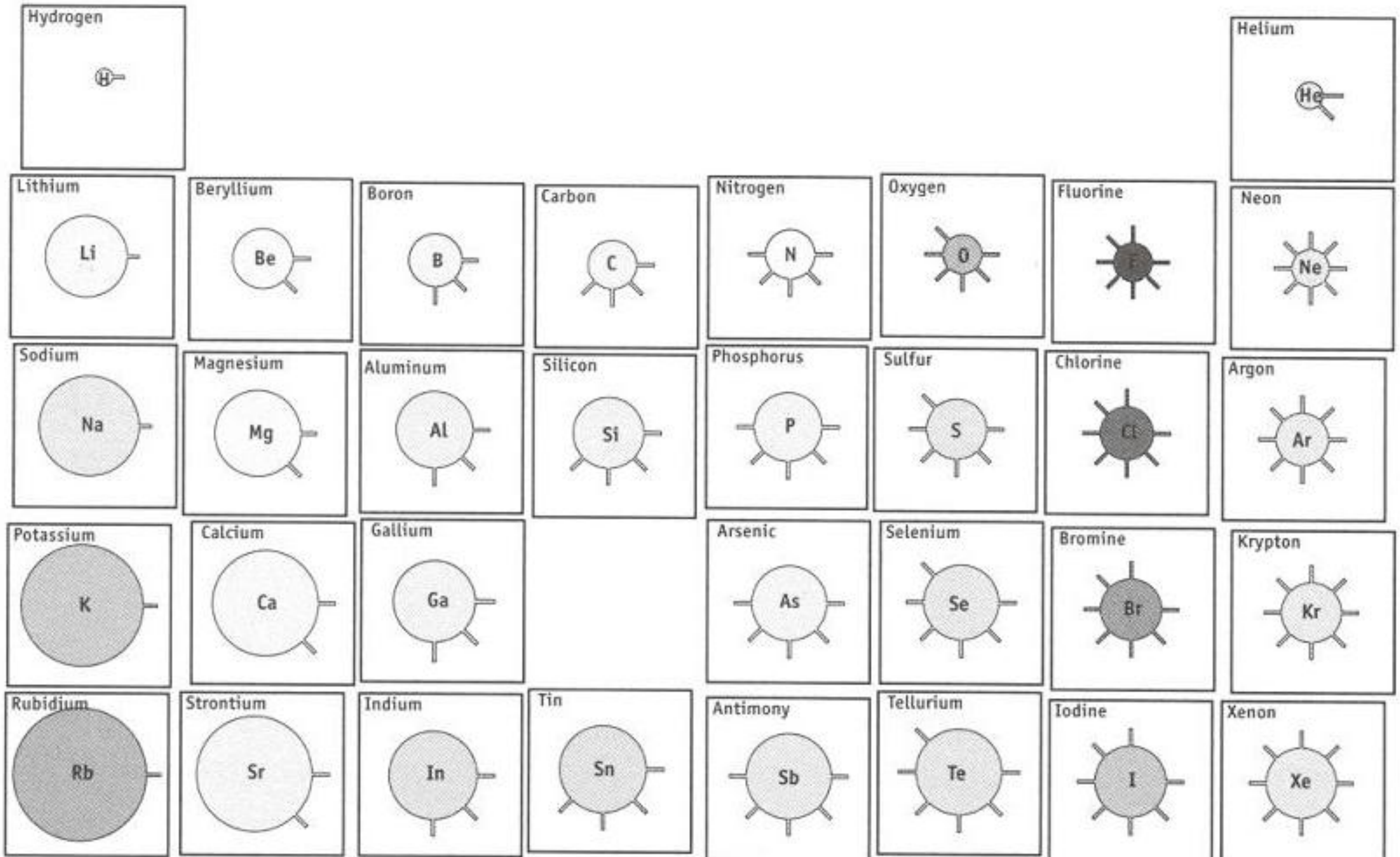
ChemCatalyst: This document was created in 1889, when chemists only knew of 63 different elements. How do you think the elements are organized? What do you think the numbers represent?

Mendeleyev's Table of the Elements - 1889

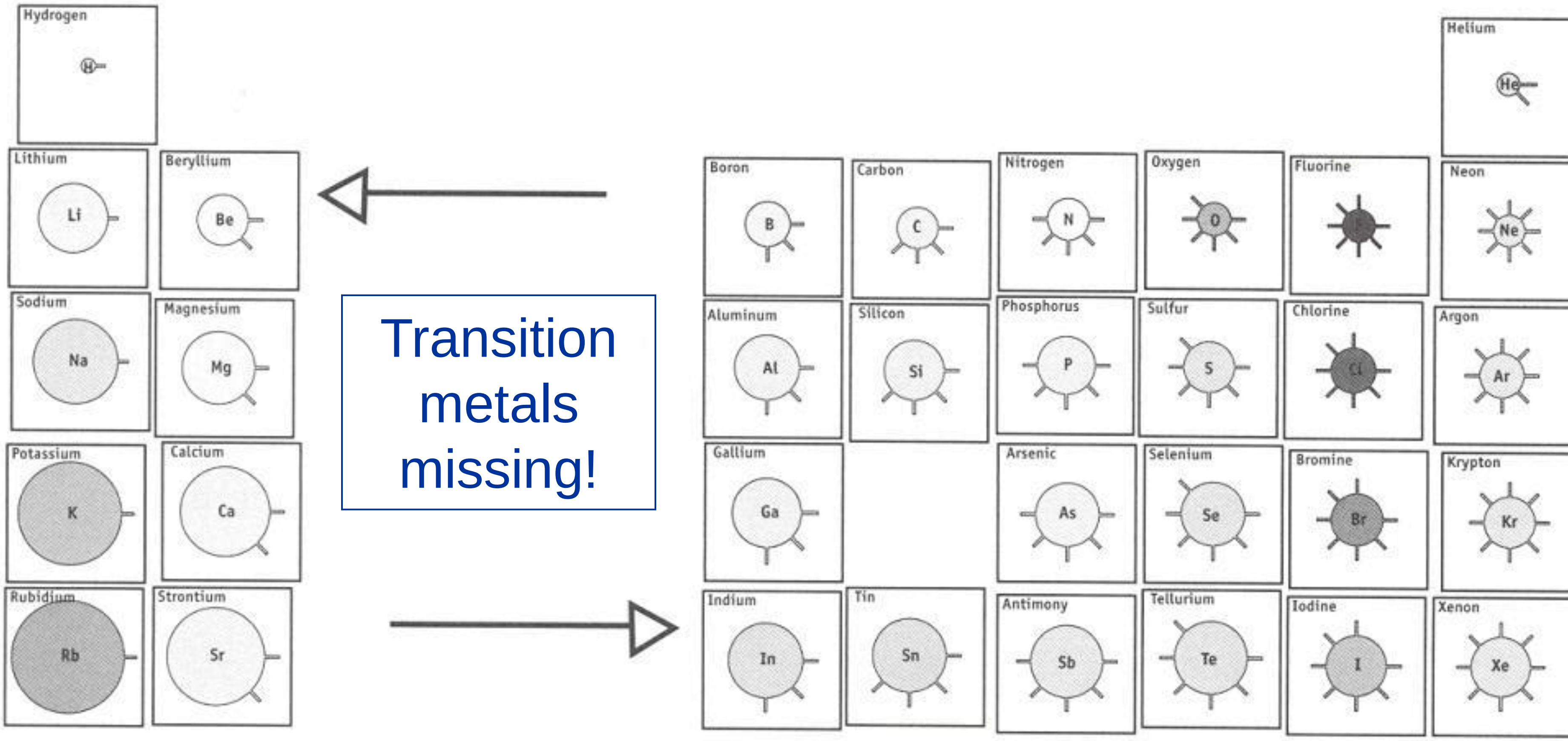
	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
1	H = 1							
2	Li = 7	Be = 9	B = 11	C = 12	N = 14	O = 16	F = 19	
3	Na = 23	Mg = 24	Al = 27	Si = 28	P = 31	S = 32	Cl = 35	
4	K = 39	Ca = 40	___ = 44	Ti = 48	V = 51	Cr = 52	Mn = 55	Fe = 56 Co = 59 Ni = 59 Cu = 63
5	Cu = 63	Zn = 65	___ = 68	___ = 72	As = 75	Se = 78	Br = 80	
6	Rb = 85	Sr = 87	Yt = 88	Zr = 90	Nb = 94	Mo = 96	___ = 100	Ru = 104 Rh = 106 Pd = 106 Ag = 108
7	Ag = 108	Cd = 112	In = 113	Sn = 118	Sb = 122	Te = 125	I = 127	
8	Cs = 133	Ba = 137	Di = 138	Ce = 140	___	___	___	___ ___ ___ ___
9	___	___	___	___	___	___	___	
10	___	___	Er = 178	La = 180	Ta = 182	W = 184	___	Os = 195 Ir = 197 Pt = 198 Au = 199
11	Au = 199	Hg = 200	Tl = 204	Pb = 207	Bi = 208	___	___	
12	___	___	___	Th = 231	___	U = 240	___	___ ___ ___ ___

Note: Mendeleyev's symbol for iodine, "J", has been changed to "I" to match modern symbols.

Create a Periodic Table Activity



Activity Compared to Real Table



1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
1 **H** $1s^1$																	2 **He** $1s^2$
3 **Li** $2s^1$	4 **Be** $2s^2$											5 **B** $2s^22p^1$	6 **C** $2s^22p^2$	7 **N** $2s^22p^3$	8 **O** $2s^22p^4$	9 **F** $2s^22p^5$	10 **Ne** $2s^22p^6$
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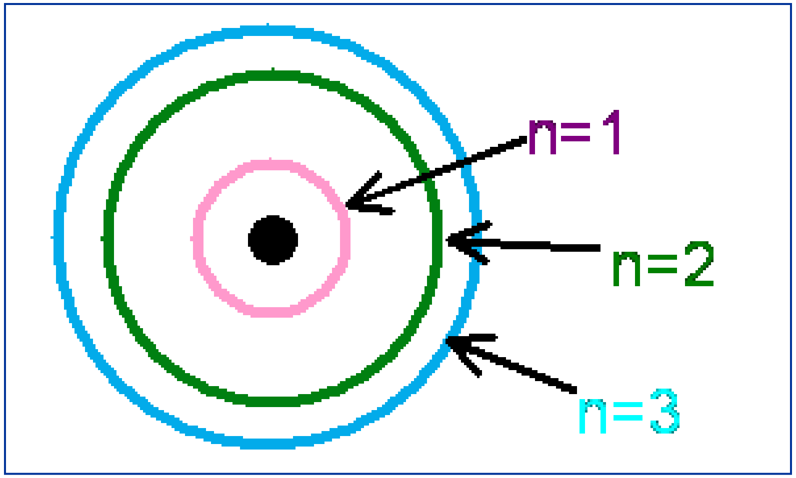
37 **Rb** $5s^1$	38 **Sr** $5s^2$	39 **Y** $4d^15s^2$	40 **Zr** $4d^25s^2$	41 **Nb** $4d^45s^1$	42 **Mo** $4d^55s^1$	43 **Tc** $4d^55s^2$	44 **Ru** $4d^75s^1$	45 **Rh** $4d^85s^1$	46 **Pd** $4d^{10}$	47 **Ag** $4d^{10}5s^1$	48 **Cd** $4d^{10}5s^2$	49 **In** $5s^25p^1$	50 **Sn** $5s^25p^2$	51 **Sb** $5s^25p^3$	52 **Te** $5s^25p^4$	53 **I** $5s^25p^5$	54 **Xe** $5s^25p^6$
55 **Cs** $6s^1$	56 **Ba** $6s^2$	57 ***La** $5d^16s^2$	72 **Hf** $5d^26s^2$	73 **Ta** $5d^36s^2$	74 **W** $5d^46s^2$	75 **Re** $5d^56s^2$	76 **Os** $5d^66s^2$	77 **Ir** $5d^76s^2$	78 **Pt** $5d^96s^1$	79 **Au** $5d^{10}6s^1$	80 **Hg** $5d^{10}6s^2$	81 **Tl** $6s^26p^1$	82 **Pb** $6s^26p^2$	83 **Bi** $6s^26p^3$	84 **Po** $6s^26p^4$	85 **At** $6s^26p^5$	86 **Rn** $6s^26p^6$
87 **Fr** $7s^1$	88 **Ra** $7s^2$	89 **†Ac** $6d^17s^2$	104 **Rf** $6d^27s^2$	105 **Db** $6d^37s^2$	106 **Sg** $6d^47s^2$	107 **Bh**	108 **Hs**	109 **Mt**	110	111	112	Unknown	114	Unknown	††116	Unknown	††118

*	58 **Ce** $4f^26s^2$	59 **Pr** $4f^36s^2$	60 **Nd** $4f^46s^2$	61 **Pm** $4f^56s^2$	62 **Sm** $4f^66s^2$	63 **Eu** $4f^76s^2$	64 **Gd** $4f^75d^16s^2$	65 **Tb** $4f^96s^2$	66 **Dy** $4f^{10}6s^2$	67 **Ho** $4f^{11}6s^2$	68 **Er** $4f^{12}6s^2$	69 **Tm** $4f^{13}6s^2$	70 **Yb** $4f^{14}6s^2$	71 **Lu** $4f^{14}5d^16s^2$
†	90 **Th** $6d^27s^2$	91 **Pa** $5f^26d^17s^2$	92 **U** $5f^36d^17s^2$	93 **Np** $5f^46d^17s^2$	94 **Pu** $5f^67s^2$	95 **Am** $5f^77s^2$	96 **Cm** $5f^76d^17s^2$	97 **Bk** $5f^97s^2$	98 **Cf** $5f^{10}7s^2$	99 **Es** $5f^{11}7s^2$	100 **Fm** $5f^{12}7s^2$	101 **Md** $5f^{13}7s^2$	102 **No** $5f^{14}7s^2$	103 **Lr** $5f^{14}6d^17s^2$

Electron Configuration

Electrons are found in energy levels

- Fill the lowest possible energy levels 1st and move outward as the energy levels fill up



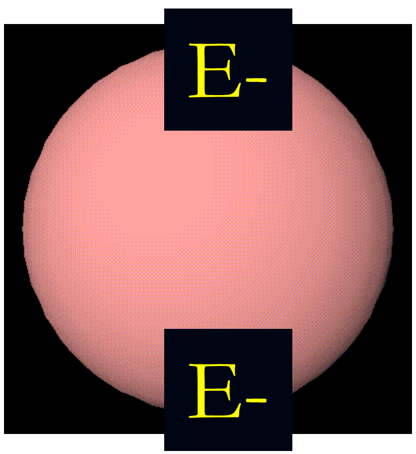
Energy levels called "rings" in lower level classes

n=1 is lowest energy level (closest to the nucleus)

Each Energy Level is Different…

- Each energy level has specific orbitals (3- D pathways) where electrons can be found
- Each energy level can hold a specific # of electrons

1st Energy Level- can hold 2 electrons



Puts them in "S" shaped orbital (always only hold 2 electrons).

$1s^2$ → # of electrons

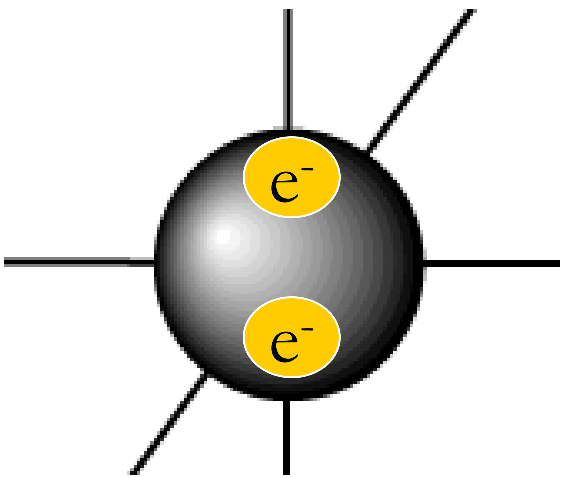
1st energy level

Sphere shape

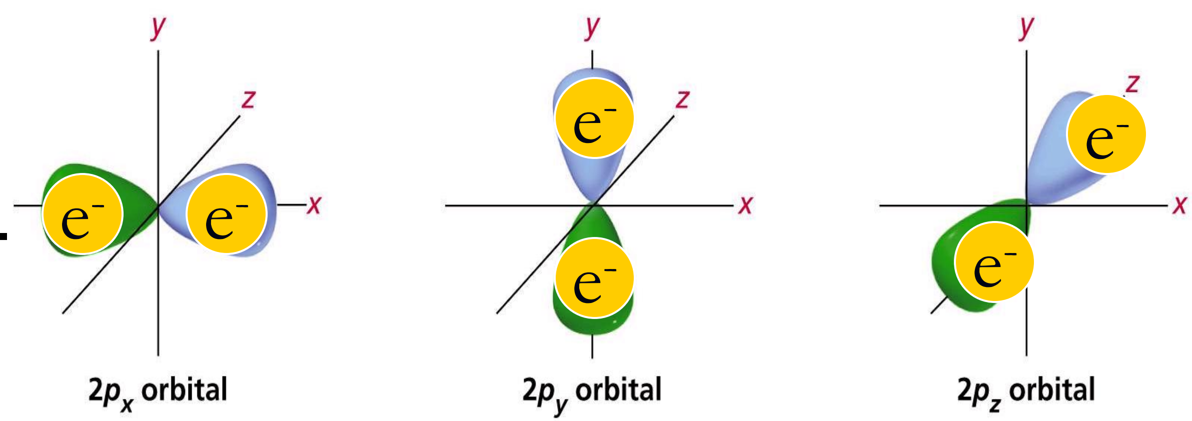
This is how you write out the location of the electrons

2^{nd} Energy Level

- Can hold up to 8 electrons
- Has an s-shaped orbital & a p-shaped orbital
  - The s-orbital always fills up 1^{st}!



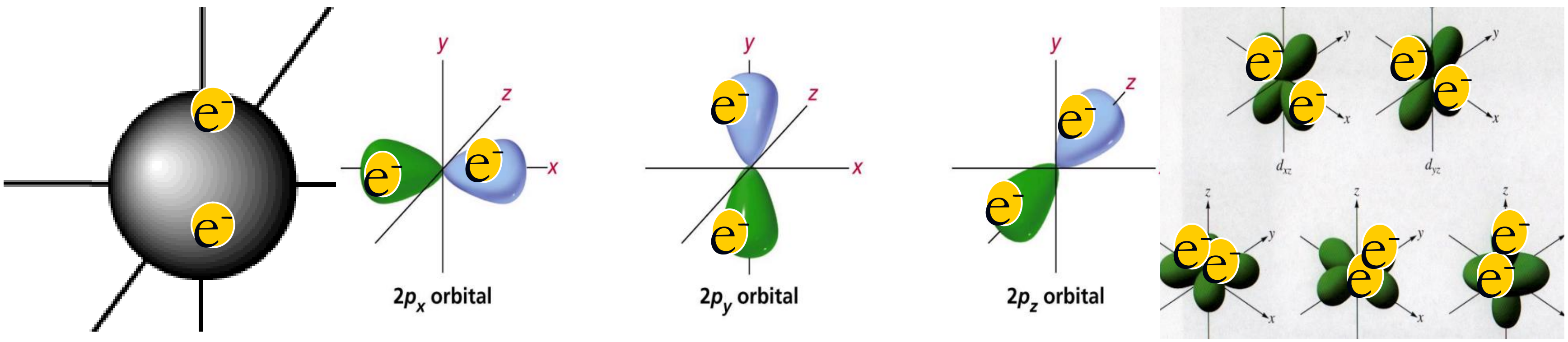
$2s^2$



$2p^6$

3rd Energy Level

- Can hold up to 18 Electrons
- Has s, p and d orbitals

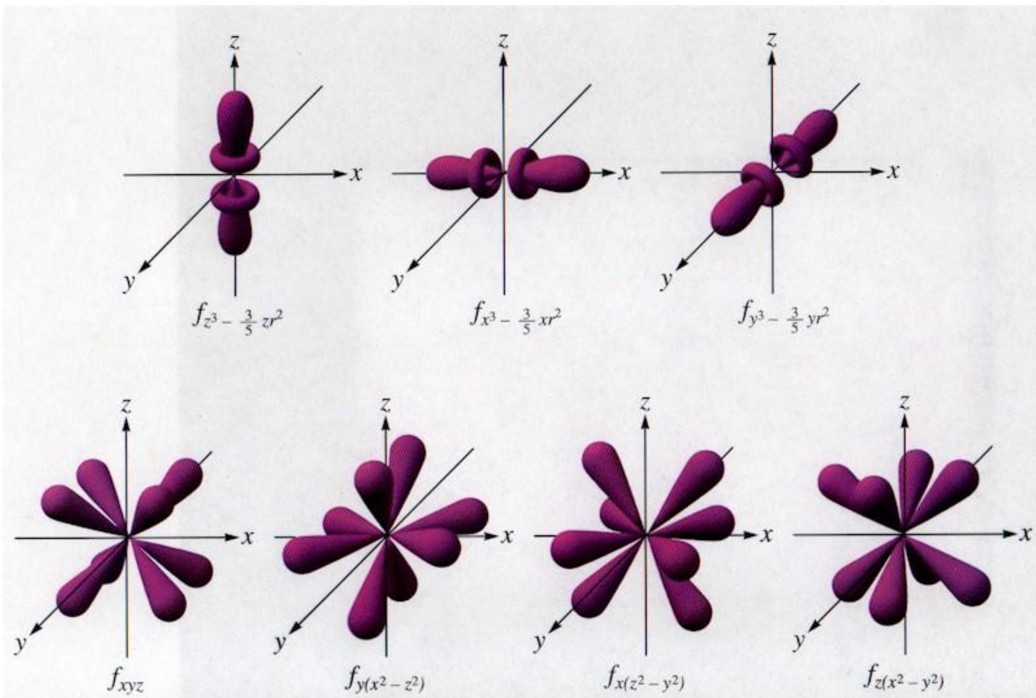


$3s^2$ $3p^6$ $3d^{10}$

- <u>NOTE:</u> The 4s orbital is actually at a lower energy, so electrons will fill it before the 3d orbital!

4th Energy Level-

- Has 4 different types of orbitals (s,p,d & f)

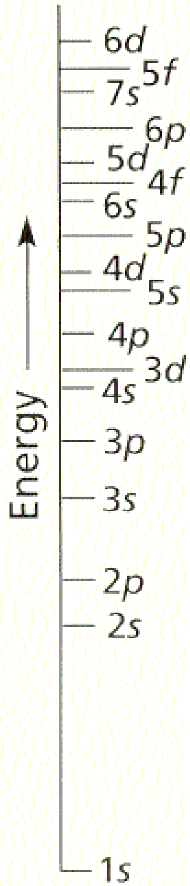


- **_f_- orbitals are the most complicated**

- 7 possible “f” orientations

- 14 electrons can fit in f orbitals (2 electrons x 7 orientations = 14)

One little trick…



- Here's the order that an atom will fill it's electrons.
- Starts with the easiest, lowest energy level to put electrons and moves up.

Diagram on pg 150 of your text book

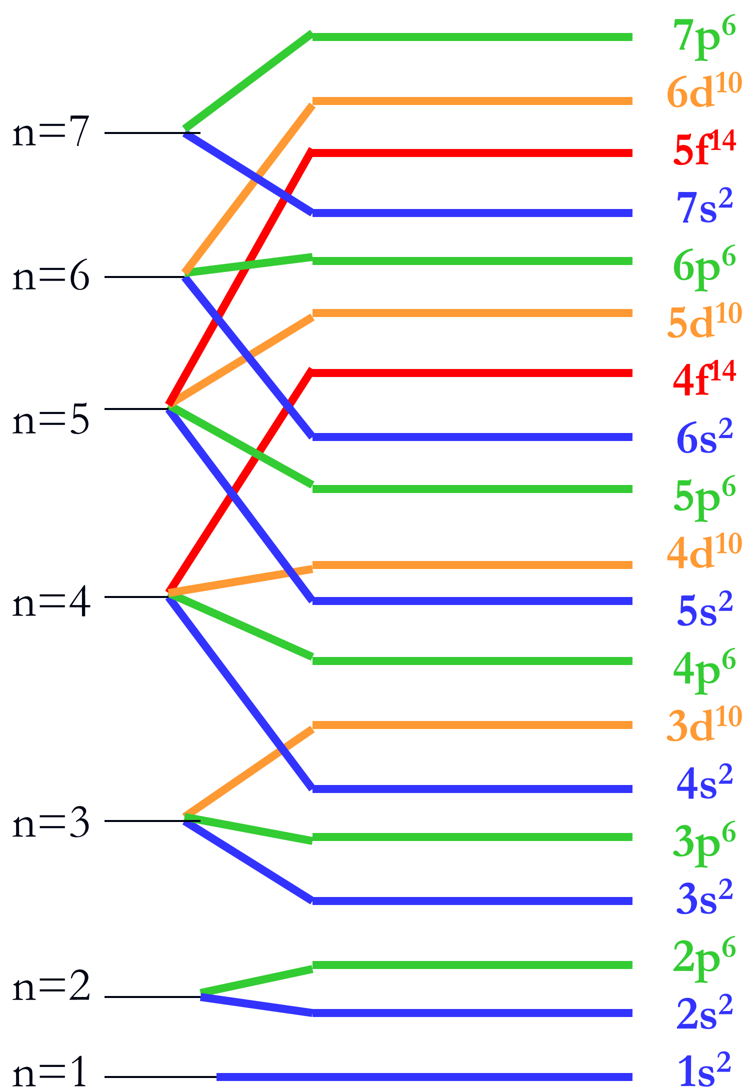
- Whoa… skips from 3p to 4s to 3d?

- Based on energy, it's easier to fill the "s" orbital on 4th energy level then the complicated "d" on the 3rd.

- Look further up the fill chart and you'll see more of this.

Order that Orbitals Fill Up… don't memorize!!!

- You will learn to use your <u>periodic table</u> to figure this out!



Writing Electron Configurations

Orbital Notation & Electron Configuration Notation

Ex: E. Config. for Fluorine (9 electrons)

$1s^2\ 2s^2\ 2p^6$

- Write the order that they fill the electrons

More Practice (a harder one)

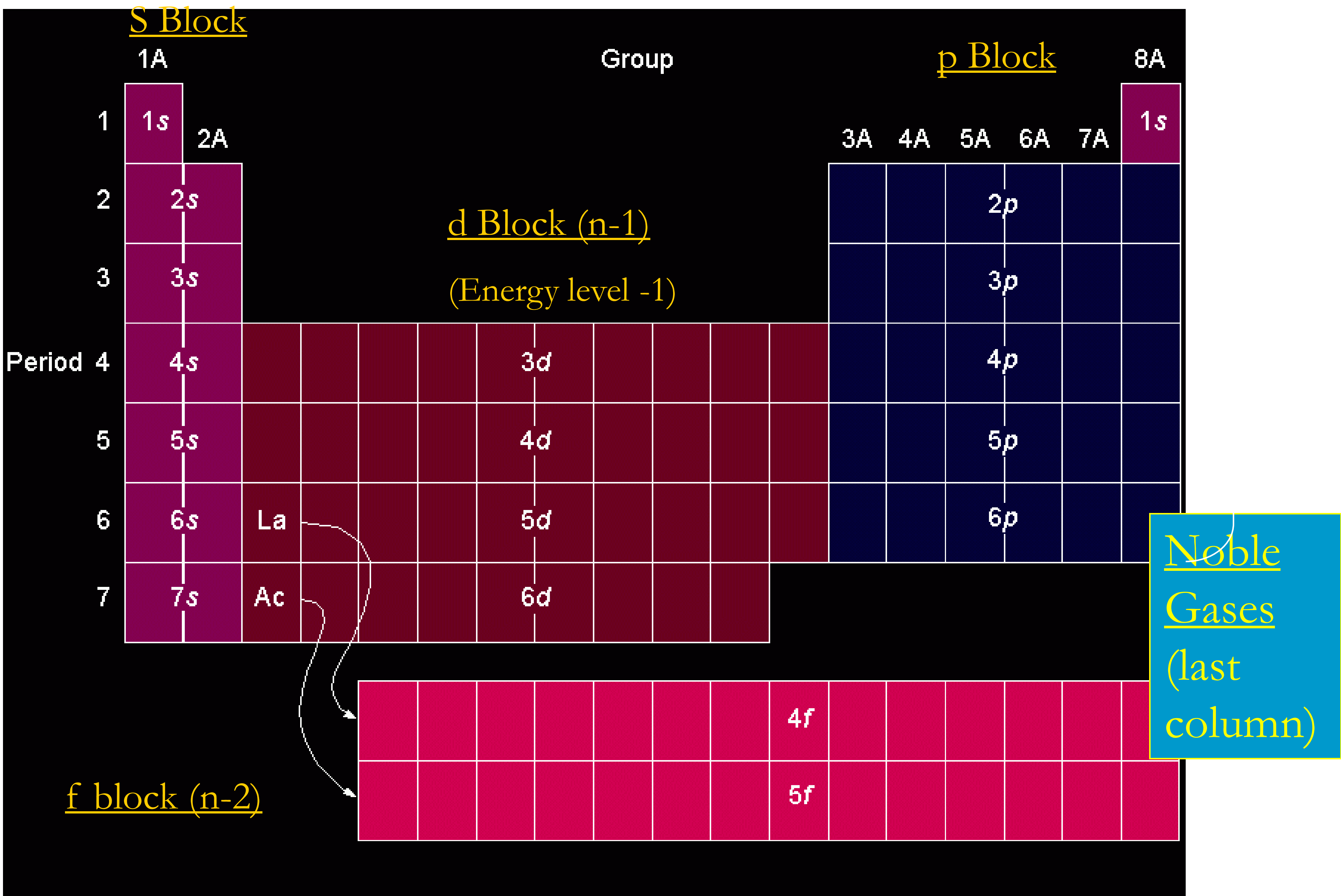
Ex: Titanium (22 electrons)

E. Configuration Notation

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \underline{4s^2\ 3d^2}$

Remember the fill order,
4s before 3d!

Using the Periodic Table for E. Config.



E. Configuration with Periodic Table

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 **H** $1s^1$																	2 **He** $1s^2$
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Practice Writing E. Configs.

- Carbon
- Magnesium
- Iron
- Iodine

Challenging:

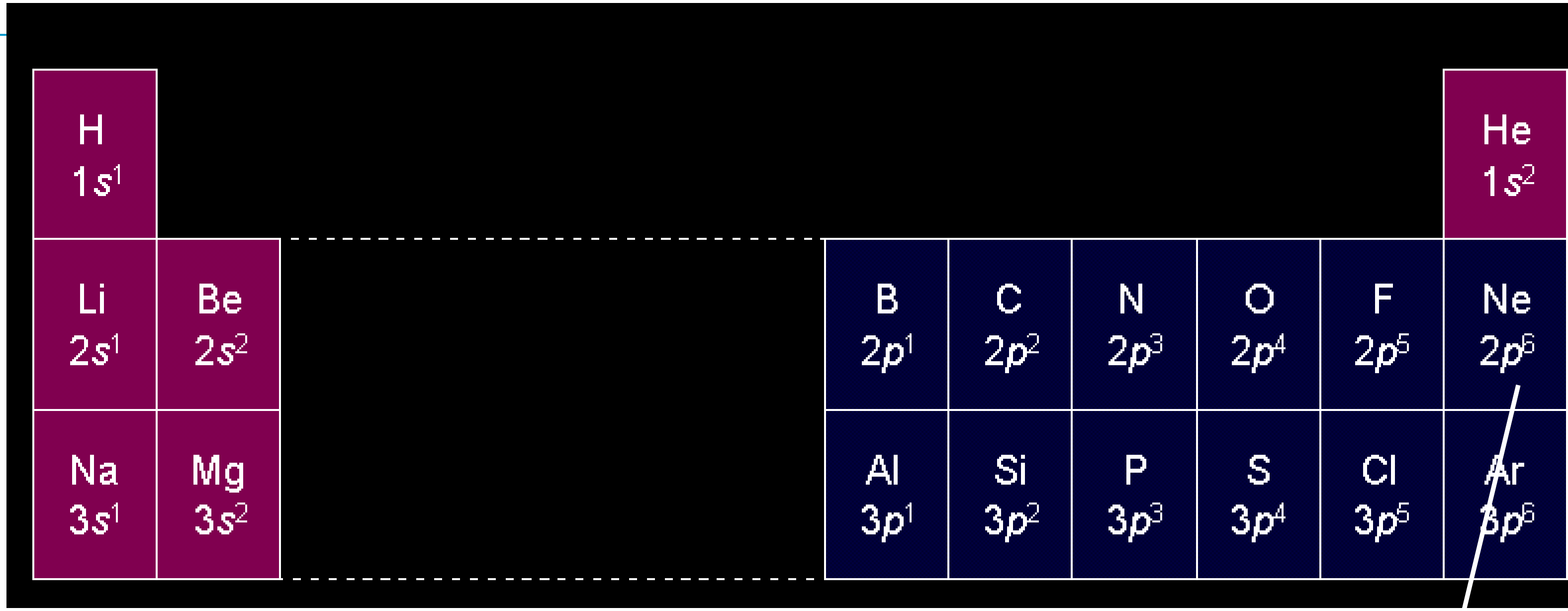
- Gold

Even more challenging:

- Plutonium

- $1s^2 2s^2 2p^2$
- $1s^2 2s^2 2p^6 3s^2$
- $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
- $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$
- $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^9$
- $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6 7s^2 \underline{6d^1} 5f^5$

Noble Gas Notation- the "short cut"



<u>For Na</u>

E. config: $1s^2\ 2s^2\ 2p^6\ 3s^1$

Noble Gas Not.: [Ne] $3s^1$

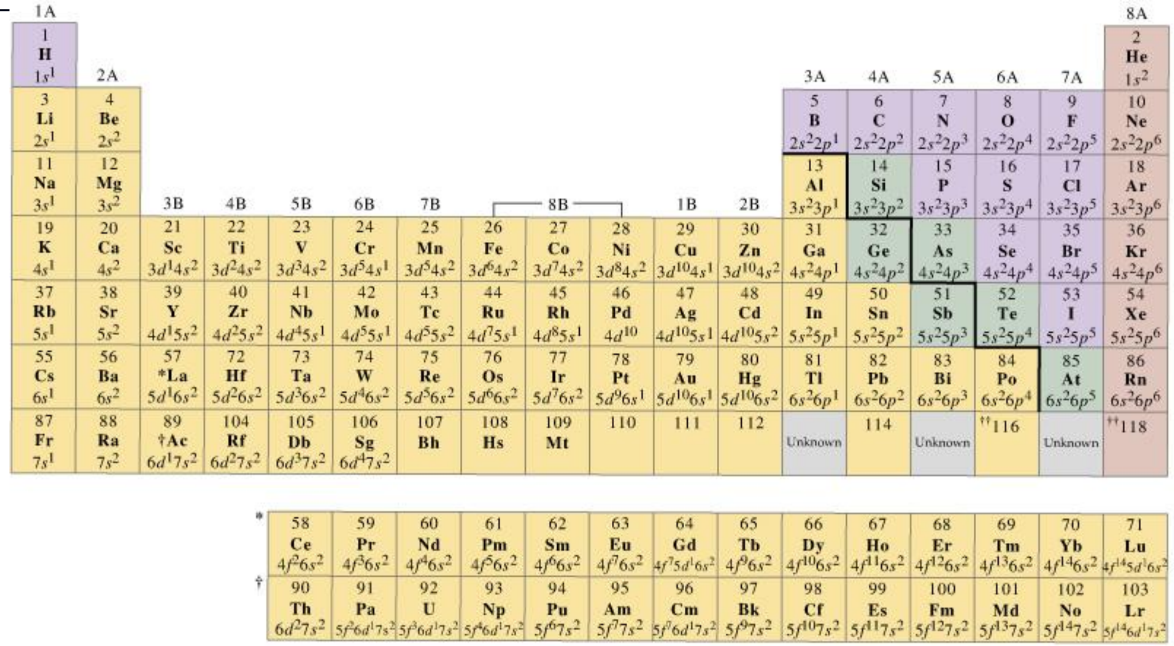
<u>For Cl</u>

E. config: $1s^2\ 2s^2\ 2p^6\ 3s^1$

Noble Gas Not.: [Ne] $3s^2\ 3p^5$

*Start at the noble gas ABOVE the element and do the configuration from there.

Noble Gas Notations through the D and F Blocks



<u>Noble Gas Notation for Br</u>

[Ar] $4s^2\ 3d^{10}\ 4p^5$

Remember d block is n-1 (row 4 -1 =3)

<u>Noble Gas Notation for Pb</u>

[Xe] $6s^2\ 4f^{14}\ 5d^{10}\ 6p^2$

Remember f block is n-2 (row 6 -2 =4)

Using Noble Gas Notation

- The noble gas notation can tell you the identity of an element

Period # **Which element in the block**

$$[He]2s^2 2p^2$$

block

Element identity = Carbon

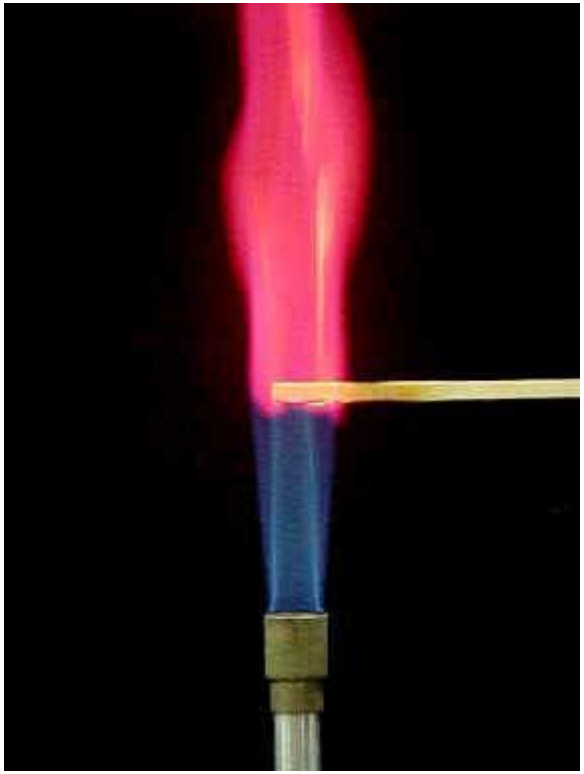
Decoding Noble Gas Notation

	Period	Block	Group	Identity
	3	**S**	**2**	**Mg**
[Ne]$3s^2$	**4**	**d**	**10**	**Ni**
[Ar]$4s^2 3d^8$	**6**	**p**	**14**	**Pb**
[Xe]$6s^2 4f^{14} 5d^{10} 6p^2$				

Electrons

History Behind Electron Configuration

- Certain elements emit distinct, visible light when heated in a flame. But why?



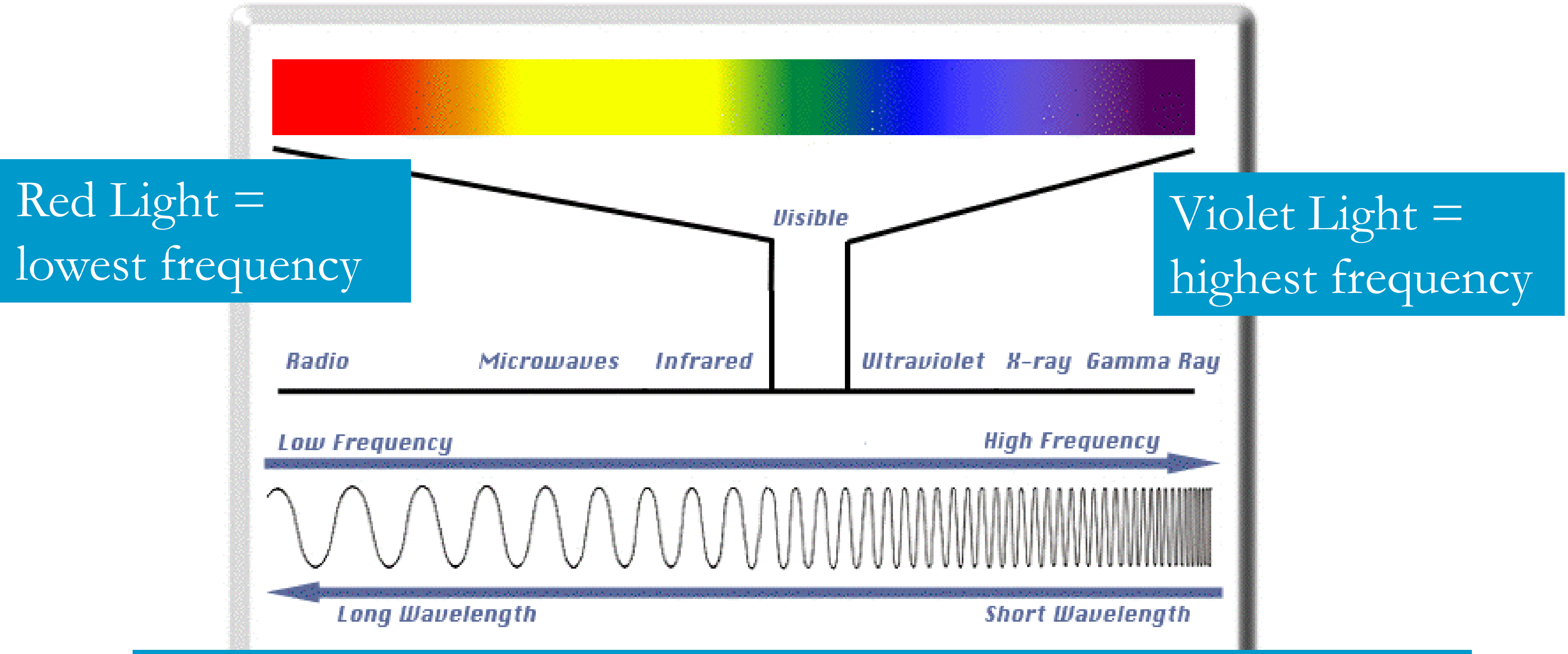
Strontium

Copper

What is light?

- It's a form of energy

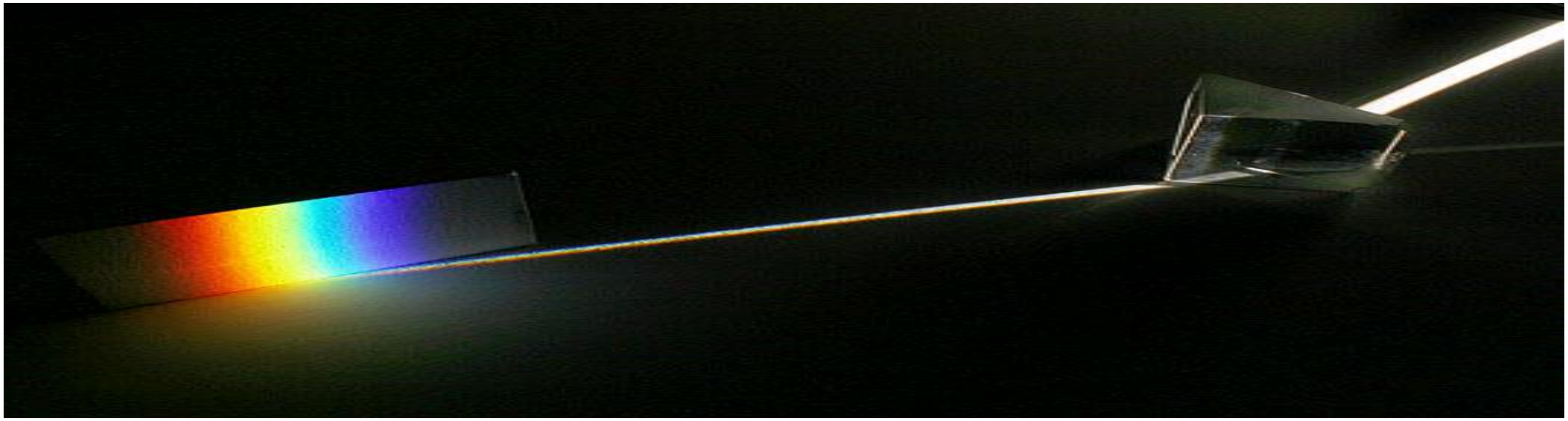
▪The **Electromagnetic Spectrum** (see image) shows other types of energy in our environment.



Visible light makes up only a small portion of the spectrum

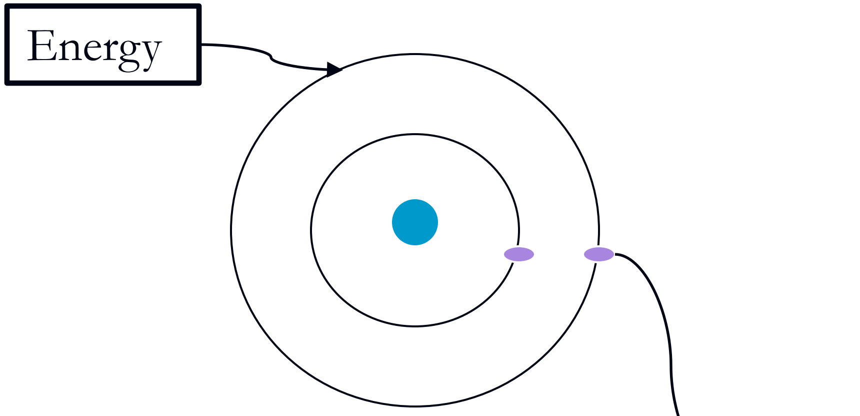
Spectroscopic Analysis

- When white light is scattered through a prism (or spectroscope), all of the colors of the visual spectrum can be seen.
  - This is seen as a "continuous spectrum" (without breaks)

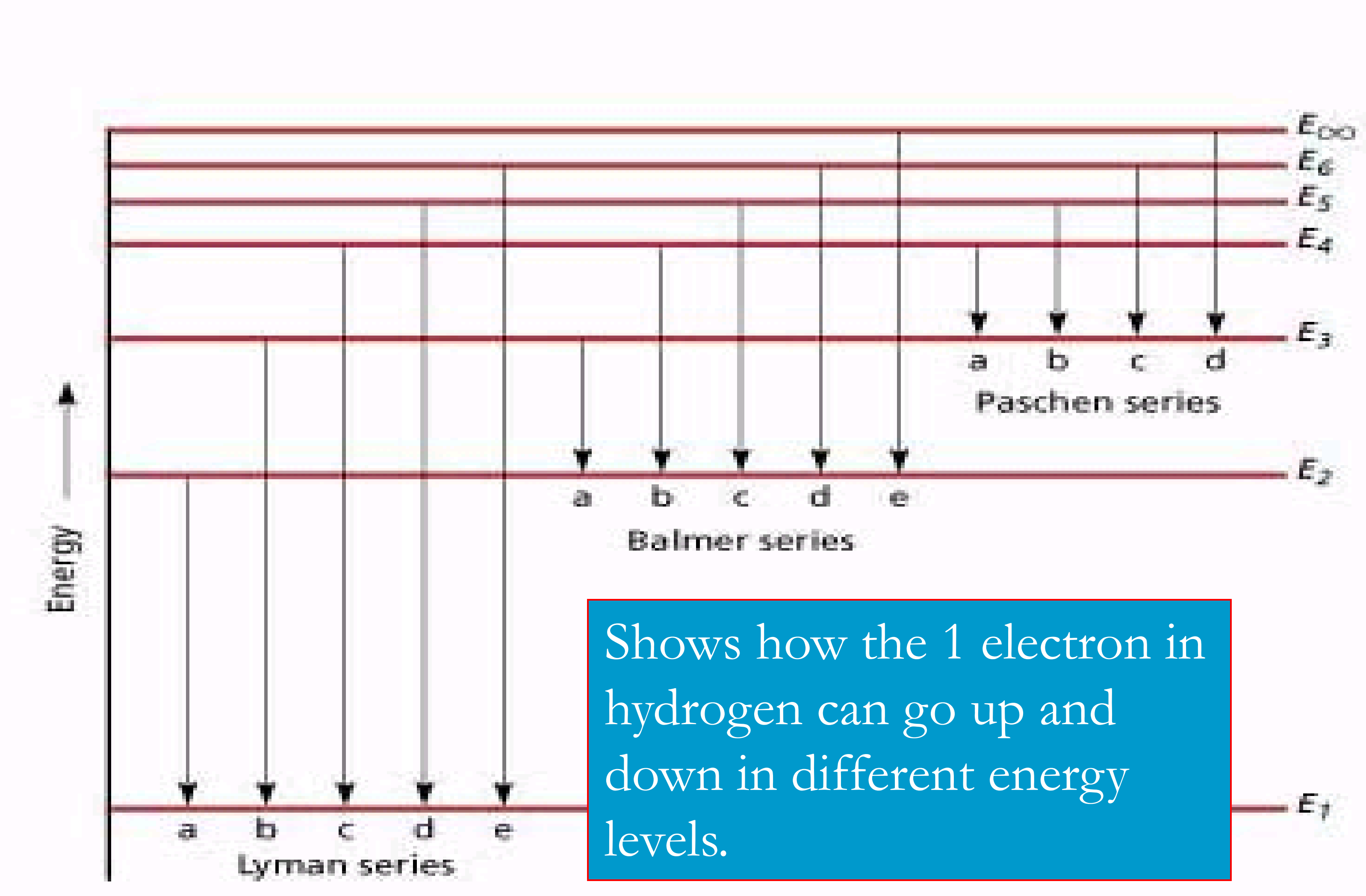


Electron Transitions

- Electrons can "jump" to higher energy levels when atoms are exposed to an energy source
  - This is known as the "excited state"
- When the electrons fall back down, they release that energy in the form of light
  - This is known as the "ground state"

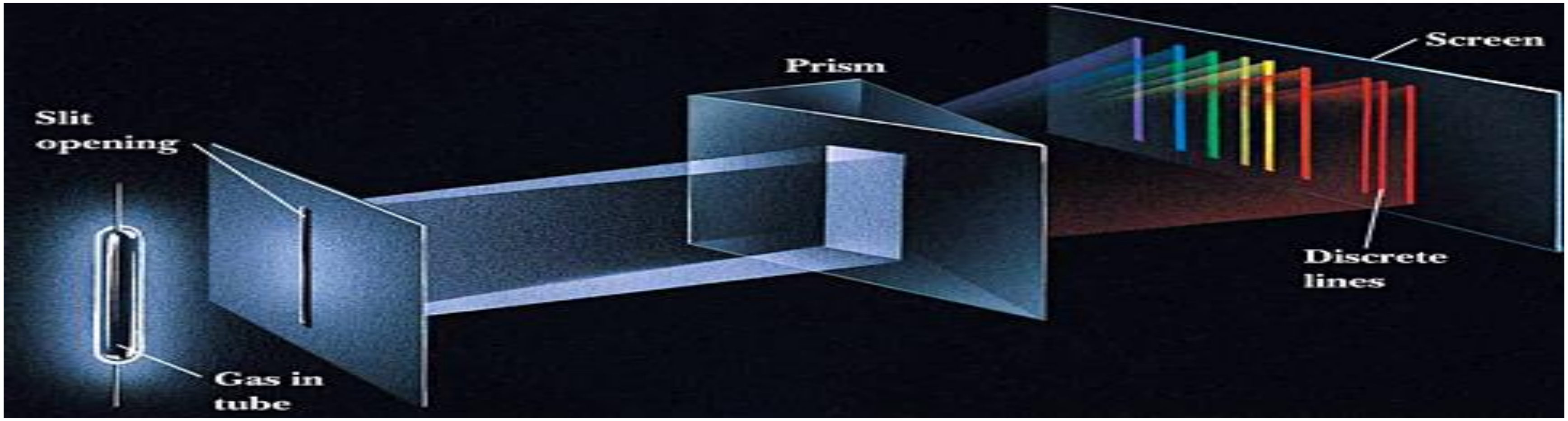


Energy Transitions for Hydrogen



Shows how the 1 electron in hydrogen can go up and down in different energy levels.

Emission Spectroscopy



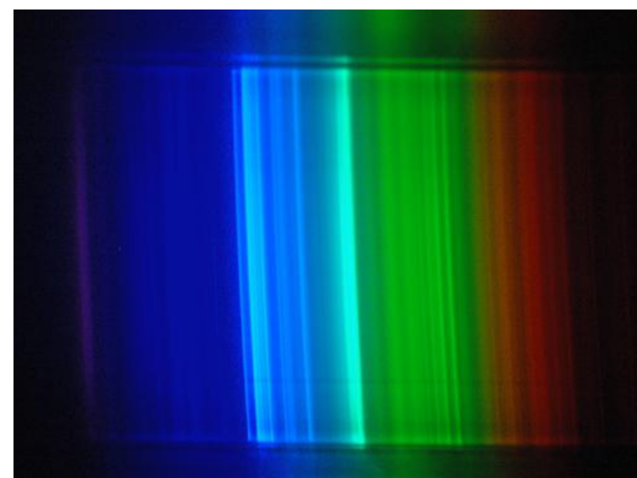
- Because atoms have different numbers of electrons, different types of atoms emit specific wavelengths and have a different pattern of spectral lines
  - This is the “line-emission spectrum”

Spectroscopy

- Elements have a unique set of spectral lines that allows us to identify them

- This is how we know the sun contains H and He, even though we've never been there.

Argon



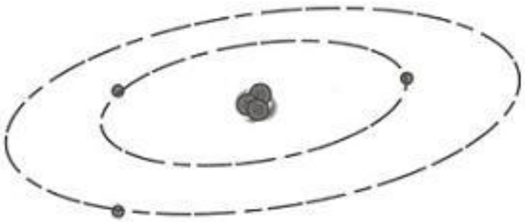
Hydrogen

Valence Electrons, Octet Rule, and Ions

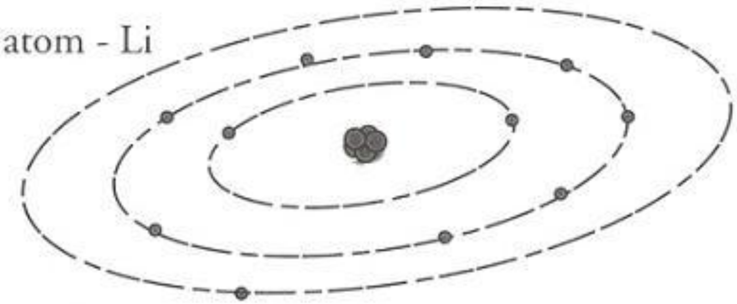
These 3 atoms have similar reactivity and chemical behavior.

A) where are they located on the periodic table?

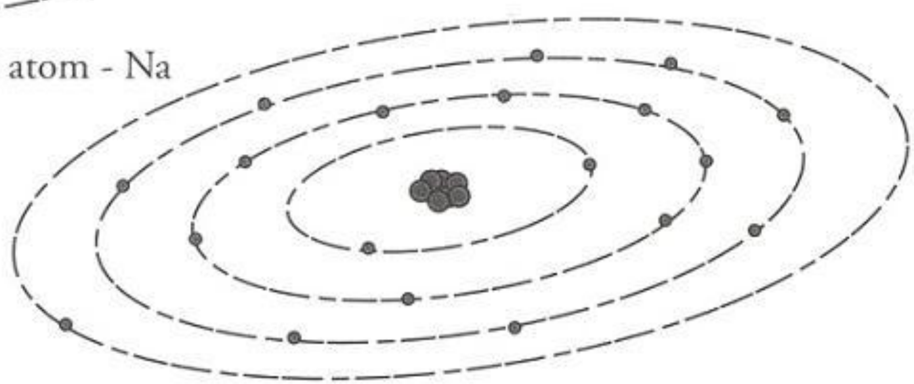
B. What do you think might be responsible for their similar properties?



Bohr model of lithium atom - Li



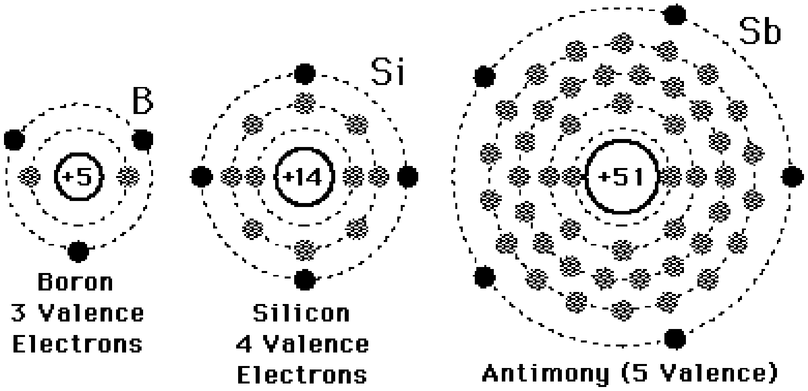
Bohr model of sodium atom - Na



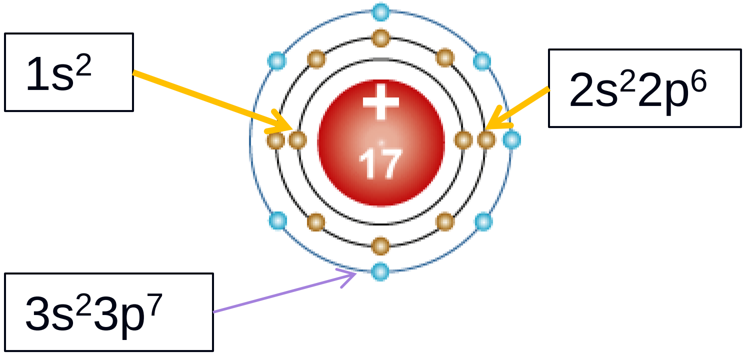
Bohr model of potassium atom - K

Valence Electrons

- **<u>Valence Electrons</u>** - electrons in the outer-most energy level
- These are the electrons that interact with other atoms
  - They determine an atom's chemical reactivity



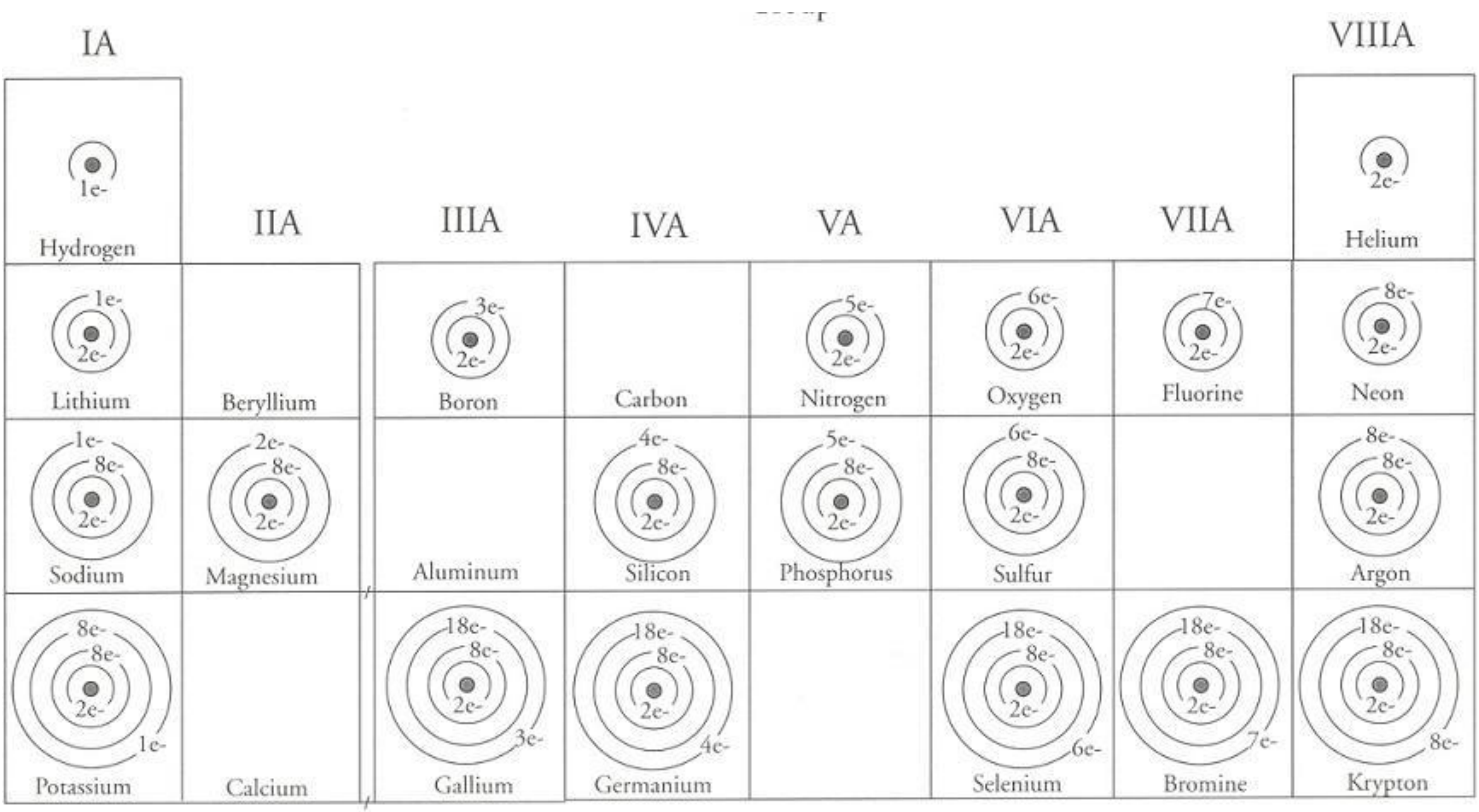
Valence Electrons & E. Congfig.



Chlorine

- In the electron configuration, the valence electrons are found in the s & p orbitals of the highest energy level.
- Examples:
  - Cl: [Ne]$3s^2 3p^5$
    - Has 7 valence electrons
  - Fe: [Ar]$4s^2 3d^6$
    - Has 2 valence electons
  - Sn: [Kr]$5s^2 4d^{10} 5p^2$
    - Has 4 valence electrons

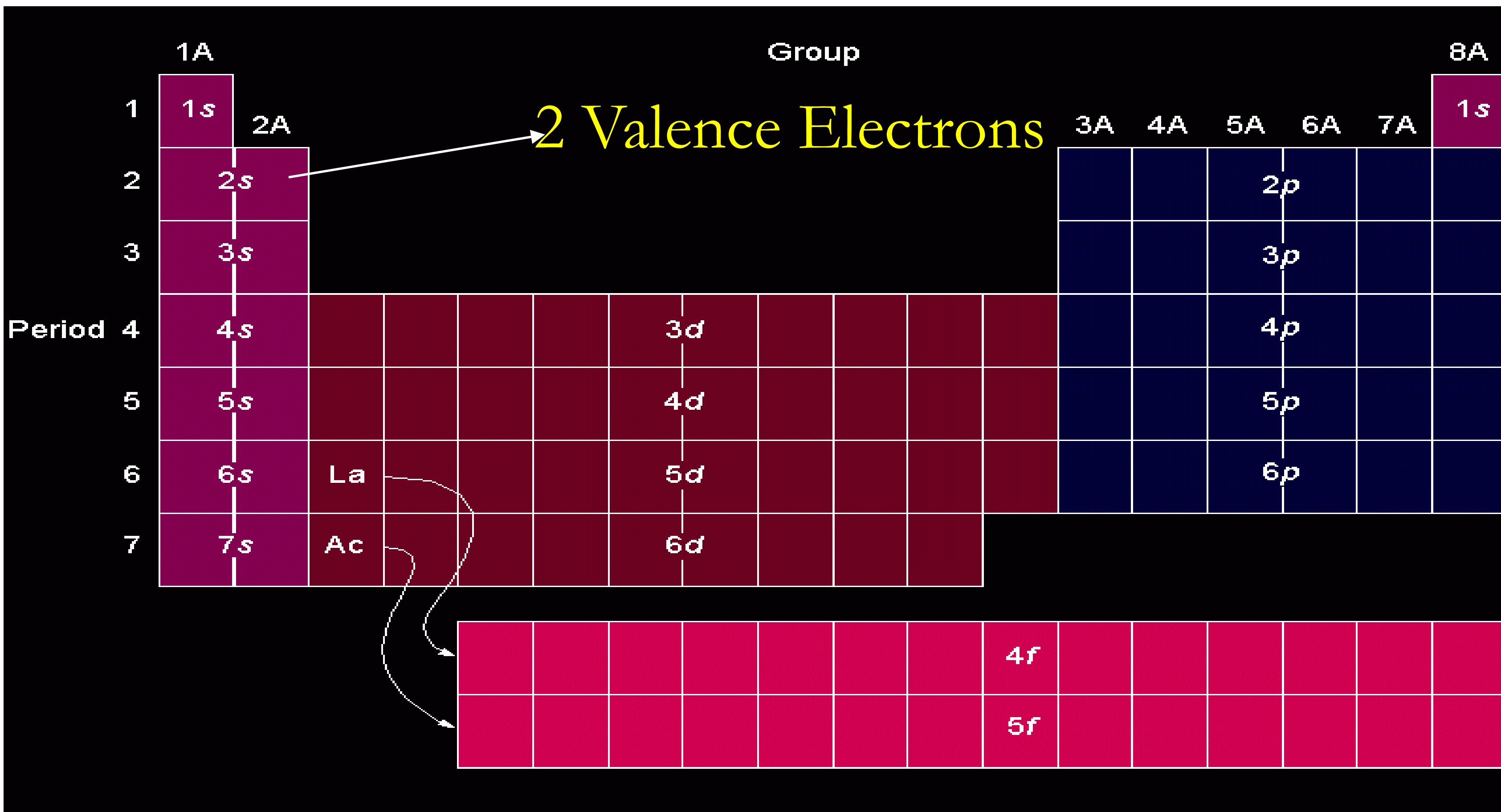
Valence Electrons and the Periodic Table



Figuring out # of Valence Electrons Using the Periodic Table (Short Cut)

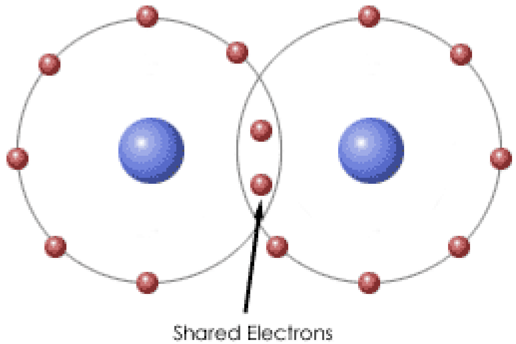
- The column that they are in is the number of valence electrons an atom has.

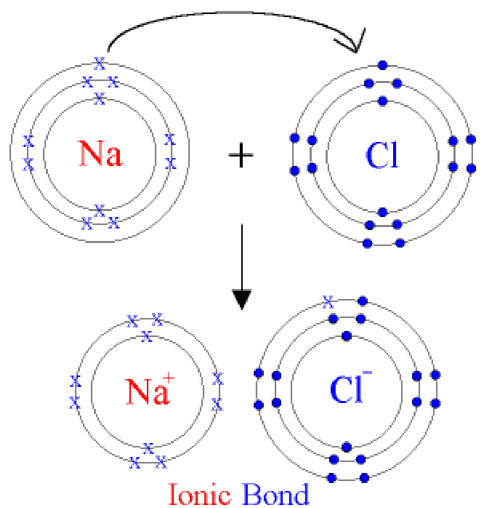
(EXCEPTION: This does not work for the D Block)



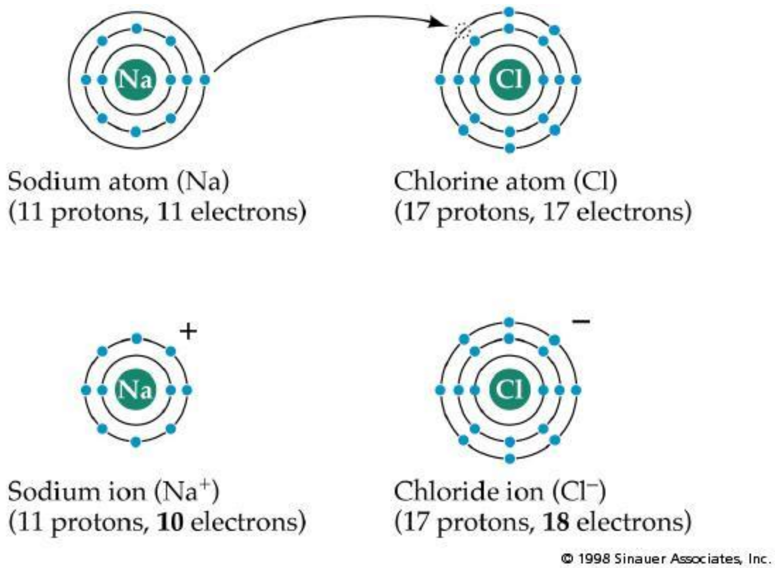
The Octet Rule

- Atoms tend to gain, lose, or share electrons to "fill" their valence shell.
- Exceptions: H & He abide by the "duet" rule.
  - They only need 2 electrons in their valence shell because the 1st energy level only holds 2 electrons





Ions

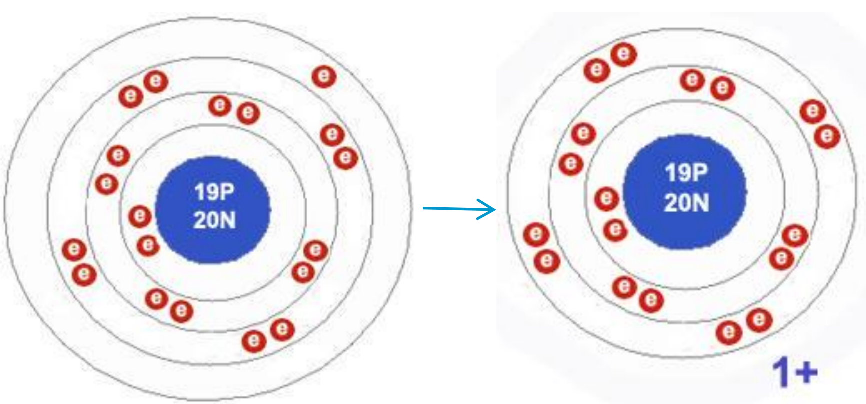


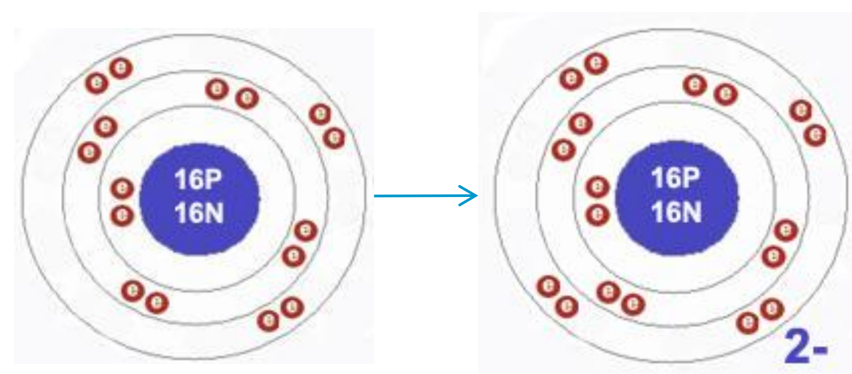
- Ions are charged particles or atoms that have gained or lost electrons to "fill" their octet.
- Anions have a negative charge.
  - They have gained electrons & electrons are negative.
  - They have more electrons than protons.
- Cations have a positive charge.
  - They have lost electrons.
  - They have more protons than electrons

Ion Examples

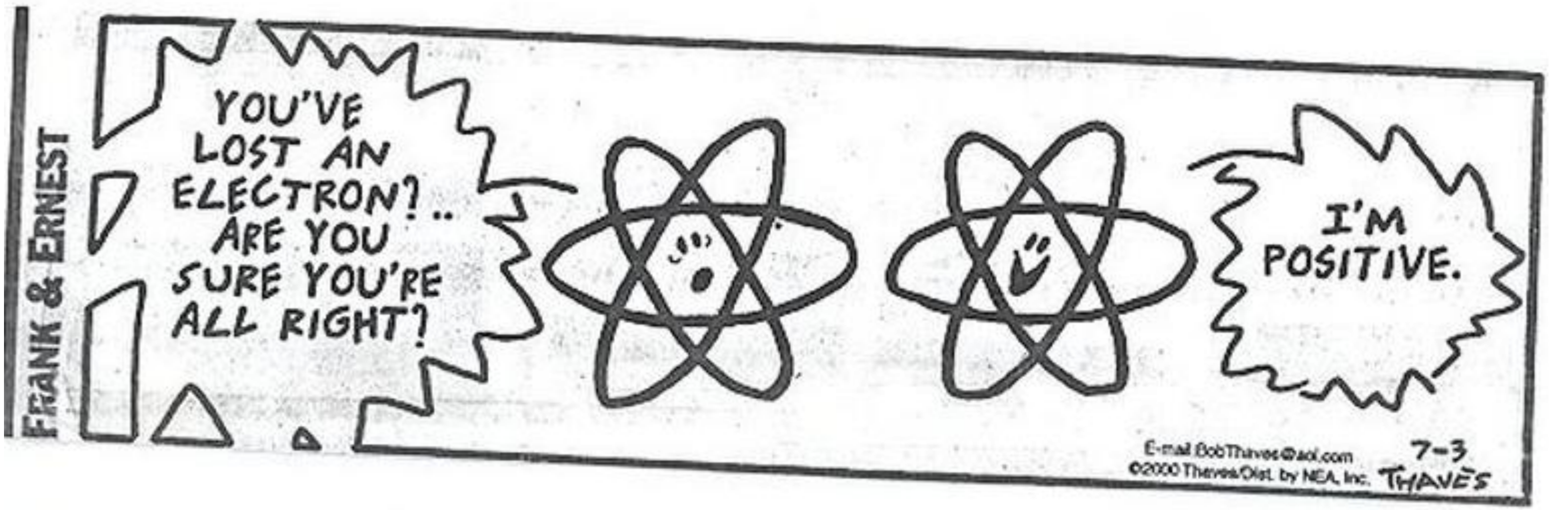
- Potassium has 1 valence electron, what ion will it form?
- It will lose 1 electron and form the ion K^+

- Sulfur has 6 valence electrons, what ion will it form?
- It will gain 2 electrons and form S^{2-}





Joke


FRANK & ERNEST
YOU'VE LOST AN ELECTRON?.. ARE YOU SURE YOU'RE ALL RIGHT?
I'M POSITIVE.
E-mail BobThaves@aol.com
©2000 Thaves/Dist. by NEA, Inc.
7-3
THAVES

joke

- Two atoms walk into a bar.
  One atom stops and says to the other,
  "I think I just lost an electron."
- The second atom asks "Are you sure?"
- The first atom replies, "I'm positive!"

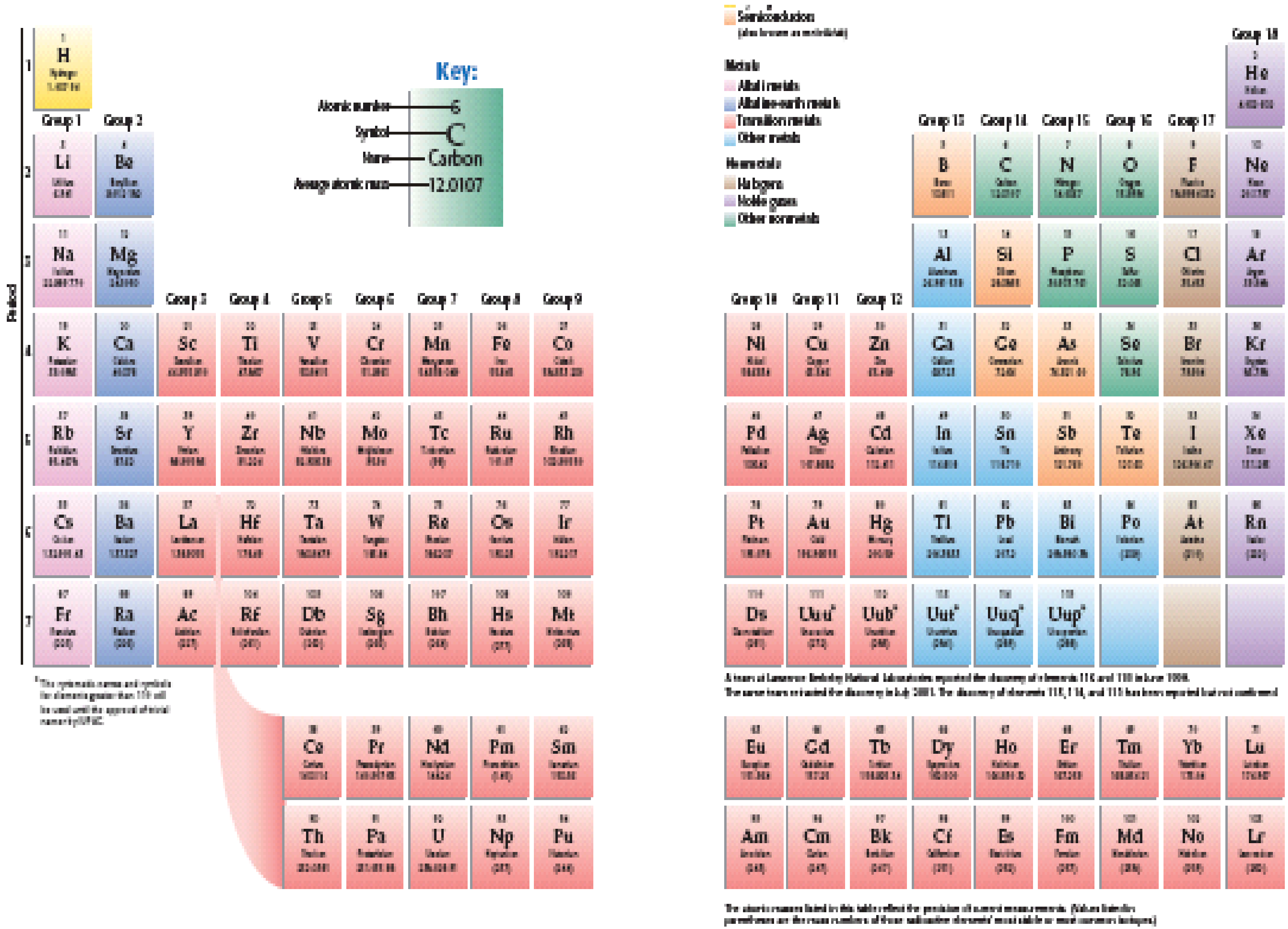
Organization of the Periodic Table

Characteristics of the Periodic Table

- Elements are arranged in order of increasing atomic number
- Elements with similar properties appear at regular intervals (“periods” or rows)
- Elements with similar properties fall in the same column (“group” or “family”)

Periods (rows)

Families / groups

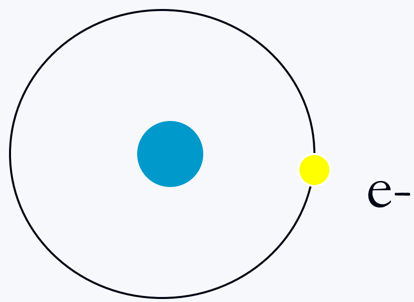


Organization of the Periodic Table

- **Metals – excellent conductors of heat & electricity**
  - Alkali metals – Group 1
  - Alkaline-earth metals – Group 2
  - Transition metals – Groups 3-12
- **Metalloids – properties of metals & non-metals (along zigzag)**
- **Non-Metals- poor conductors of heat & electricity. Usually brittle solids or gases.**
  - Halogens – Group 17
  - Noble gases – Group 18
  - Other solid non-metals – above metalloids

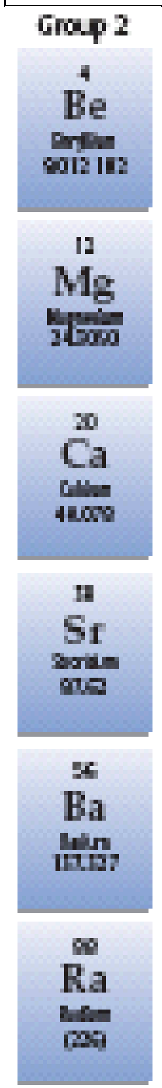
Alkali Metals

- Group 1 of the Periodic Table
- All have 1 valence electron

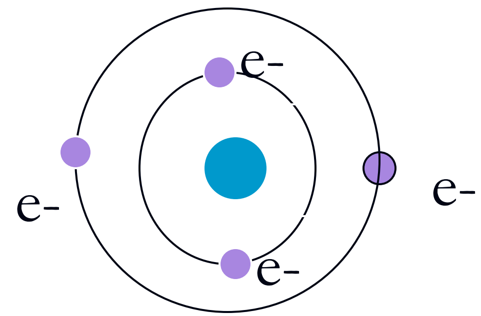


- Highly reactive (with water)
- Silvery in appearance
- Soft enough to be cut with a knife

Alkaline-Earth Metals

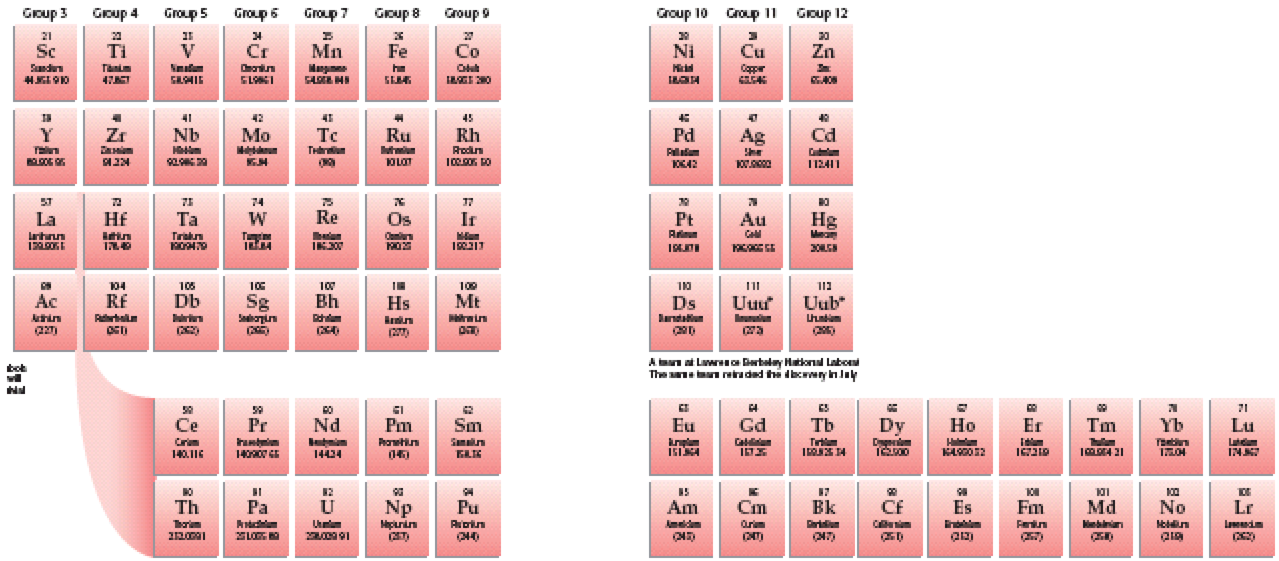


- Group 2 of the Periodic Table
- All have 2 valence electrons

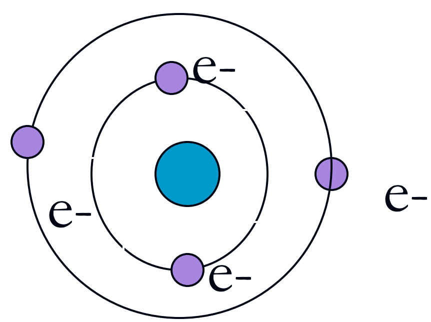


- Harder, denser, stronger the alkali metals
- Also reactive, but not as much as alkali metals

Transition Metals

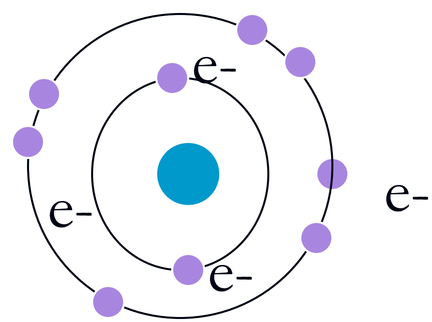


- Groups 3-12 of the periodic table
- All have 2 valence electrons



Halogens

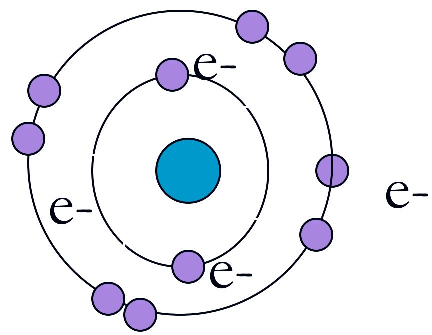
- Group 17 of the Periodic Table
- All have 7 valence electrons



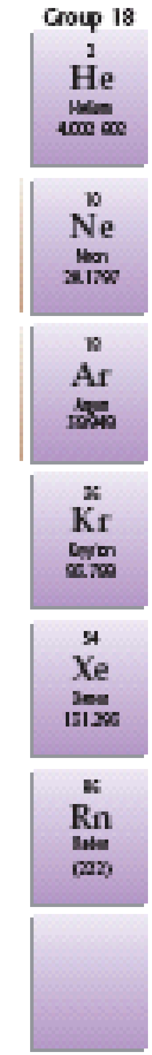
- Despite chemical similarities, some are solids, liquids, and gases
- Most reactive non-metals
- React with metals to make salts

Noble Gases

- Group 18 of the Periodic Table
- All have 8 valence electrons, a complete octet



- Total lack of reactivity, inert
  - "too *noble* to react with anyone else"



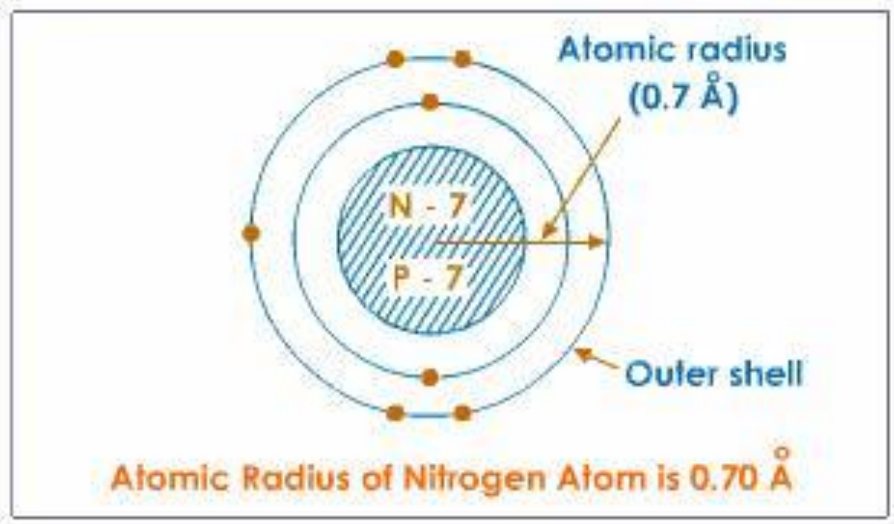
PERIODIC TRENDS

Periodic Trends

- Characteristics of elements are predictable based on their location on the Periodic Table.
- These characteristics are dependent on the structure of the atom and the location of its electrons.
- Periodic Trends include:
  - Reactivity
  - Atomic radius (size)
  - Ionization energy
  - Electronegativity

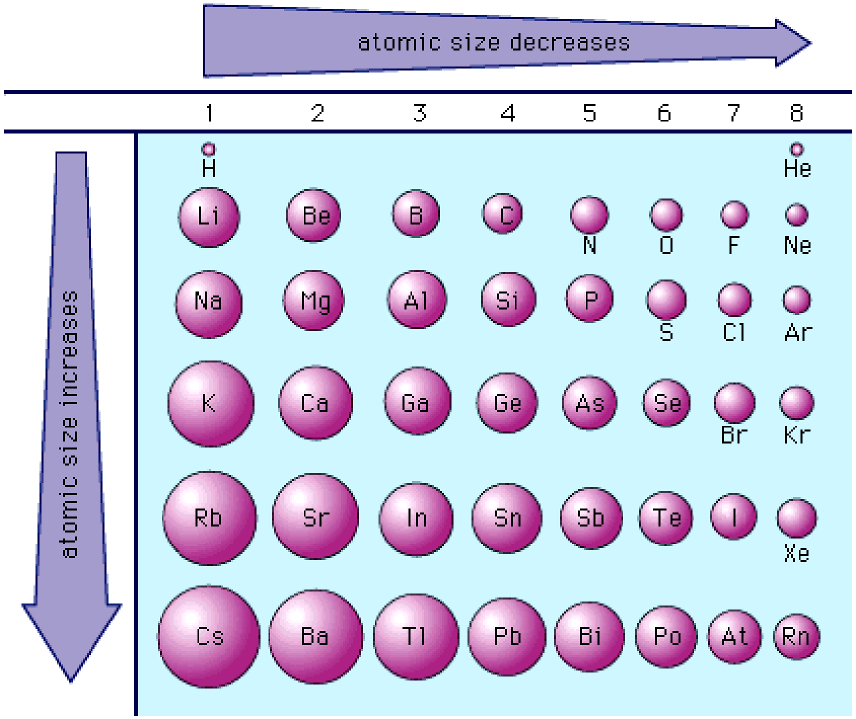
Atomic Radii

- Size of the atom – measured using half the distance between the nuclei of two identical atoms bonded together
- Trend – decreases across a period, increases down a group



- Largest atom = Francium
- Smallest atoms = Helium

Atomic Radii



- As you move across a period, you are adding electrons to the same energy level, but also adding more protons
  - These protons attract the electron cloud closer, decreasing the atomic radius.
- As you move down a group, you add energy levels.
  - Each energy level is farther away from the nucleus, increasing the atomic radius.

Ionization Energy (IE)

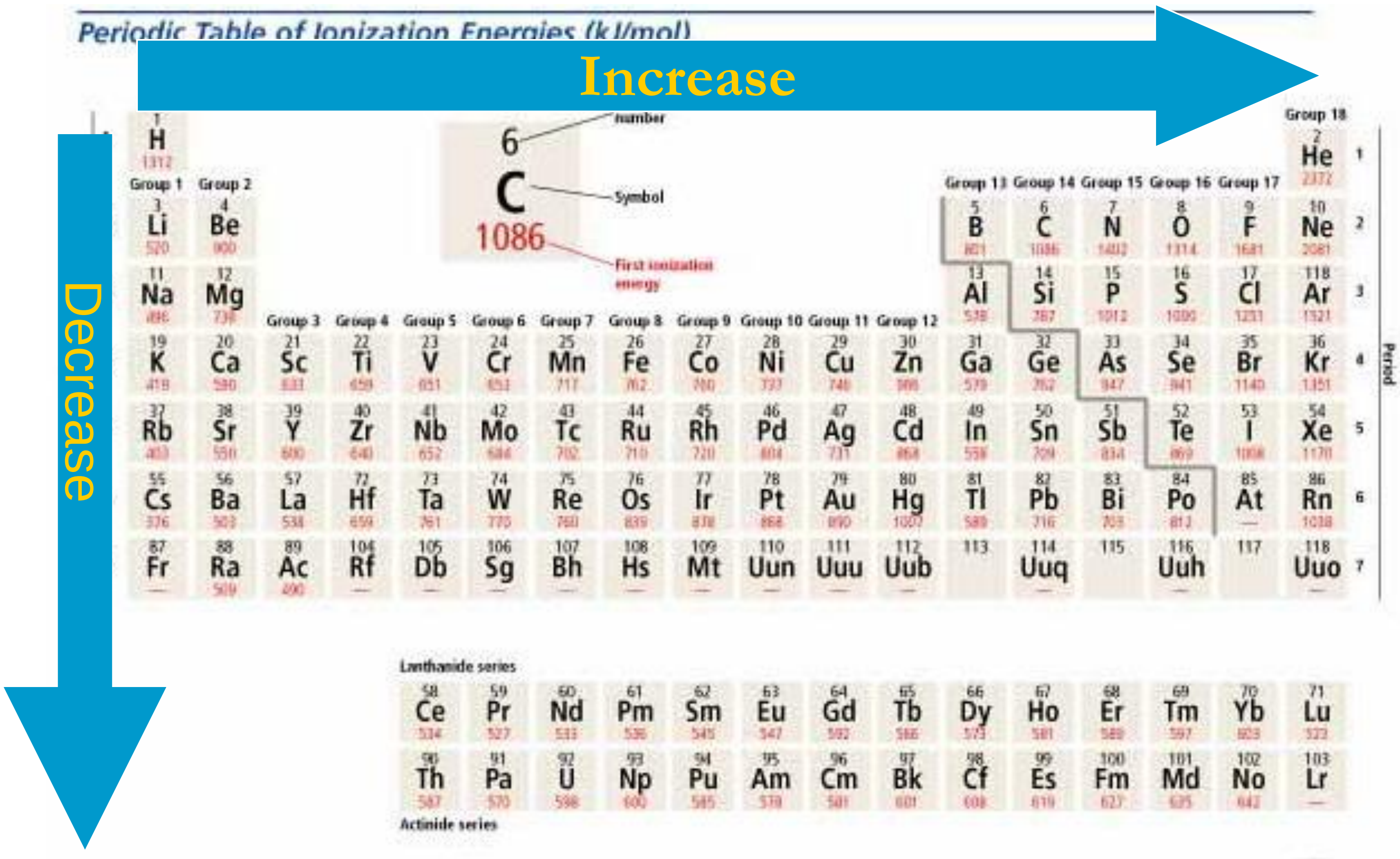
- The energy required to remove one electron from a neutral atom

Ex: Noble Gases require a **ton of energy** to lose an electron because they are "happy" with their full shells

Ex: Alkali Metals have **low ionization** energies because they want to lose their outer electron.

- Trend – increases across a period, decreases down a group

Ionization Energy



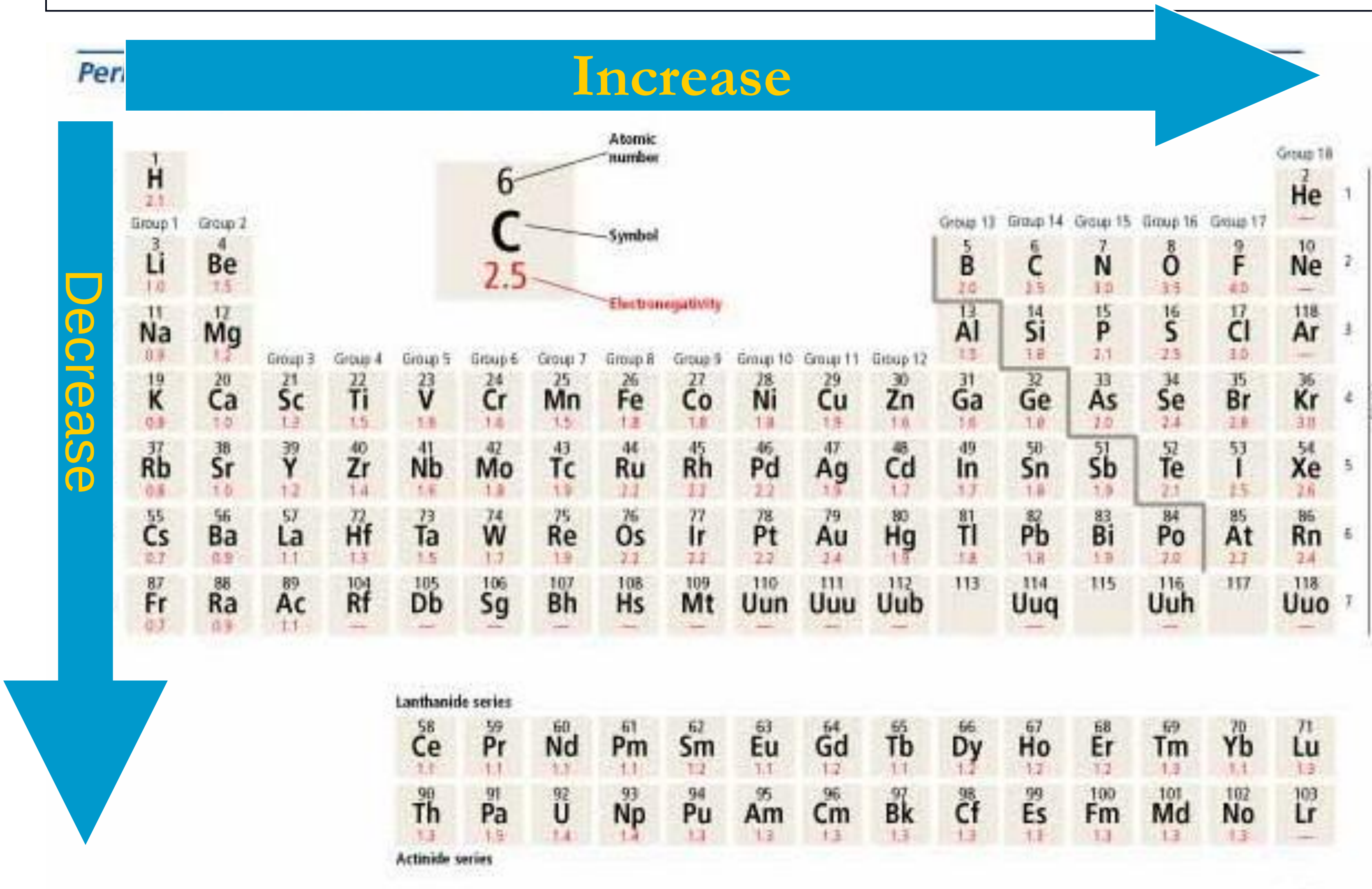
Electronegativity

- The ability of an atom to attract electrons (how "greedy" it is)

Ex: Flourine really wants another electron to get to the octet rule so it has a very high electronegativity. Anything close to Fluorine will have a high electronegativity

- Trend – increase across a period, decrease down a group

Electronegativity



Heavy metal (joke)
thinkgeek.com

Mental_Floss magazine