Atomic Theory

Where it came from and what we know now

History of the Atom

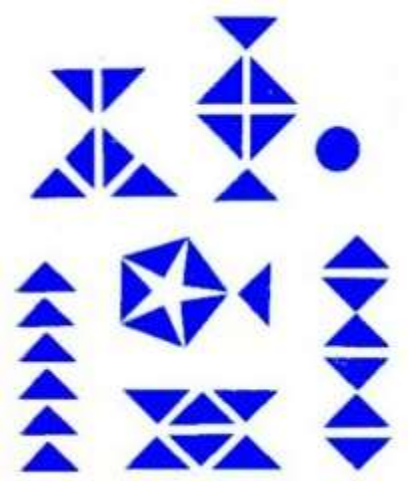
The first mention of the atom came from Democritus in ancient Greece

He suggested that the universe was made up of small, indivisible units called atoms

460-370 (BC)

He believed that the differences in the atoms had to do with their shape, and that these differing shapes gave them their properties

Unfortunately, he had no evidence for his theory. He was a philosopher…all they do is think…



History of the Atom

1766-1844

The next big step in atomic theory came from John Dalton

He noticed that all atoms of a certain element were exactly the same and that when different atoms combined, they formed new compounds.

He observed the reactions of chemicals with each other and saw that they consistently combined the same way.

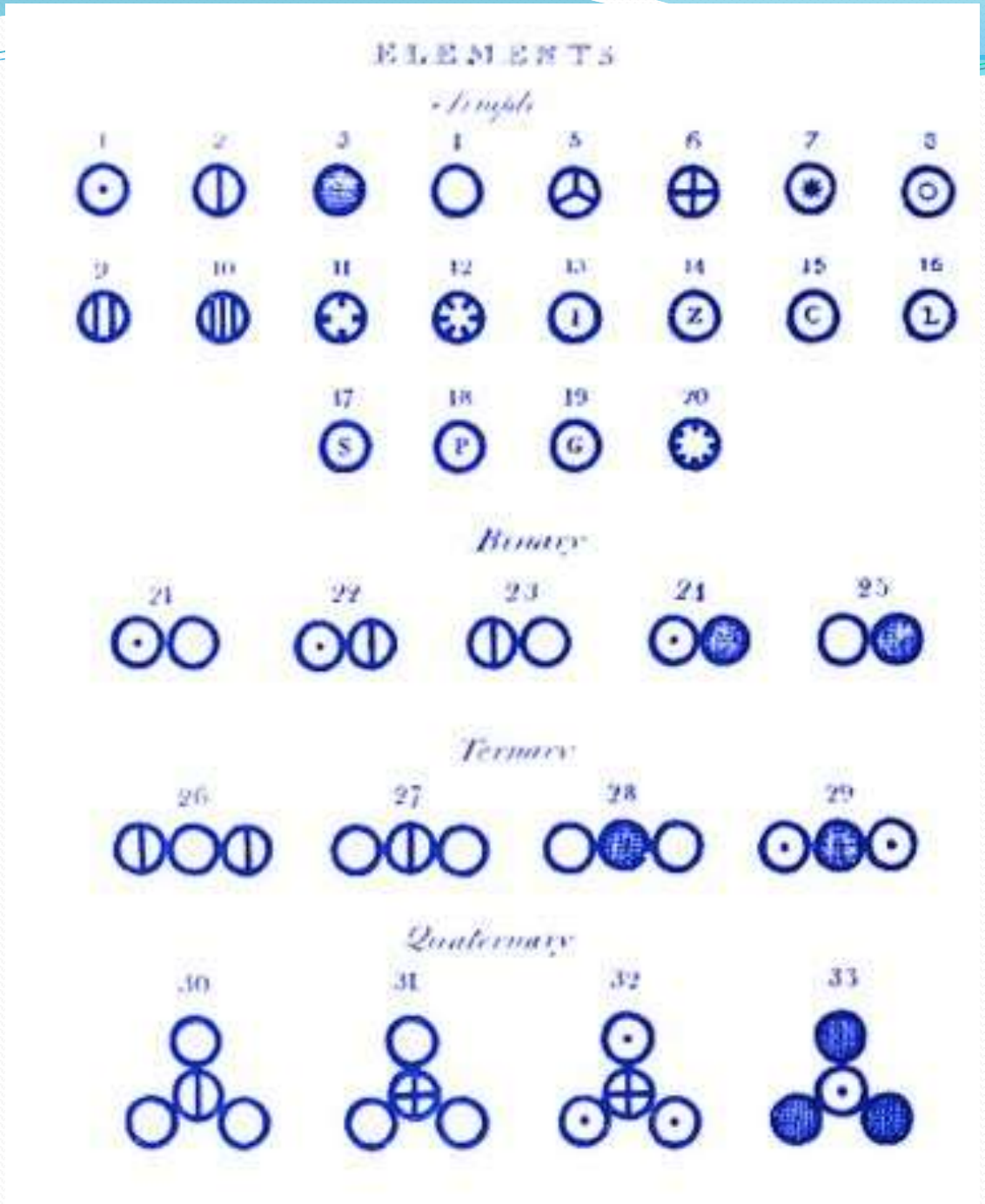
1 = Hydrogen

2= Nitrogen

3= Carbon

4= Oxygen

Etc.



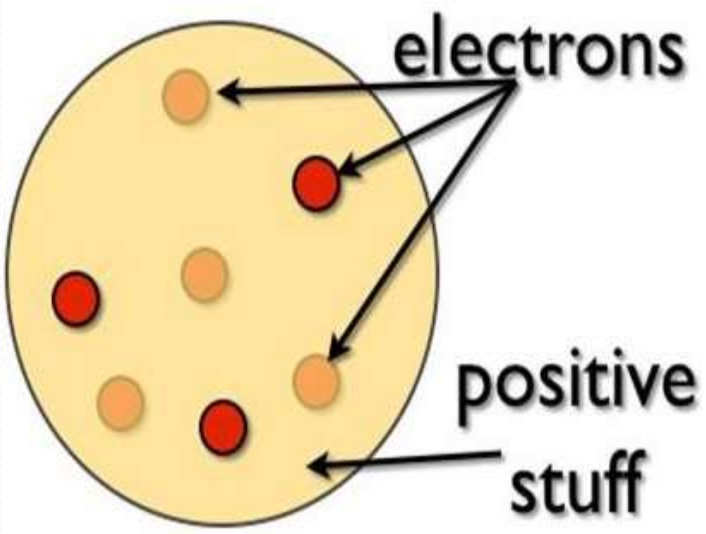
History of the Atom

J. J. Thomson discovered the presence of negatively charged particles of an atom

His Cathode Ray Tube experiment allowed him to discover that, when the cathode ray was introduced to a magnetic field, the ray would deflect towards the positive terminal

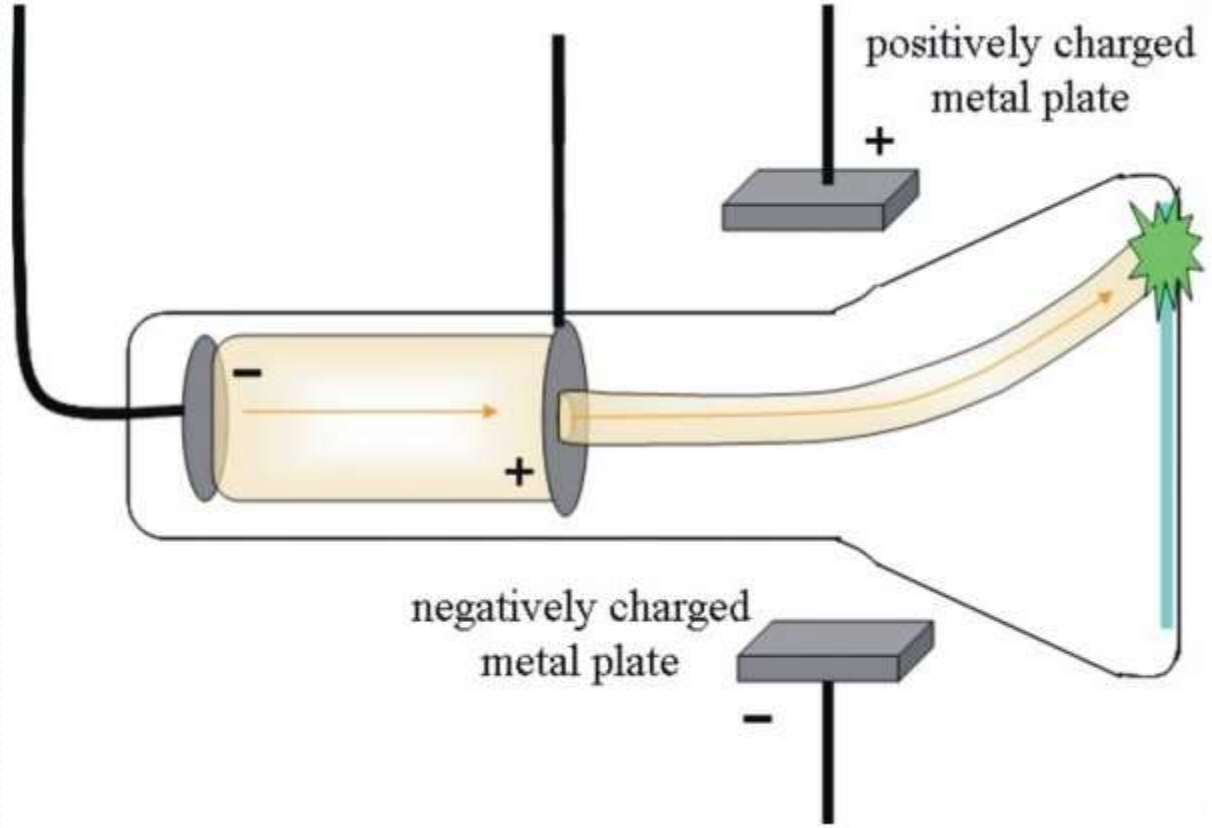
He created the "plum pudding" theory of the atom, where the raisins in the pudding represented the electrons

1856-1940



History of the Atom

1856-1940



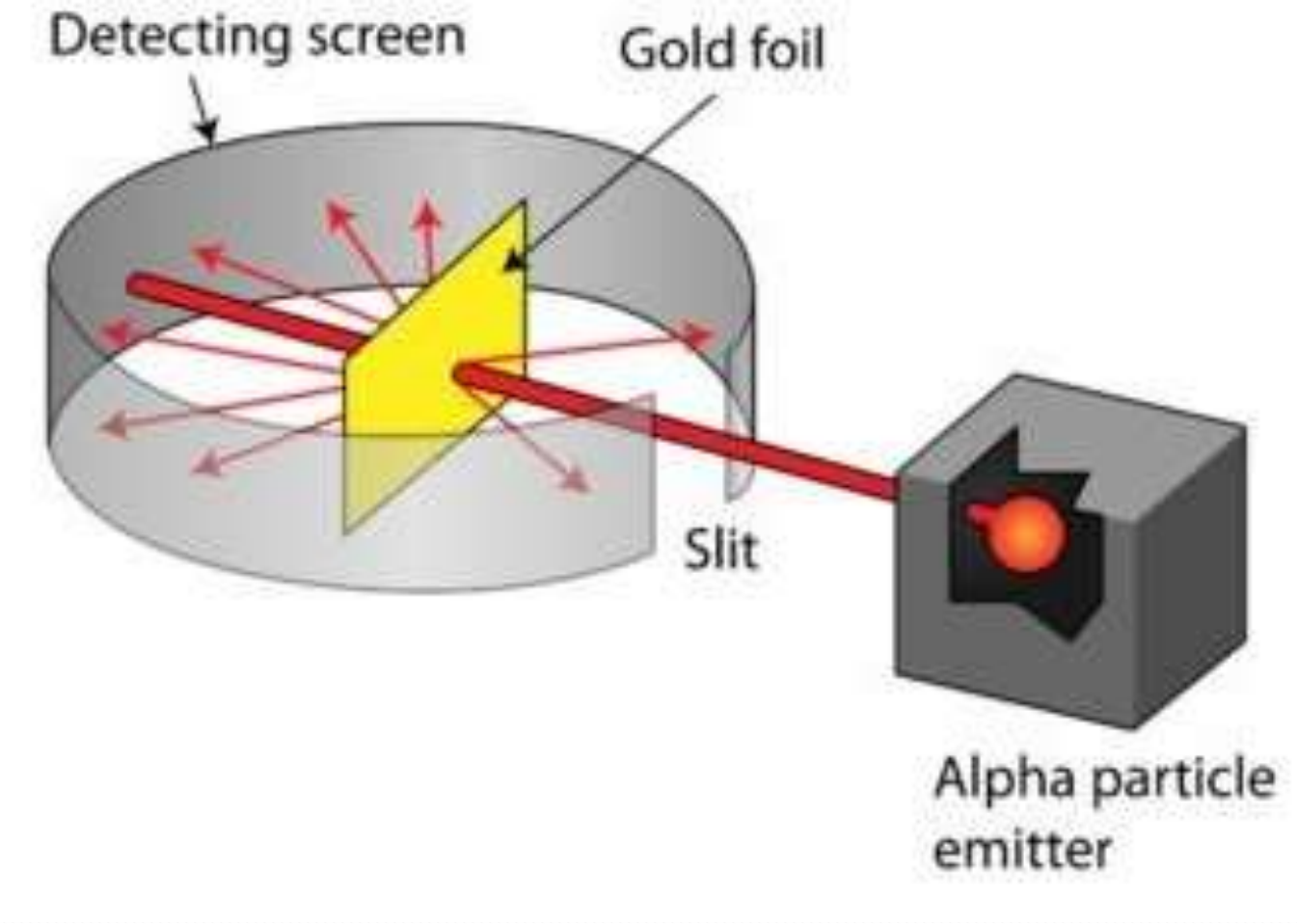
Cathode Ray Tube Experiment

History of the Atom

1871-1937

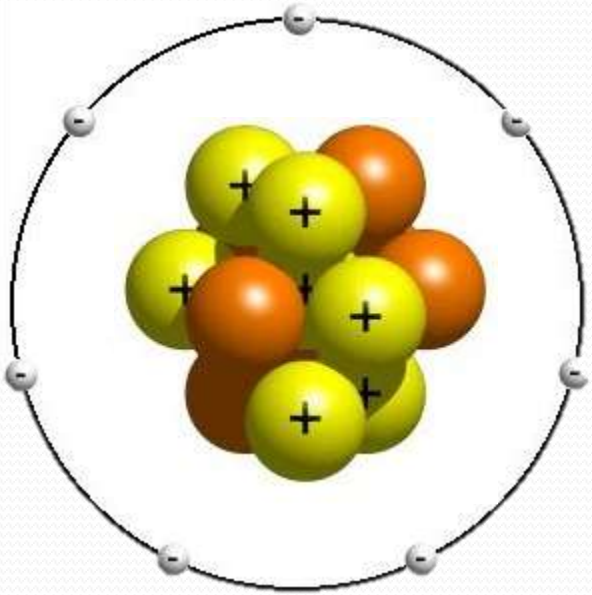
Earnest Rutherford, using alpha particles and gold foil, discovered that most of the mass of an atom was centrally located

History of the Atom



What the atom now looks like!

1. The universe is made up of tiny indivisible units, we now call atoms



2. All atoms of the same element are exactly alike, and can combine with other elements to create compounds

3. Atoms have negatively charged particles

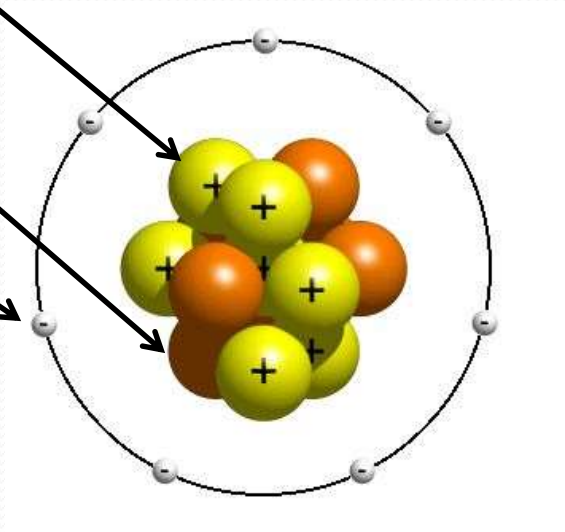
4. Most of the mass of an atom is concentrated at the center

What is the atom composed of?

Protons – Positively charged, located in the nucleus

Neutrons – No charge, located in the nucleus

Electrons – Negative Charge, Located in the electron cloud



What is the atom made up of?

Protons – Positively charged, located in the nucleus

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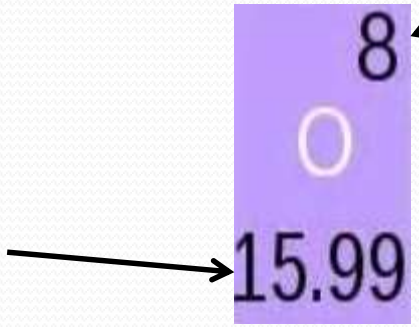
Particle	Charge	Mass (Kg)	Location in the atom
Proton	+1	1.67×10^{-27}	Nucleus
Neutron	0	1.67×10^{-27}	Nucleus
Electron	-1	9.11×10^{-31}	Electron cloud

What do the protons tell us about the element?

Protons tell us what element it is. It is the atomic number.

Oxygen has 8 protons

The atomic mass of oxygen is 16. It has 8 neutrons, on average



Neutrons add mass to the atom. To get the atomic mass, you add the number of protons to the number of neutrons. The number of neutrons in an atom is not constant.

What they tell us about the atom

If an atom has a different number of neutrons than the stable element, it is said to be an isotope. The atomic mass is a ratio of all of the isotopes that naturally exist in the world

Why are electrons so important?

Electrons are found in what is known as the electron cloud. The cloud consists of different energy orbitals.

The specific location of each electron is unknowable since they are constantly transitioning from one orbital to the next.

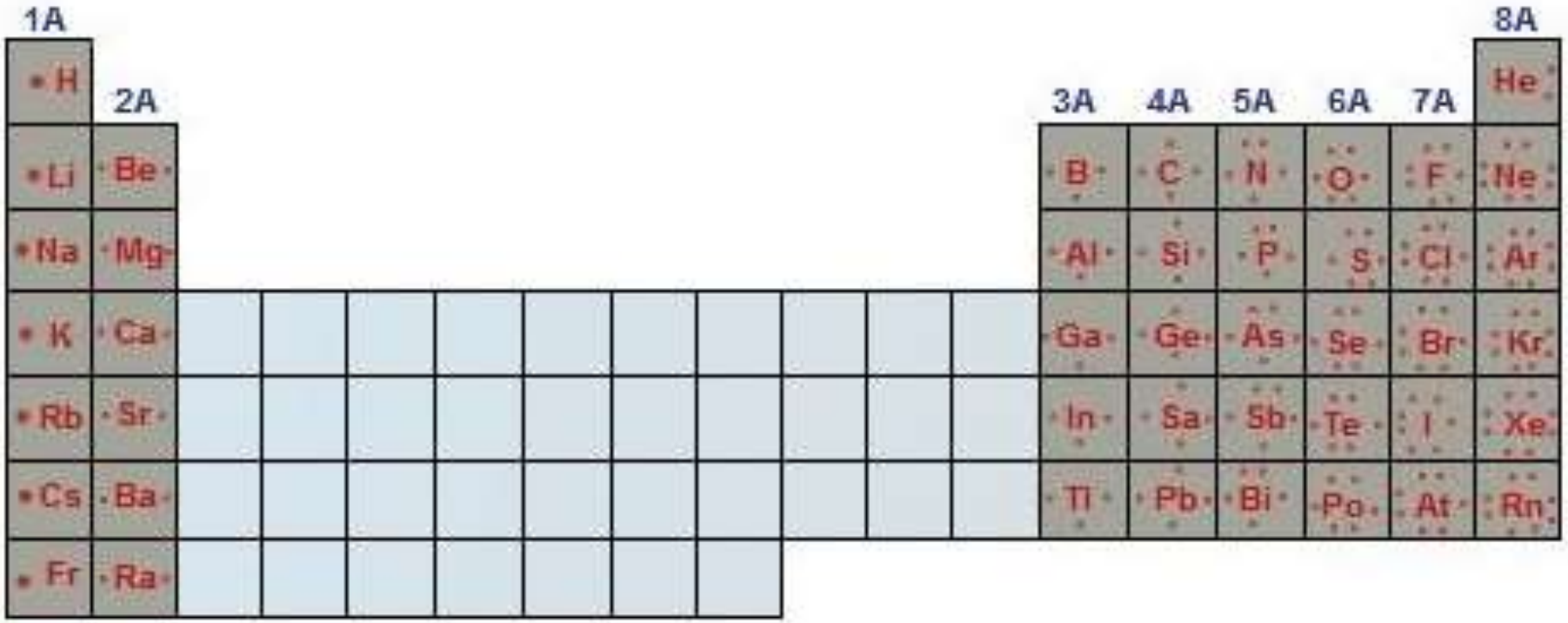
Valence electrons

The valence electrons are located on the outer most orbital of the electron, and can be determined by which group of the periodic table they reside in.

How many valence electrons an element has determines its reactivity

Valence electrons

As we move from left to right across the groups, we increase our valence electrons



What does this tell us?

Atoms want to be stable, and an atom is most stable when its outer shell is full. A full shell has 8 electrons.

Valence Electrons

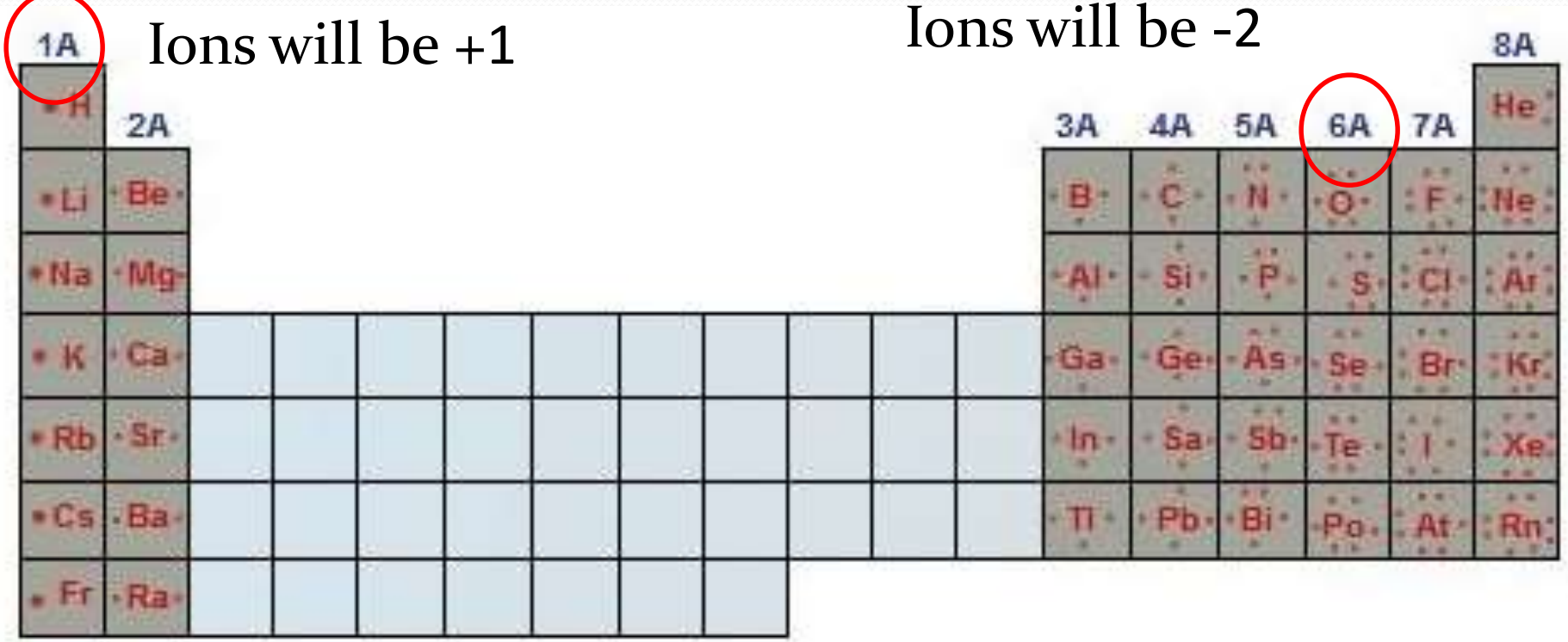
Lets look at the first period.

1 Valence electron

Ions will be +1

6 Valence electrons

Ions will be -2

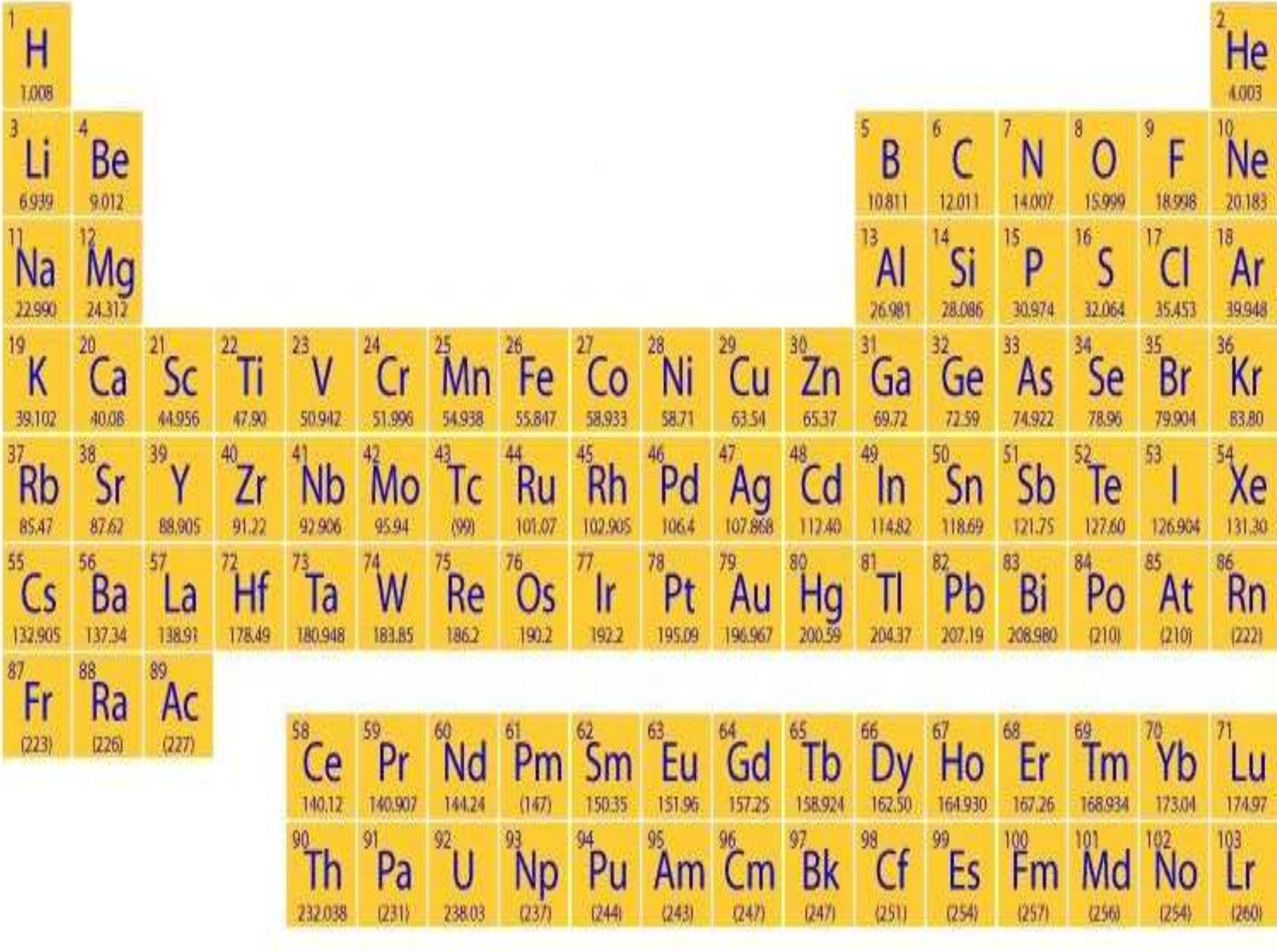


A new way to look at mass

Moles: The S.I. base unit we use to measure the amount of a substance.

1 mole is defined as the number of atoms in 12 grams of carbon-12

There are 6.022×10^{23} atoms in 12 grams of carbon-12. this is known as Avogadro's number


1 H 1.008
2 He 4.003
3 Li 6.939
4 Be 9.012
5 B 10.811
6 C 12.011
7 N 14.007
8 O 15.999
9 F 18.998
10 Ne 20.183
11 Na 22.990
12 Mg 24.312
13 Al 26.981
14 Si 28.086
15 P 30.974
16 S 32.064
17 Cl 35.453
18 Ar 39.948
19 K 39.102
20 Ca 40.08
21 Sc 44.956
22 Ti 47.90
23 V 50.942
24 Cr 51.996
25 Mn 54.938
26 Fe 55.847
27 Co 58.933
28 Ni 58.71
29 Cu 63.54
30 Zn 65.37
31 Ga 69.72
32 Ge 72.59
33 As 74.922
34 Se 78.96
35 Br 79.904
36 Kr 83.80
37 Rb 85.47
38 Sr 87.62
39 Y 88.905
40 Zr 91.22
41 Nb 92.906
42 Mo 95.94
43 Tc (99)
44 Ru 101.07
45 Rh 102.905
46 Pd 106.4
47 Ag 107.868
48 Cd 112.40
49 In 114.82
50 Sn 118.69
51 Sb 121.75
52 Te 127.60
53 I 126.904
54 Xe 131.30
55 Cs 132.905
56 Ba 137.34
57 La 138.91
72 Hf 178.49
73 Ta 180.948
74 W 183.85
75 Re 186.2
76 Os 190.2
77 Ir 192.2
78 Pt 195.09
79 Au 196.967
80 Hg 200.59
81 Tl 204.37
82 Pb 207.19
83 Bi 208.980
84 Po (210)
85 At (210)
86 Rn (222)
87 Fr (223)
88 Ra (226)
89 Ac (227)
58 Ce 140.12
59 Pr 140.907
60 Nd 144.24
61 Pm (147)
62 Sm 150.35
63 Eu 151.96
64 Gd 157.25
65 Tb 158.924
66 Dy 162.50
67 Ho 164.930
68 Er 167.26
69 Tm 168.934
70 Yb 173.04
71 Lu 174.97
90 Th 232.038
91 Pa (231)
92 U 238.03
93 Np (237)
94 Pu (244)
95 Am (243)
96 Cm (247)
97 Bk (247)
98 Cf (251)
99 Es (254)
100 Fm (257)
101 Md (256)
102 No (254)
103 Lr (260)

Converting between mass and moles

Ex 1. Convert 2 moles of lead to mass:Type equation here.

$$\frac{2 \text{ Moles Pb}}{1 \text{ Mole Pb}} \left| \frac{207.19 \text{ g}}{} \right. = 414.38 \text{ g Pb}$$

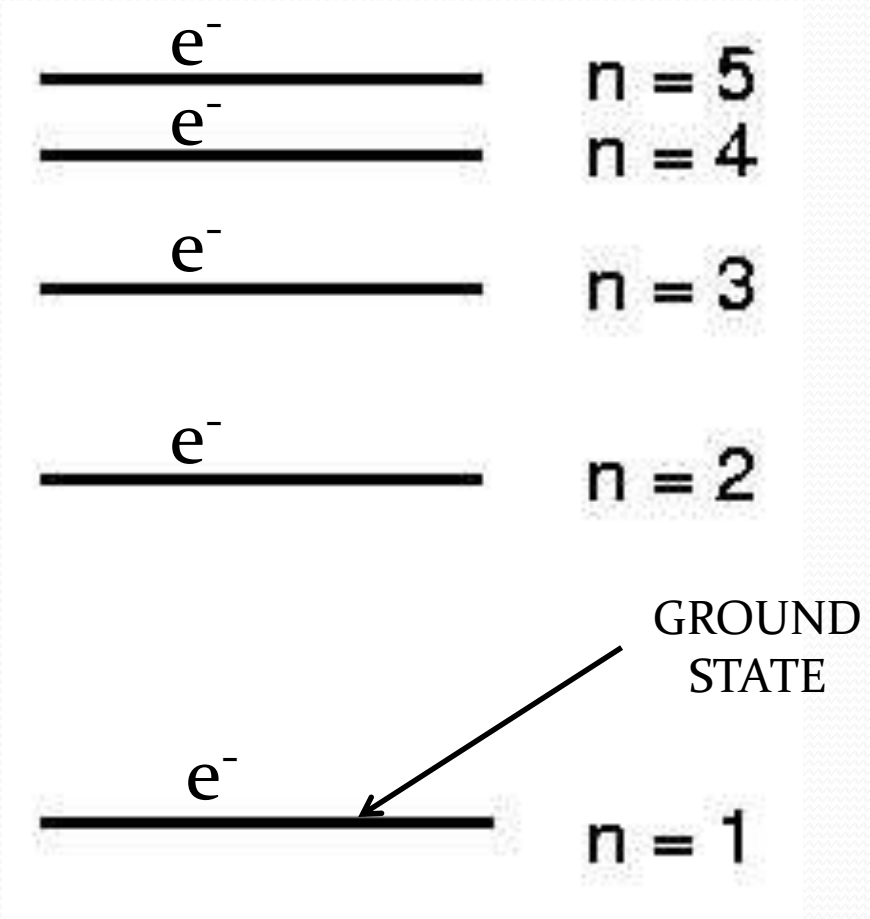
Ex 2. How many moles are there in 54.5 grams of carbon?

$$\frac{54.5 \text{ g C}}{12.011 \text{ g}} \left| \frac{1 \text{ Mole C}}{} \right. = 4.54 \text{ moles C}$$

Modern Atomic Theory

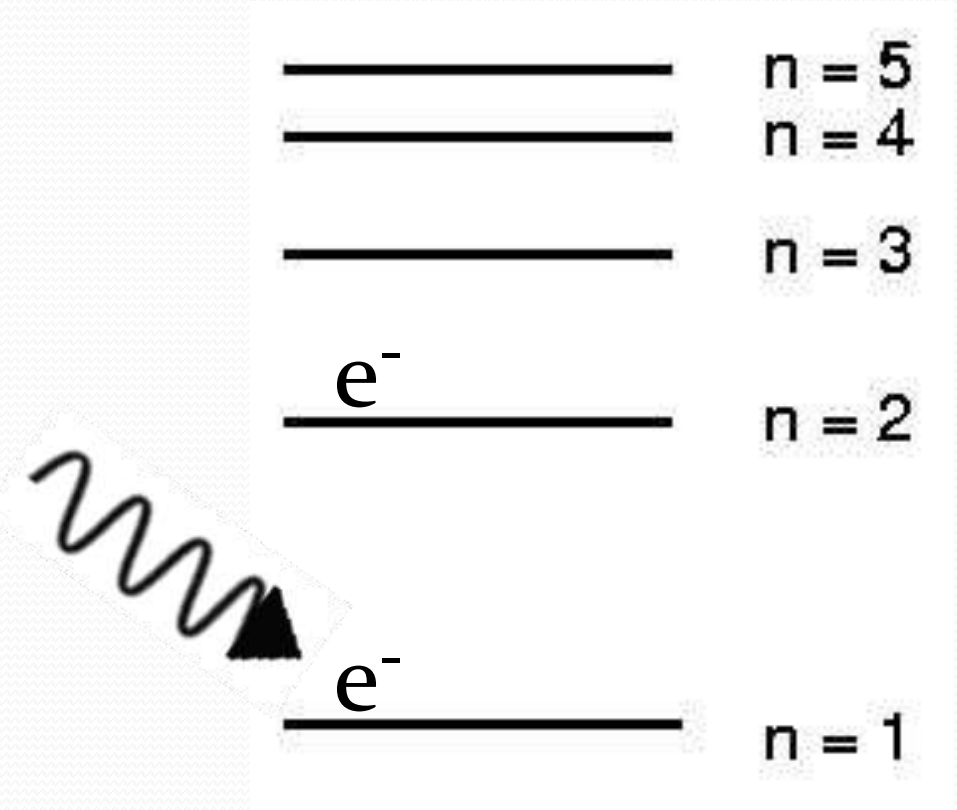
The atom is made up of a nucleus with protons and neutrons, and the electrons are in the electron cloud.

We now know that electrons exist is very specific energy levels; never in between.



Modern atomic Theory

The electrons jump from level to level when they are bombarded by photons and other energy sources



Modern Atomic Theory

The number of energy levels filled depends on the number of electrons present.

Energy level	Number of orbitals by type				Total number of orbitals	Number of electrons
	s	p	d	f		
1	1				1=1	2
2	1	3			1+3=4	8
3	1	3	5		1+3+5=9	18
4	1	3	5	7	1+3+5+7=16	32

Modern Atomic Theory

Element	Number of electrons	Orbital
Hydrogen (H)	1	$1s^1$
Carbon (C)	6	$1s^2\ 2s^2\ 2p^2$
Oxygen (O)	8	$1s^2\ 2s^2\ 2p^4$
Neon (Ne)	10	$1s^2\ 2s^2\ 2p^6$
Sulfur (S)	16	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
Potassium (K)	19	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

Modern Atomic Theory

Oxygen (O): $1s^2\ 2s^2\ 2p^4$