

Structure of the Atom



What is the Atom and what is it made of?

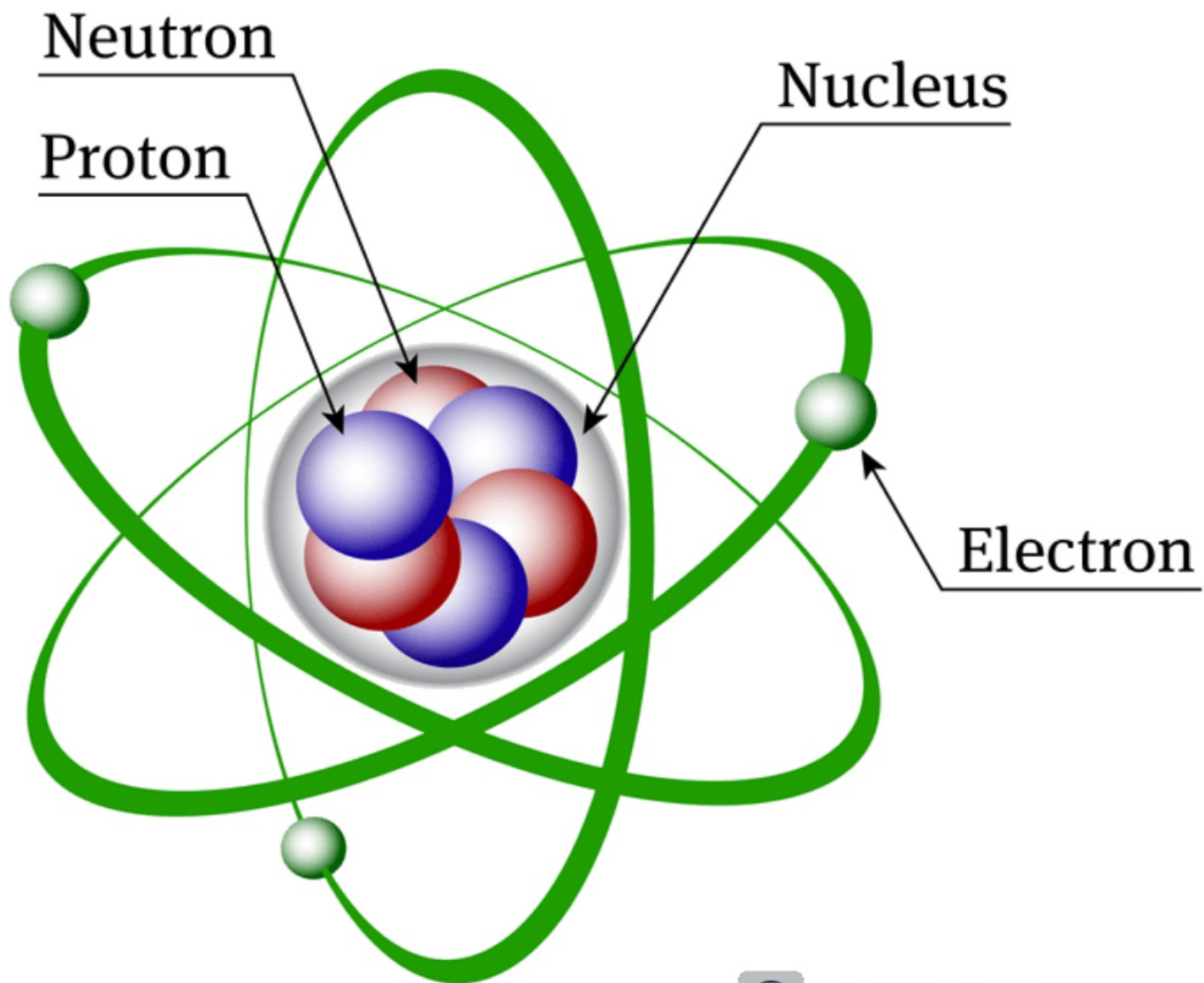
Proton

Neutron

Electron

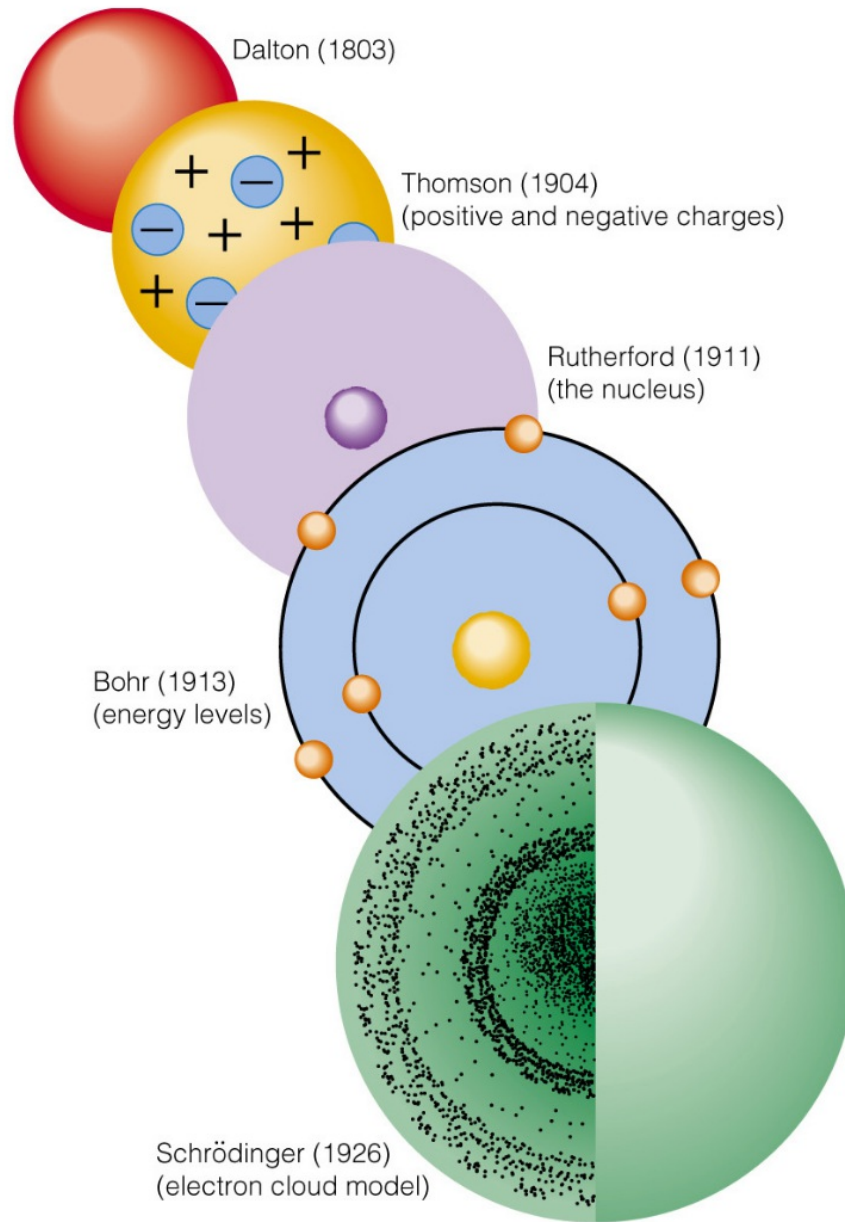
	Proton	Neutron	Electron
Symbol	p^+	0 or n	e^-
Where is it found?	Nucleus	Nucleus	Orbiting Nucleus
What is its charge?	Positive 1 (1+)	No Charge	Negative 1 (1-)

 **Neutron Joke**



 **Intro to Chem**

The Atomic Model - a timeline of discovery



~400 B.C.

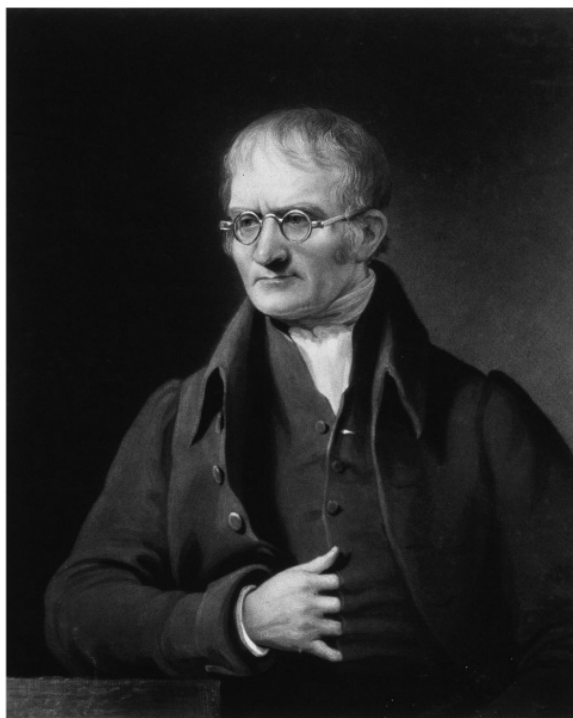
Democritus
(~460-370 B.C.)



- The Greek philosopher Democritus proposed the idea that elements consisted of tiny, solid particles that could not be subdivided.
- He called these particles "atomos", meaning "uncuttable."
- Aristotle criticized this theory because he didn't believe that empty space could exist and because of Aristotle, Democritus's atomic theory was rejected.

1808 A.D.

John Dalton
(1766-1844)



- John Dalton, an English scientist, published the book: *A New System of Chemical Philosophy* in which he outlined his theories on atomic structure
- Dalton's theory challenged the way matter was looked at for the last 2000 years.
- Dalton is known as the "godfather" of modern day Chemistry

Dalton's Atomic Theory:

1. Matter is composed of extremely small particles called atoms
2. Atoms are indivisible and indestructible
3. Atoms of a given element are identical in size, mass, and chemical properties
4. Atoms of a specific element are different from those of another element.
5. Different atoms combine in simple whole-numbers to form compounds.
6. In a chemical reaction, atoms are separated, combined, or rearranged.

1904 A.D.

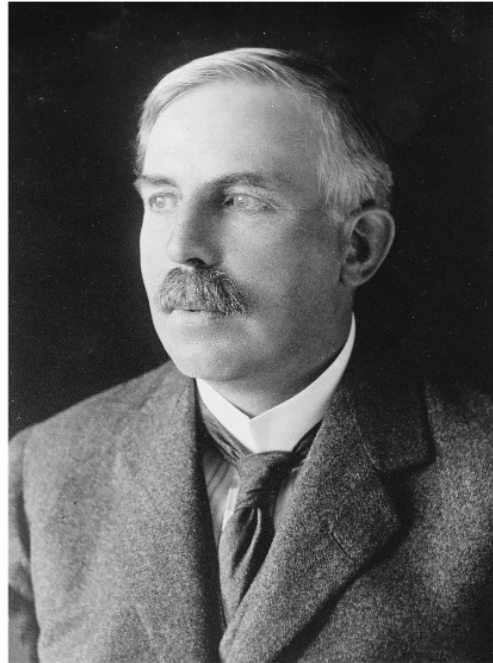
Joseph John Thomson
(1856-1940)



- Joseph John Thomson, an English physicist, proposed a model that consisted of a spherical atom containing small, negatively charged particles
- He thought that these "electrons" were evenly embedded in a positive sphere, much like chocolate chips in a ball of cookie dough.
- Overall though the atom is neutral - the positive sphere cancels out the negative electrons.

1911 A.D.

Ernest Rutherford
(1871-1937)



- Ernest Rutherford, a New Zealand-born English physicist
- Rutherford with German physicist Hans Geiger and undergraduate Ernest Marsden conducted an experiment to test Thomson's atomic model
- The results did not match Thomson's model so Rutherford theorized that the atom is mostly made up of empty space with a small positive nucleus in the center

1913 A.D.

Niels Bohr
(1885-1962)



- Niels Bohr a Danish physicist hypothesized that electrons travel in fixed orbitals around the nucleus.
- Bohr said that the electrons could jump between orbitals as they absorbed or released specific amounts of energy.
- Bohr's model of electron arrangement (more on this later)

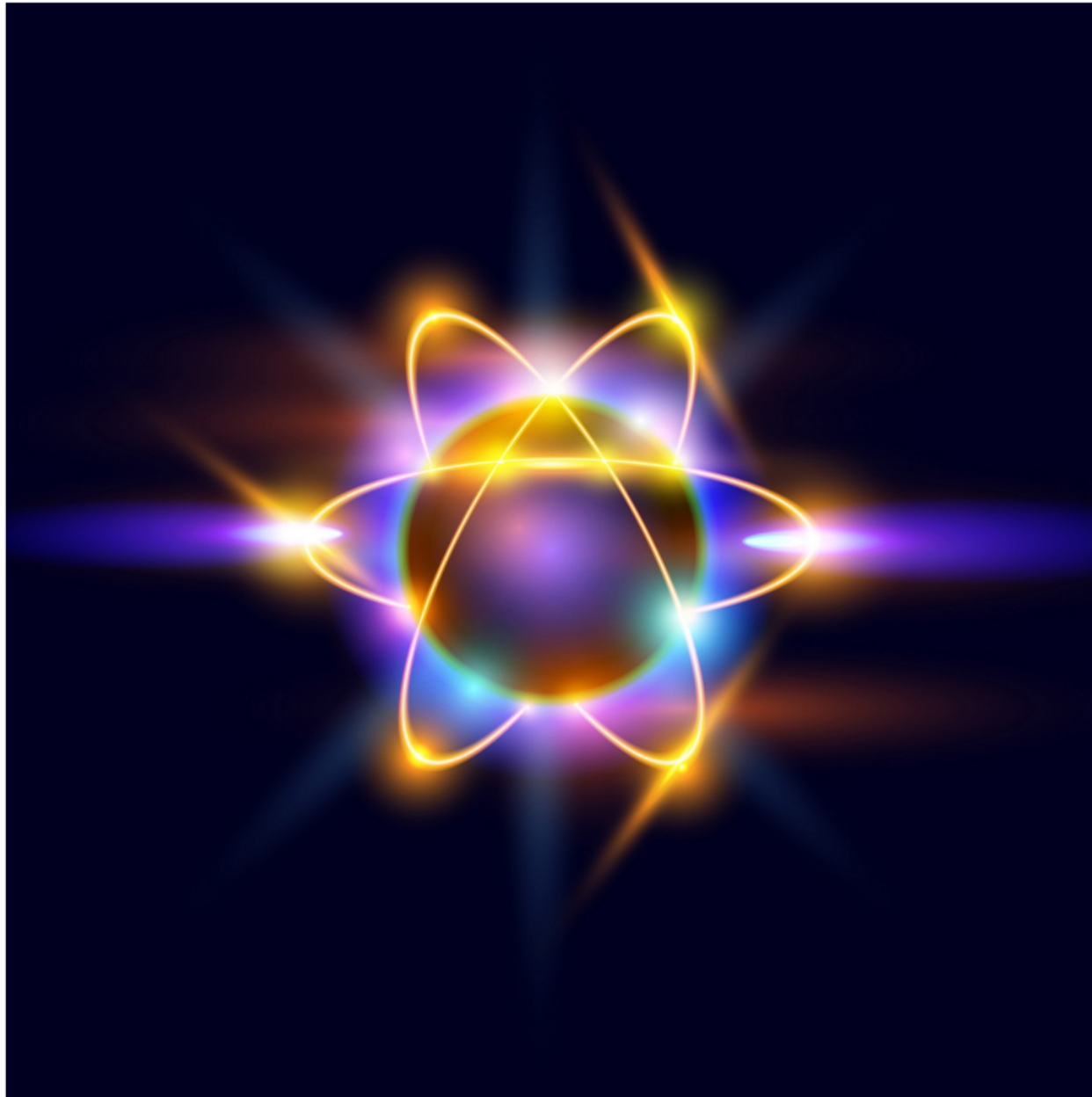
1926 A.D.

Erwin Schrodinger
(1887-1961)



- Erwin Schrodinger an Austrian physicist developed an equation that better helped explain the movement of electrons about the nucleus of the atom
- His work led to the discovery of the Electron Cloud

Masses of Atoms



Atomic Mass Unit

Mass of a Proton	1.6726×10^{-24} g
Mass of a Neutron	1.6749×10^{-24} g
Mass of an Electron	9.1093×10^{-28} g

- An Electron is 1,800 times smaller than either a Proton or Neutron
- Because the Electron's mass is so small, we can ignore it when calculating the mass of the atom
- Since Protons and Neutrons are almost the same exact size scientists simplified the number and said that each, proton and neutron, are equal to 1 AMU (Atomic Mass Unit)

Atomic Number

- is the number of protons present in the nucleus
- the protons identifies the type of atom

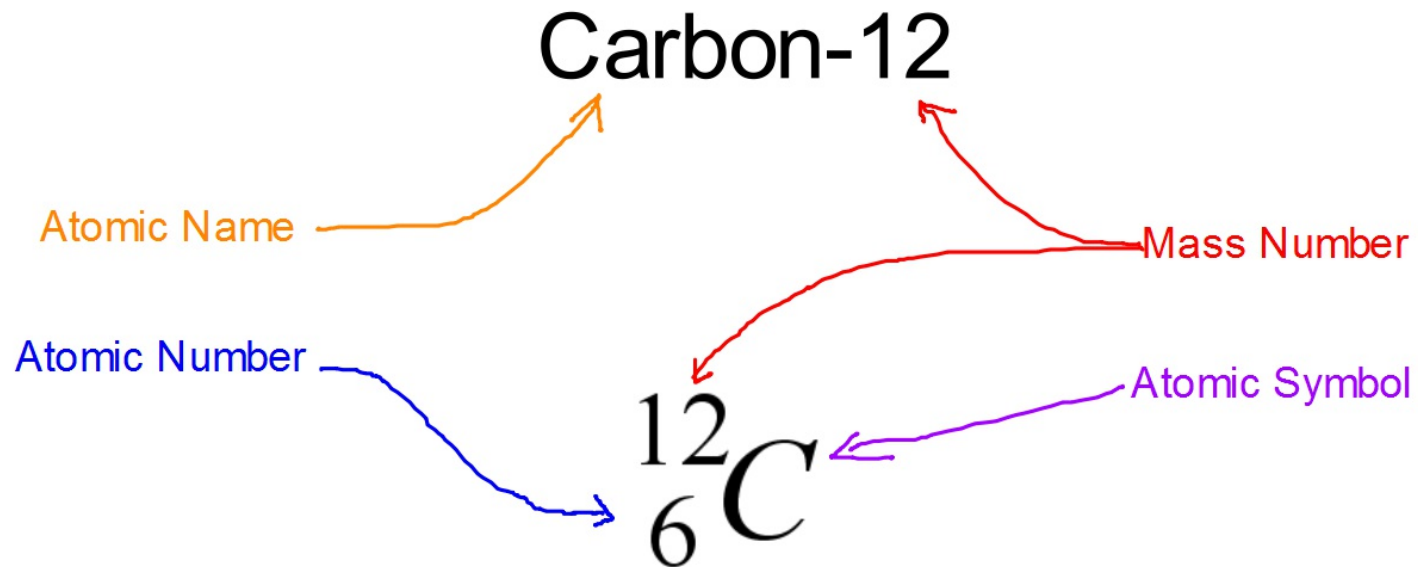
Mass Number

- is the sum of the number of protons and the number of neutrons in the nucleus of an atom

Mass number = number of protons + number of neutrons

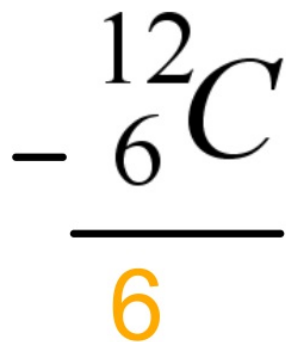
Isotopes

- are atoms of the same element that have different numbers of neutrons



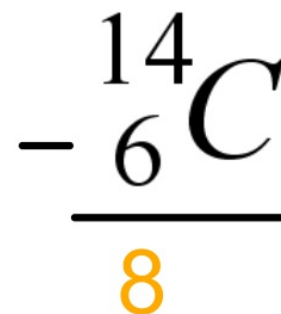
Carbon-12

$$6 + 6 = 12$$



Carbon-14

$$6 + 8 = 14$$



Mass Number

Atomic Number
(# of Protons)

Number of Neutrons

Average Atomic Mass

- is the weighted average mass of all naturally occurring isotopes of an element, measured in atomic mass units (amu), according to their natural abundances.
- Example:

In nature Boron exists naturally in two different isotopes, Boron-11 and Boron-10.

























































































































80% or four out of five atoms of Boron are Boron-11 and 20% or 1 out of five atoms of Boron are Boron-10.

The following calculations gives the weighted average of these two masses.

$$\frac{4}{5}(11\text{amu}) + \frac{1}{5}(10\text{amu}) = 10.8\text{amu}$$

The Periodic Table - Organizing the Elements

The Elements

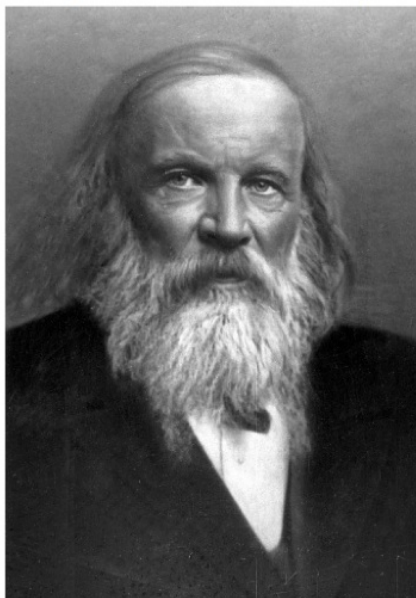
 H 1 Hydrogen																		 He 2 Helium						
 Li 3 Lithium	 Be 4 Beryllium																		 B 5 Boron	 C 6 Carbon	 N 7 Nitrogen	 O 8 Oxygen	 F 9 Fluorine	 Ne 10 Neon
 Na 11 Sodium	 Mg 12 Magnesium																		 Al 13 Aluminum	 Si 14 Silicon	 P 15 Phosphorus	 S 16 Sulfur	 Cl 17 Chlorine	 Ar 18 Argon
 K 19 Potassium	 Ca 20 Calcium	 Sc 21 Scandium	 Ti 22 Titanium	 V 23 Vanadium	 Cr 24 Chromium	 Mn 25 Manganese	 Fe 26 Iron	 Co 27 Cobalt	 Ni 28 Nickel	 Cu 29 Copper	 Zn 30 Zinc	 Ga 31 Gallium	 Ge 32 Germanium	 As 33 Arsenic	 Se 34 Selenium	 Br 35 Bromine	 Kr 36 Krypton							
 Rb 37 Rubidium	 Sr 38 Strontium	 Y 39 Yttrium	 Zr 40 Zirconium	 Nb 41 Niobium	 Mo 42 Molybdenum	 Tc 43 Technetium	 Ru 44 Ruthenium	 Rh 45 Rhodium	 Pd 46 Palladium	 Ag 47 Silver	 Cd 48 Cadmium	 In 49 Indium	 Sn 50 Tin	 Sb 51 Antimony	 Te 52 Tellurium	 I 53 Iodine	 Xe 54 Xenon							
 Cs 55 Cesium	 Ba 56 Barium	 La 57 Lanthanum	 Hf 72 Hafnium	 Ta 73 Tantalum	 W 74 Tungsten	 Re 75 Rhenium	 Os 76 Osmium	 Ir 77 Iridium	 Pt 78 Platinum	 Au 79 Gold	 Hg 80 Mercury	 Tl 81 Thallium	 Pb 82 Lead	 Bi 83 Bismuth	 Po 84 Polonium	 At 85 Astatine	 Rn 86 Radon							
 Fr 87 Francium	 Ra 88 Radium	 Ac 89 Actinium	 Rf 104 Rutherfordium	 Db 105 Dubnium	 Sg 106 Seaborgium	 Bh 107 Bohrium	 Hs 108 Hassium	 Mt 109 Meitnerium	 Ds 110 Darmstadtium	 Rg 111 Roentgenium	 Uub 112 Ununbium	 Uut 113 Ununtrium	 Uuq 114 Ununquadium	 Uup 115 Ununpentium	 Uuh 116 Ununhexium	 Uus 117 Ununseptium	 Uuo 118 Ununoctium							
 La 57 Lanthanum	 Ce 58 Cerium	 Pr 59 Praseodymium	 Nd 60 Neodymium	 Pm 61 Promethium	 Sm 62 Samarium	 Eu 63 Europium	 Gd 64 Gadolinium	 Tb 65 Terbium	 Dy 66 Dysprosium	 Ho 67 Holmium	 Er 68 Erbium	 Tm 69 Thulium	 Yb 70 Ytterbium	 Lu 71 Lutetium										
 Ac 89 Actinium	 Th 90 Thorium	 Pa 91 Protactinium	 U 92 Uranium	 Np 93 Neptunium	 Pu 94 Plutonium	 Am 95 Americium	 Cm 96 Curium	 Bk 97 Berkelium	 Cf 98 Californium	 Es 99 Einsteinium	 Fm 100 Fermium	 Md 101 Mendelevium	 No 102 Nobelium	 Lr 103 Lawrencium										

Photographs show samples of the pure or nearly pure element except as follows: H₂, O₂, N₂, F₂, and Ne which are shown as gases; He, Ar, Kr, and Xe which are shown as liquids; Br which is shown as a liquid; I which is shown as a solid; Po, At, Rn, Fr, Ra, and the transactinoids which are shown as hypothetical elements. The color and texture of the elements are shown as they appear in nature, except as noted. The elements are listed in order of increasing atomic number.

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1864 A.D.

Dmitri Mendeleev
(1834-1907)



- A Russian chemist named Dmitri Mendeleev presented a way to organize all the known elements (at that time).
- He found that the physical and chemical properties repeated based on a predictable pattern associated with elements atomic masses.
- Mendeleev left blank spots in his table for elements that were not yet discovered.

1913 A.D.

Henry G.J. Moseley
(1887-1915)



- An English Scientist named Henry G.J. Moseley rearranged all the known elements based on increasing atomic number instead of atomic masses.
- This arrangement helped to solve the problem with fluctuating masses.
- This is the modern arrangement of the periodic table.

Periodic Table of the Elements

1 hydrogen 1 H 1.0079																	18 helium 2 He 4.0026	
2 lithium 3 Li 6.941	2 beryllium 4 Be 9.0122											13 boron 5 B 10.811	14 carbon 6 C 12.011	15 nitrogen 7 N 14.007	16 oxygen 8 O 15.999	17 fluorine 9 F 18.998	18 neon 10 Ne 20.180	
11 sodium 11 Na 22.990	12 magnesium 12 Mg 24.305											13 aluminum 13 Al 26.982	14 silicon 14 Si 28.086	15 phosphorus 15 P 30.974	16 sulfur 16 S 32.065	17 chlorine 17 Cl 35.453	18 argon 18 Ar 39.948	
19 potassium 19 K 39.098	20 calcium 20 Ca 40.078	3 scandium 21 Sc 44.956	4 titanium 22 Ti 47.867	5 vanadium 23 V 50.942	6 chromium 24 Cr 51.996	7 manganese 25 Mn 54.938	8 iron 26 Fe 55.845	9 cobalt 27 Co 58.933	10 nickel 28 Ni 58.693	11 copper 29 Cu 63.546	12 zinc 30 Zn 65.39	31 gallium 31 Ga 69.723	32 germanium 32 Ge 72.61	33 arsenic 33 As 74.922	34 selenium 34 Se 78.96	35 bromine 35 Br 79.904	36 krypton 36 Kr 83.80	
37 rubidium 37 Rb 85.468	38 strontium 38 Sr 87.62	39 yttrium 39 Y 88.906	40 zirconium 40 Zr 91.224	41 niobium 41 Nb 92.906	42 molybdenum 42 Mo 95.94	43 technetium 43 Tc [98]	44 ruthenium 44 Ru 101.07	45 rhodium 45 Rh 102.91	46 palladium 46 Pd 106.42	47 silver 47 Ag 107.87	48 cadmium 48 Cd 112.41	49 indium 49 In 114.82	50 tin 50 Sn 118.71	51 antimony 51 Sb 121.76	52 tellurium 52 Te 127.60	53 iodine 53 I 126.90	54 xenon 54 Xe 131.29	
55 caesium 55 Cs 132.91	56 barium 56 Ba 137.33	57-70 lanthanide series ■	71 lutetium 71 Lu 174.97	72 hafnium 72 Hf 178.49	73 tantalum 73 Ta 180.95	74 tungsten 74 W 183.84	75 rhenium 75 Re 186.21	76 osmium 76 Os 190.23	77 iridium 77 Ir 192.22	78 platinum 78 Pt 195.08	79 gold 79 Au 196.97	80 mercury 80 Hg 200.59	81 thallium 81 Tl 204.38	82 lead 82 Pb 207.2	83 bismuth 83 Bi 208.98	84 polonium 84 Po [209]	85 astatine 85 At [210]	86 radon 86 Rn [222]
87 francium 87 Fr [223]	88 radium 88 Ra [226]	89-102 actinide series ■	103 lawrencium 103 Lr [262]	104 rutherfordium 104 Rf [261]	105 dubnium 105 Db [262]	106 seaborgium 106 Sg [266]	107 bohrium 107 Bh [264]	108 hassium 108 Hs [269]	109 meitnerium 109 Mt [268]	110 darmstadtium 110 Ds [271]	111 roentgenium 111 Rg [272]	112 ununbium 112 Uub [277]	113 ununtrium 113 Uut [284]	114 ununquadium 114 Uuq [289]	115 ununpentium 115 Uup [288]	116 ununhexium 116 Uuh [292]	117 ununseptium 117 Uus [291]	118 ununoctium 118 Uuo [294]

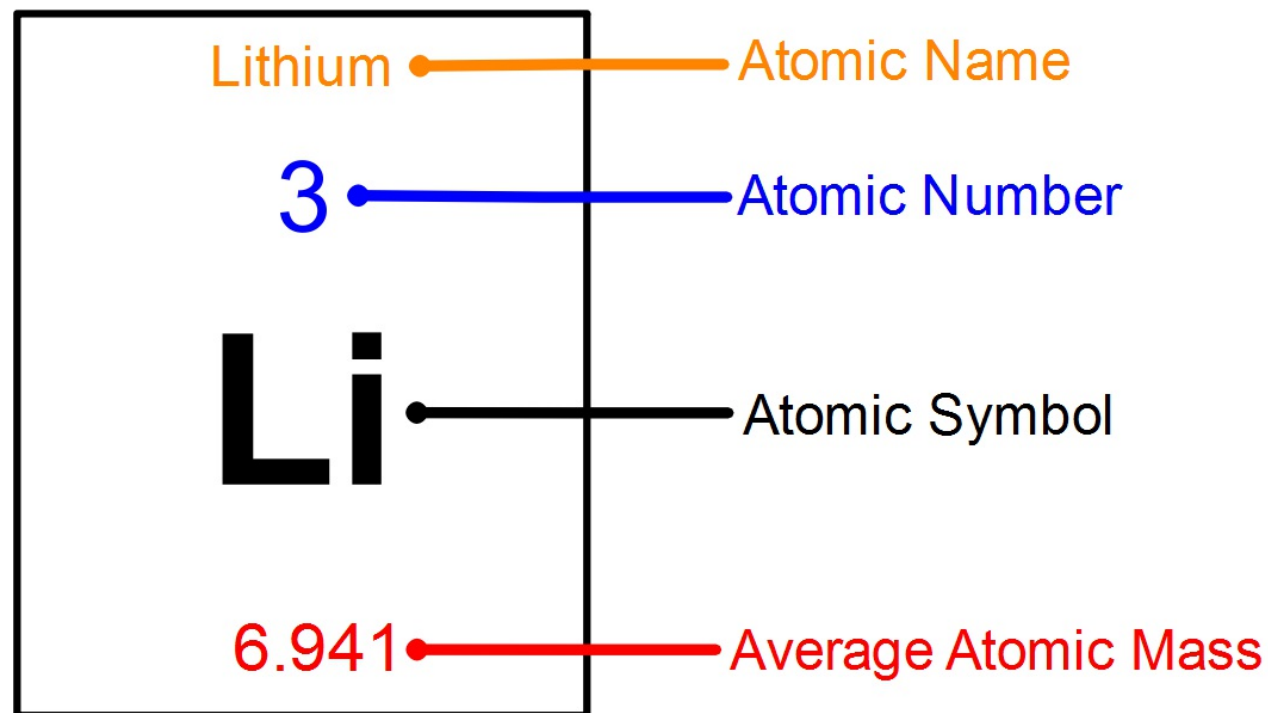
■ Lanthanide series

■ Actinide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

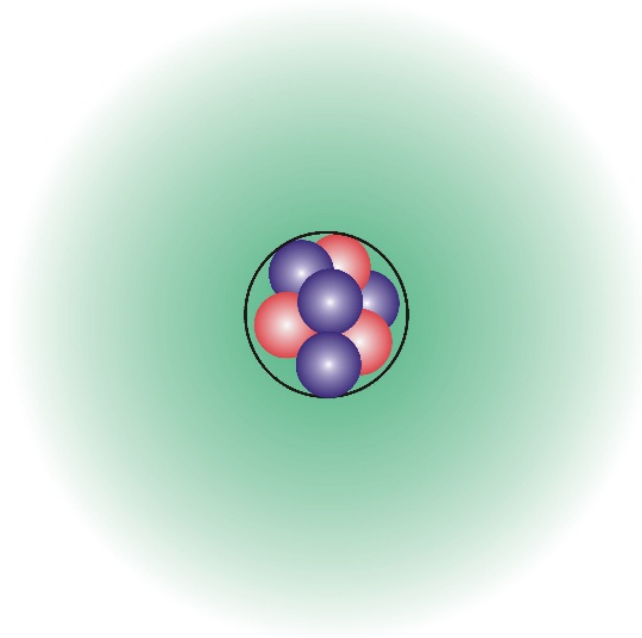
The Atom and the Periodic Table

- The horizontal rows of elements in the periodic table are called periods and are numbered 1 through 7.
- The vertical columns in the periodic table are called groups (also called families), and they are numbered 1 through 18.
- Elements in each group share similar properties.



Electron Cloud Structure

- is where the electrons are located around the nucleus of the atom
- The number of protons equals the number of electrons
- Ex: Oxygen has 8 protons so it has 8 electrons
- Different electrons in the electron cloud have differing amounts of energy



Rows on the Periodic Table

Energy Level	Max # of e⁻	Row #
1st Energy Level	2e ⁻	1
2nd Energy Level	8e ⁻	2
3rd Energy Level	8e ⁻	3

- Electrons closer to the nucleus have a lower amount of energy compared to those further away
- Scientist model these differences in energy by placing electrons in energy levels
- Energy Levels coincide with the number of rows on the periodic table
- Each energy level can only contain specific amounts of electrons

Bohr's Model



Bohr and Lewis Dot

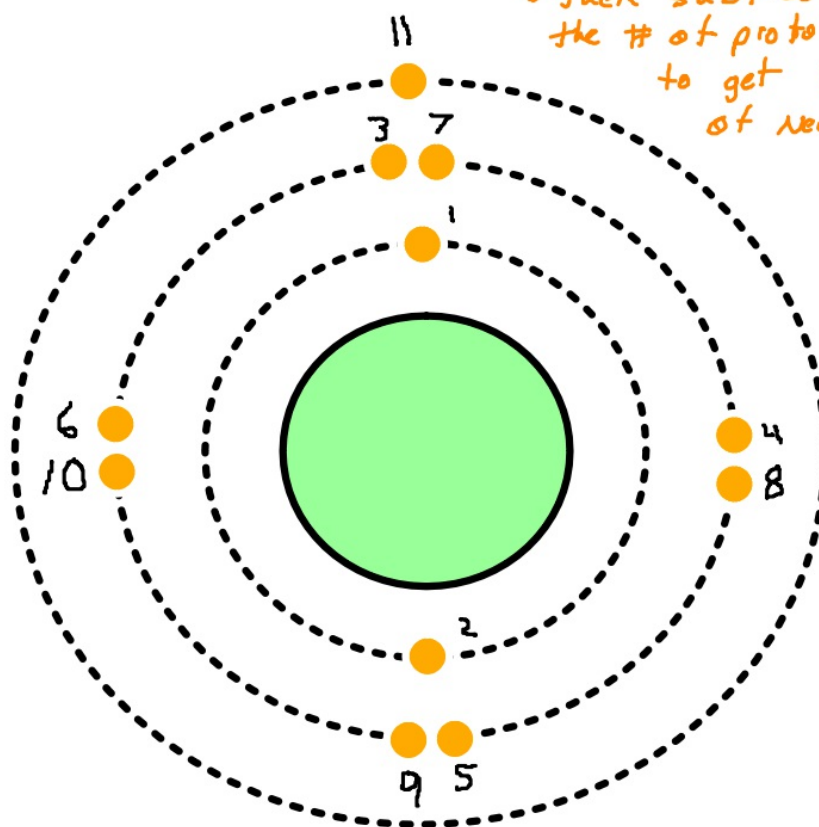
Sodium (Na)

1. Determine the number of protons, neutrons, and electrons for each atom's element
2. Draw a nucleus inserting the # of protons and # of neutrons that are inside
3. Determine the number of electron rings to draw around the nucleus by what row it is on the Periodic Table
4. Place the electrons on the correct energy ring - filling each to capacity

Protons = 11
Neutrons = 12
Electrons = 11
Period = 3

Atomic # 11

- use the average atomic mass and round it to 23
- then subtract the # of protons to get # of neutrons

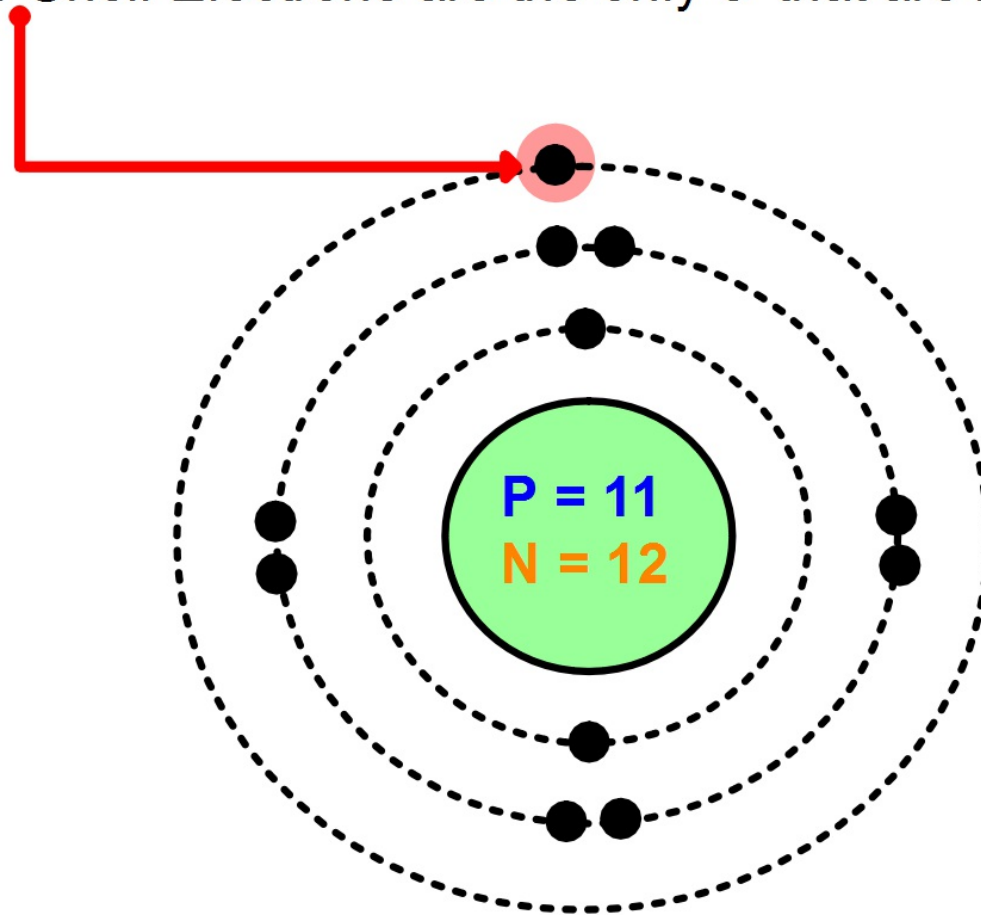


Stability

- All atoms want to become as stable as possible
- The most stable atoms are those with full outer shells (Group 18)
- Octet Rule: the tendency of all elements to seek a way to have a full outer shell thereby creating the most stable versions of themselves
- Valence Shell: is the outer most energy level that is occupied by e^-

Valence Shell Electrons

- Valence Shell Electrons: are the e^- that are found in the Valence Shell
- Valence Shell Electrons are the only e^- that are involved in bonding



(F.) Oxidation Charges

(F.) Roman Numerals

1⁺ I
1

2⁺ II
2

3⁺ III
13

4^{+/-} IV
14

3⁻ V
15

2⁻ VI
16

1⁻ VII
17

0 VIII
18

hydrogen 1 H 1.0079	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	helium 2 He 4.0026	
lithium 3 Li 6.941	magnesium 12 Mg 24.305											aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948	
sodium 11 Na 22.990	calcium 20 Ca 40.078	3	4	5	6	7	8	9	10	11	12	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80	
potassium 19 K 39.098	strontium 38 Sr 87.62	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29	
rubidium 37 Rb 85.468	barium 56 Ba 137.33	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]	
caesium 55 Cs 132.91	radium 88 Ra [226]	57-70	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	ununtrium 113 Uut [284]	ununquadium 114 Uuq [289]	ununpentium 115 Uup [288]	ununhexium 116 Uuh [292]	ununseptium 117 Uus [291]	unoctium 118 Uuo [294]
francium 87 Fr [223]		89-102	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]	ununbium 112 Uub [277]	ununtrium 113 Uut [284]	ununquadium 114 Uuq [289]	ununpentium 115 Uup [288]	ununhexium 116 Uuh [292]	ununseptium 117 Uus [291]	unoctium 118 Uuo [294]

■ Lanthanide series

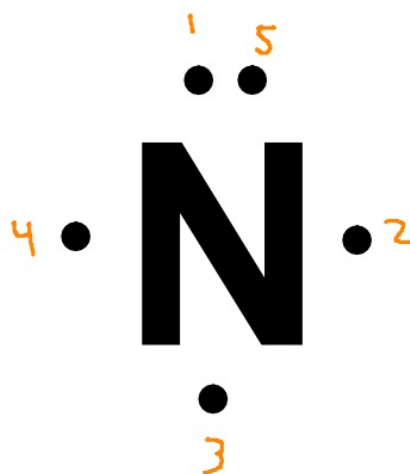
■ Actinide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

Lewis's Dot Diagram

1. Write the atomic symbol for the element
2. Place the number of dots around the atomic symbol that are equal to its number of valence shell electrons

Nitrogen is
in column #15
(Roman numeral V)
so it has 5
valence e^-



- put them in by cardinal directions (N, E, S, W)
- Then pair them up in the same order (N, E, S, W)

