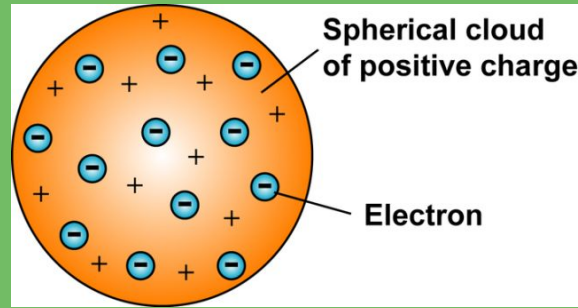


ScienceCraft

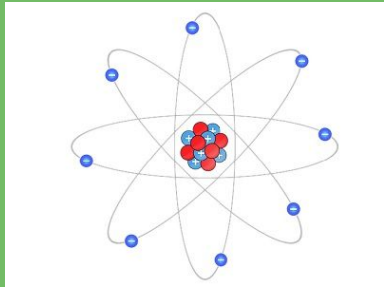
Atoms and Molecules

What is an atom?



Outdated "plum pudding" model

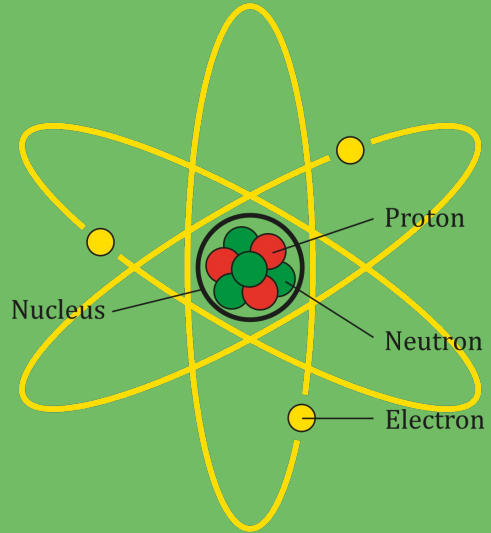
Bohr model



- ✗ Brownian motion: **random movement** can only be explained by atoms and molecules **colliding** with each other at a microscopic level
- ✗ An atom is the **smallest common unit** of matter
- ✗ **All matter** is made up of atoms
- ✗ An element is a **pure substance** that **cannot be broken down further** by chemical means



Charge



- ✗ An atom consists of 3 major parts
- ✗ **Protons** have a positive charge
- ✗ **Neutrons** have no charge
- ✗ **Electrons** rotate around the nucleus and have a negative charge
 - ✗ Located in the **orbitals**
- ✗ Charge is responsible for phenomena like electricity
 - ✗ Electricity is simply the “**flow of electrons**” in an effort to create equilibrium

Particle	Relative Mass	Relative Charge	Charge / C	Mass / kg
Protons	1	+ 1	$+ 1.6 \times 10^{-19}$	1.67×10^{-27}
Neutrons	1	neutral	0	1.67×10^{-27}
Electrons	0.0005	- 1	$- 1.6 \times 10^{-19}$	9.11×10^{-31}



H 1 (1.01)																		He 2 (4.00)	
Li 3 (6.94)	Be 4 (9.01)											B 5 (10.81)	C 6 (12.01)	N 7 (14.01)	O 8 (15.99)	F 9 (18.99)	Ne 9 (18.99)		
Na 11 (22.99)	Mg 12 (24.30)											Al 13 (26.98)	Si 14 (28.08)	P 15 (30.97)	S 16 (32.06)	Cl 17 (35.45)	Ar 18 (39.95)		
K 19 (39.10)	Ca 20 (40.08)	Sc 21 (44.95)	Ti 22 (47.88)	V 23 (50.94)	Cr 24 (51.99)	Mn 25 (54.94)	Fe 26 (55.85)	Co 27 (58.93)	Ni 28 (58.69)	Cu 29 (63.55)	Zn 30 (65.38)	Ga 31 (69.72)	Ge 32 (72.59)	As 33 (74.92)	Se 34 (78.96)	Br 35 (79.90)	Kr 36 (83.80)		
Rb 37 (85.47)	Sr 38 (87.62)	Y 39 (88.90)	Zr 40 (91.22)	Nb 41 (92.91)	Mo 42 (95.94)	Tc 43 (98.91)	Ru 44 (101.07)	Rh 45 (102.90)	Pd 46 (107.87)	Ag 47 (107.87)	Cd 48 (112.41)	In 49 (114.82)	Sn 50 (118.69)	Sb 51 (121.75)	Te 52 (127.60)	I 53 (126.90)	Xe 54 (131.29)		
Cs 55 (132.90)	Ba 56 (137.33)	La 57 (138.90)	Hf 72 (178.49)	Ta 73 (180.95)	W 74 (183.85)	Re 75 (186.21)	Os 76 (190.20)	Ir 77 (192.22)	Pt 78 (195.08)	Au 79 (196.97)	Hg 80 (200.59)	Tl 81 (204.38)	Pb 82 (207.20)	Bi 83 (208.98)	Po 84 (208.98)	At 85 (209.99)	Rn 86 (222.02)		
Fr 87 (223.02)	Ra 88 (226.02)	Ac 89 (227.03)	Rf 104 (261.10)	Db 105 (262.11)	Sg 106 (263.12)	Bh 107 (264.12)	Hs 108 (277.13)	Mt 109 (268.14)	Ds 110 (268.14)	Rg 111 (280*)	Cn 112 (285*)	Fl 114 (289*)		Lv 116 (297*)					
			Ce 58 (140.11)	Pr 59 (140.91)	Nd 60 (144.24)	Pm 61 (146.92)	Sm 62 (150.36)	Eu 63 (151.96)	Gd 64 (157.25)	Tb 65 (158.93)	Dy 66 (162.50)	Ho 67 (164.93)	Er 68 (167.26)	Tm 69 (168.93)	Yb 70 (173.04)	Lu 71 (174.97)			
			Th 90 (232.04)	Pa 91 (231.04)	U 92 (238.05)	Np 93 (237.05)	Pu 94 (244.06)	Am 95 (243.06)	Cm 96 (247.07)	Bk 97 (247.07)	Cf 98 (251.08)	Es 99 (252.08)	Fm 100 (257.10)	Md 101 (258.10)	No 102 (259.10)	Lr 103 (262.11)			



Metal Metalloid Nonmetal

- ✗ Elements fall into 3 categories
- ✗ **Metals** are **good conductors**, **malleable**, and are **solid** at room temperature
 - ✗ Except for mercury*
- ✗ **Nonmetals** are **poor conductors**, **not malleable**, and **vary in states** at room temperature
- ✗ **Metalloids** are a **hybrid** of the two, often serving as **semiconductors**

Periodic Table

Periodic Table of the Elements

Group

1A 2A 3A 4A 5A 6A 7A 8A

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

1 H Hydrogen 1.0078 2 He Helium 4.0026

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

11 Na Sodium 22.990 12 Mg Magnesium 24.305 13 Al Aluminum 26.982 14 Si Silicon 28.086 15 P Phosphorus 30.974 16 S Sulfur 32.059 17 Cl Chlorine 35.446 18 Ar Argon 39.948

19 K Potassium 39.098 20 Ca Calcium 40.078 21 Sc Scandium 44.956 22 Ti Titanium 47.88 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

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 98.906 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

55 Cs Cesium 132.91 56 Ba Barium 137.33 57 La Lanthanum 138.905 58 Ce Cerium 140.12 59 Pr Praseodymium 140.907 60 Nd Neodymium 144.24 61 Pm Promethium 144.912 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 174.967

72 Hf Hafnium 178.49 73 Ta Tantalum 180.95 74 W Tungsten 183.84 75 Re Rhenium 186.21 76 Os Osmium 190.23 77 Ir Iridium 192.22 78 Pt Platinum 195.08 79 Au Gold 196.97 80 Hg Mercury 200.59 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) 87 Fr Francium (223) 88 Ra Radium (226) 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 Berkeleium 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

Period

1 2 3 4 5 6 7

Alkali metals

Alkaline earth metals

Lanthanides

Actinides

Transition metals

Unknown properties

Post-transition metals

Metalloids

Other nonmetals

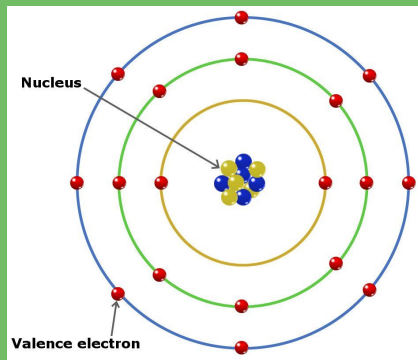
Halogens

Noble gases

- ✗ **Alkali metals:** Very reactive in water, soft
- ✗ **Alkaline earth metals:** Less reactive, slower to produce heat
- ✗ **Lanthanides:** Silvery white, tarnish in air
- ✗ **Actinides:** Highly radioactive
- ✗ **Transition metals:** Hard, conductive, malleable
- ✗ **Post-transition metals:** Poorer conductors but still metallic
- ✗ **Metalloids:** Semiconductors
- ✗ **Nonmetals:** Common gases
- ✗ **Halogens:** Highly reactive with alkali metals, produce salts
- ✗ **Noble Gases:** Inert, odorless gas



Periodic Table



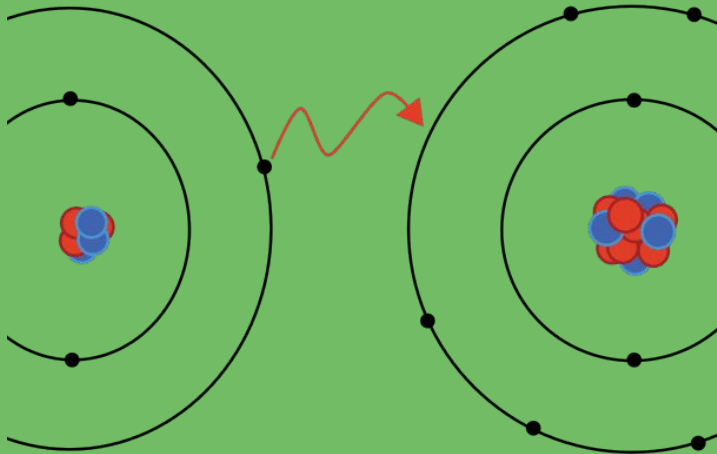
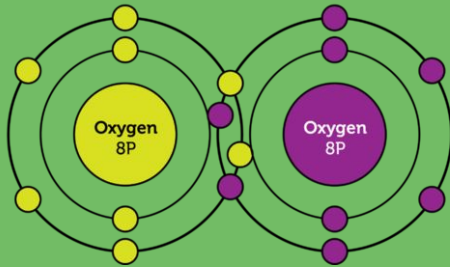
ENERGY LEVEL	MAX # OF ELECTRONS
1	2
2	8
3	18
4	32
5	50

Valence Electrons in Each Group																		8				
1																		8				
1	2																3	4	5	6	7	8
1	2																3	4	5	6	7	8
1	2												3	4	5	6	7	8				
1	2												3	4	5	6	7	8				
1	2												3	4	5	6	7	8				
1	2												3	4	5	6						

- ✗ Atoms have different numbers of electrons
- ✗ There are a certain number of electrons in each **energy level** of the orbitals
 - ✗ Often seen as the “2-8-8” rule
- ✗ The number of atoms in the outer shell are known as **valence electrons**
 - ✗ The number of valence electrons determines how reactive an element is

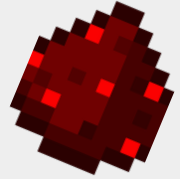


Bonding



✗ **Ionic bonds:** Bonds that result in an electron being passed to another atom

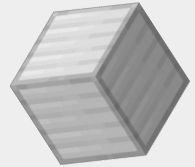
✗ NaCl is an example



✗ **Covalent bonds:** Bonds where atoms **share** an electron

✗ For example, O tends to bond with itself as O₂

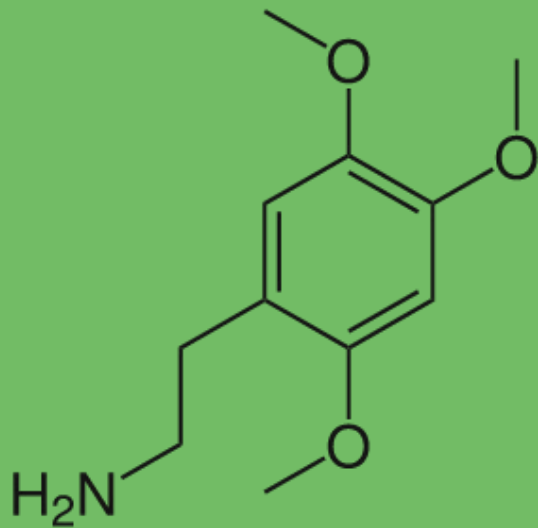
✗ When multiple atoms bond together, they become a **molecule**



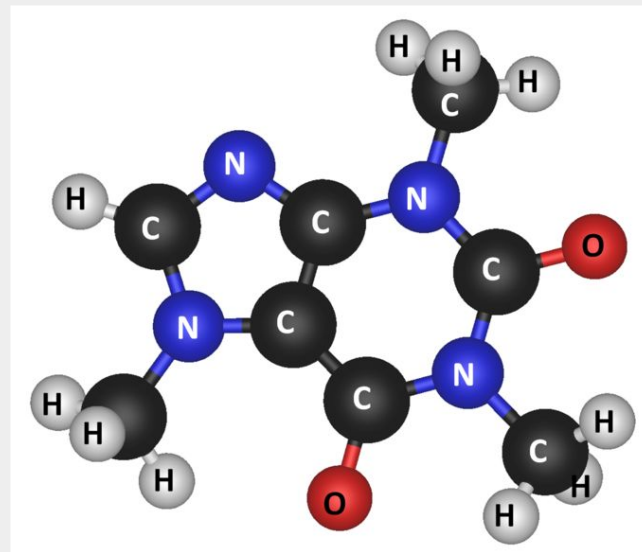
✗ A **compound** is made up of **two or more** unique bonded atoms



Visualizing Molecules



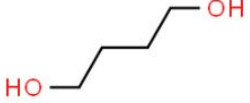
- ✗ Molecules are often very complex if you wanted to view each proton, neutron, and electron.
- ✗ Oftentimes you will see **simplified models** like the one below



Challenge: Build a molecule





- ✗ Use Chemspider to look up a molecule of your choice



HO-CH₂-CH₂-CH₂-CH₂-OH

1,4-Butanediol

Molecular Formula	C ₄ H ₁₀ O ₂
Average mass	90.121 Da
Monoisotopic mass	90.068077 Da
ChemSpider ID	13835209

 **3D** 

- ✗ Find the **3D** visualization and build it, making sure to **label**

