

General Biology 1

BIO1101

Syllabus & Textbook: <http://goo.gl/rvgdrH>

Lecturer: Michael Gotesman, PhD
Email: mgotesman@citytech.cuny.edu

<u>Letter Grade</u>	<u>Numerical Ranges</u>
A	93-100
A-	90-92.9
B+	87-89.9
B	83-86.9
B-	80-82.9
C+	77-79.9
C	70-76.9
D	60-69.9
F	59.9 and below

OER

Lecture: <https://openlab.citytech.cuny.edu/bio-oer/page/2/>

Lab: <https://openlab.citytech.cuny.edu/bio-oer/>

Grade Breakdown:

Exams (4): 20% Each

Quizzes: 20% Average

Recap: Lecture 3

1. Matter

Mass and Space

2. Atoms

- 1) Protons, Neutrons, and Electrons
- 2) Elements/Isotopes
- 3) Valence Electrons (Octet) - Octogan

3. Periodic Table

4. Molecules

- 1) Two or more atoms combine H_2O , $\text{C}_6\text{H}_{12}\text{O}_6$, O_2
- 2) Redox – Reduction/Oxidation
 - Gain of Electron is Reduction
 - Gain of Hydrogen (H^-) is Reduction
 - Gain of Oxygen is Oxidation

5. Reactions

- 1) Activation Energy
- 2) Catalyst/Enzyme

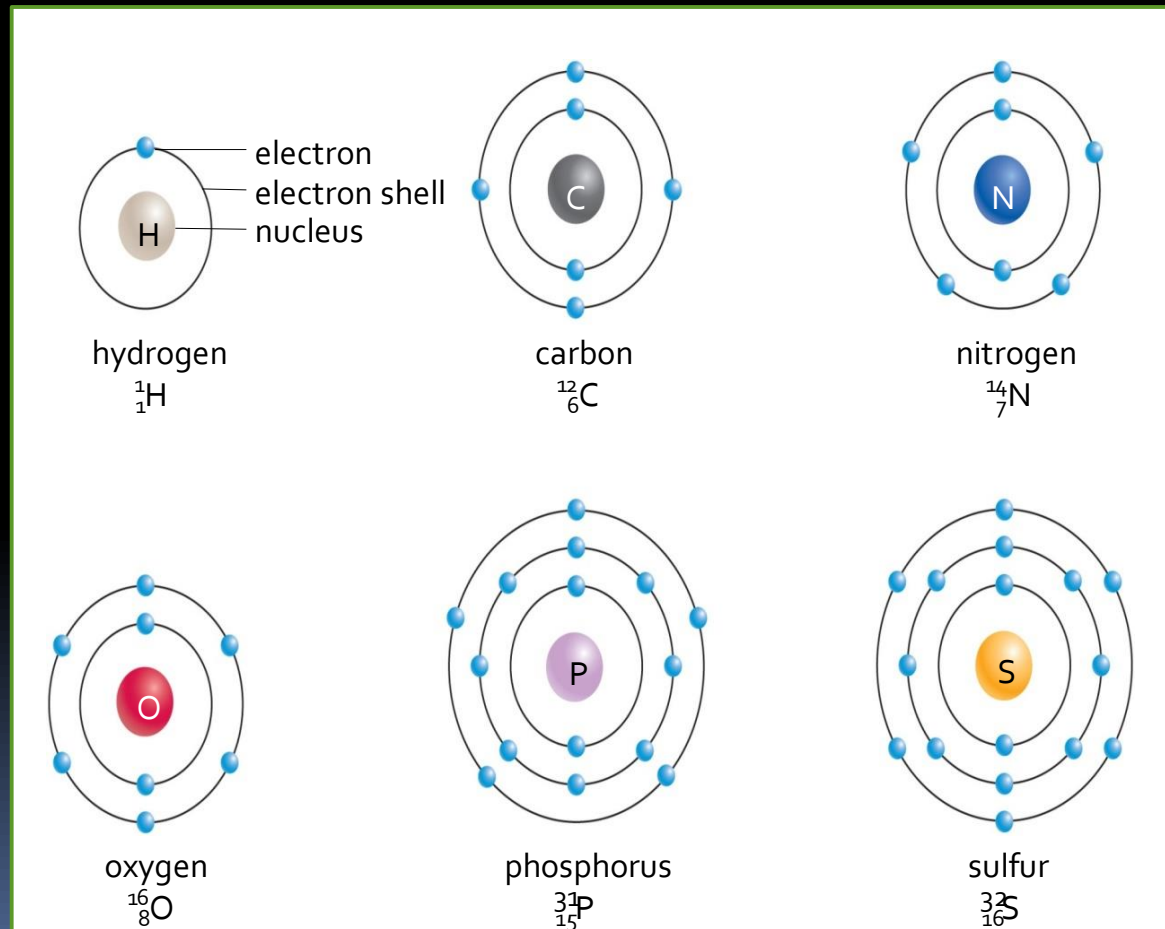
Outline

- Review:
 - Atomic symbol
 - Electron configuration
- Chemical Bonds
 - Covalent Bonding
 - Electronegativity
 - Polar and nonpolar covalent bonds
 - Ionic Bonding
 - Weak Bonds
 - Hydrogen Bonding
 - Van der Waals forces

The Octet Rule for -- Distribution of Electrons

Neils Bohr models (1910's) show electron shells as concentric circles around nucleus

- Each shell has two or more electron orbitals
 - Innermost shell has two orbitals
 - Outer most orbital (valence) should have 8 electrons (octet)



Dmitri Mendeleev's Table: 1869

*Nickel has a lower mass than Cobalt

*Au is right next to Hg, huh????? – Who cares?

Hg named after the planet Mercury (the origin of the symbol Hg is the Latin word "hydrargyrum" meaning "liquid silver")

Reihen	Gruppe I. — R ² O	Gruppe II. — RO	Gruppe III. — R ² O ³	Gruppe IV. RH ⁴ RO ³	Gruppe V. RH ³ R ² O ⁵	Gruppe VI. RH ¹ RO ³	Gruppe VII. RH R ² O ⁷	Gruppe VII. — RO ⁴
1	H = 1							
2	Li = 7	Be = 9.4	B = 11	C = 12	N = 14	O = 16	F = 19	
3	Na = 23	Mg = 24	Al = 27.3	Si = 28	P = 31	S = 32	Cl = 35.5	
4	K = 39	Ca = 40	— = 44	Tl = 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 = 104, Pd = 106, Ag = 108.
7	(Ag = 108)	Cd = 112	In = 113	Sa = 118	Sb = 122	Te = 125	J = 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	—	— — — —

Periodic Table:

H 1
Hydrogen

Sun and Stars

Li 3
Lithium

Batteries

Na 11
Sodium

Salt

K 19
Potassium

Fruits and Vegetables

Rb 37
Rubidium

Global Navigation

Cs 55
Cesium

Atomic Clocks

Fr 87
Francium

Laser Atom Traps

Be 4
Beryllium

Emeralds

Mg 12
Magnesium

Chlorophyll

Ca 20
Calcium

Shells and Bones

Sr 38
Strontium

Fireworks

Ba 56
Barium

X-Ray Diagnosis

Ra 88
Radium

Luminous Watches

B 5
Boron

Sports Equipment

Al 13
Aluminum

Airplanes

Ga 31
Gallium

Light-Emitting Diodes (LEDs)

In 49
Indium

Liquid Crystal Displays (LCDs)

Tl 81
Thallium

Low-Temperature Thermometers

C 6
Carbon

Basis of Life's Molecules

Si 14
Silicon

Stone, Sand, and Soil

Ge 32
Germanium

Semiconductor Electronics

Sn 50
Tin

Plated Food Cans

Pb 82
Lead

Weights

N 7
Nitrogen

Protein

P 15
Phosphorus

Bones

As 33
Arsenic

Poison

Sb 51
Antimony

Car Batteries

Bi 83
Bismuth

Fire Sprinklers

O 8
Oxygen

Air

S 16
Sulfur

Egg Yolks

Se 34
Selenium

Copiers

Te 52
Tellurium

Thermoelectric Coolers

Po 84
Polonium

Anti-Static Brushes

F 9
Fluorine

Toothpaste

Cl 17
Chlorine

Swimming Pools

Br 35
Bromine

Photography Film

I 53
Iodine

Disinfectant

At 85
Astatine

Radioactive Medicine

He 2
Helium

Balloons

Ne 10
Neon

Advertising Signs

Ar 18
Argon

Light Bulbs

Kr 36
Krypton

Flashlights

Xe 54
Xenon

High-Intensity Lamps

Rn 86
Radon

Surgical Implants

Atomic Number number of protons

Atomic Symbol A Z

Name ium

Widgets

How it is (or was) used or where it occurs in nature

elements.wlonk.com

Legend:

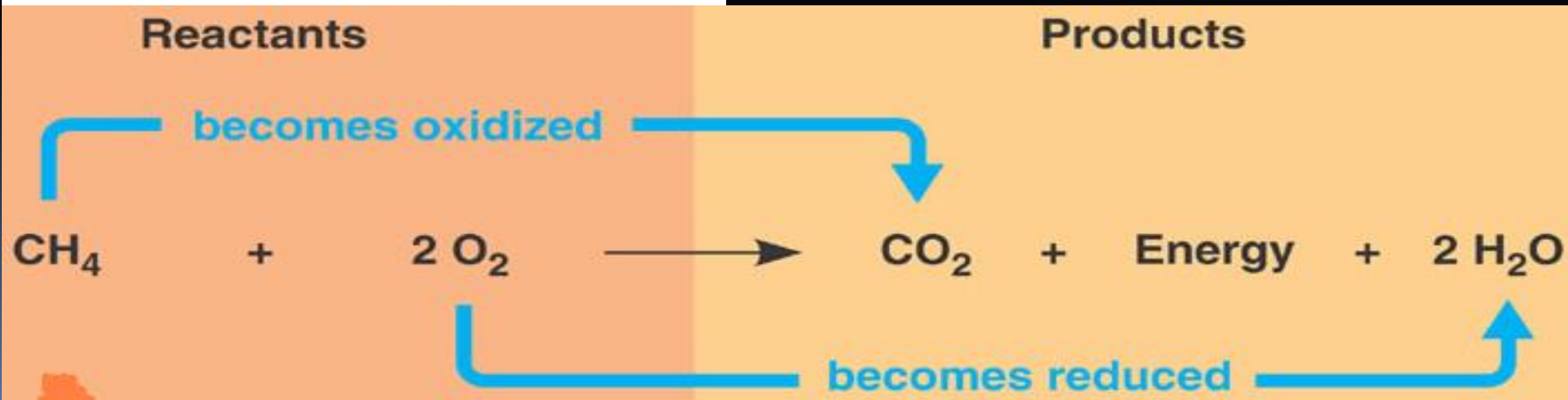
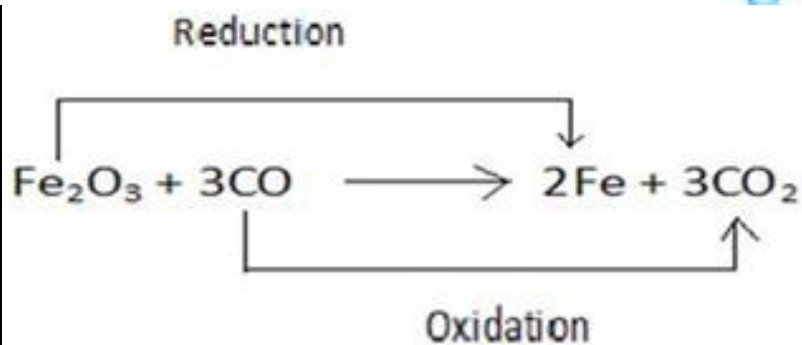
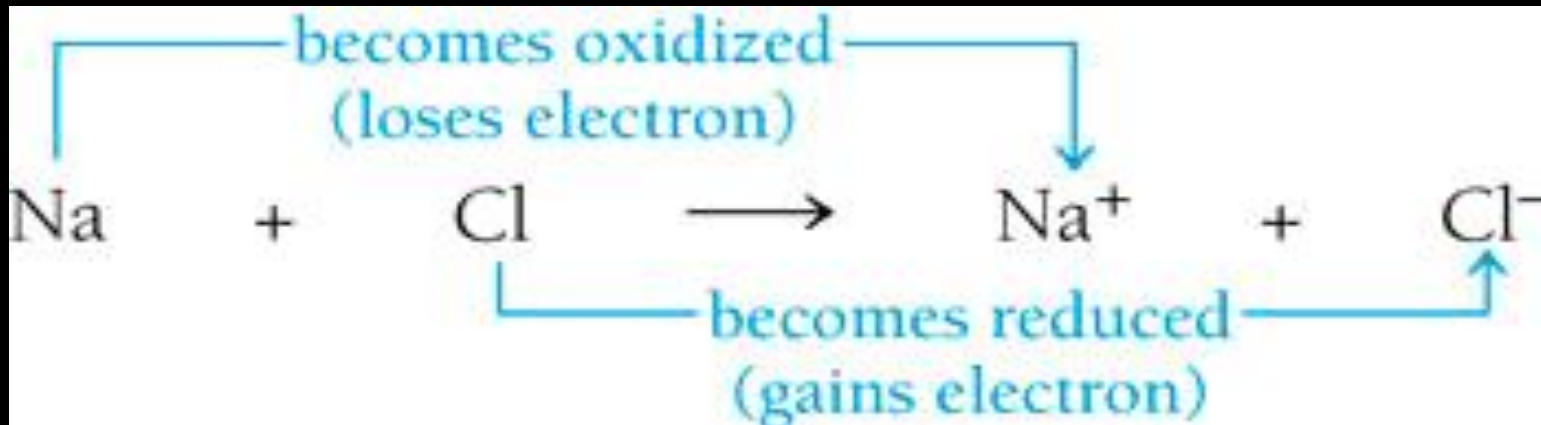
- Solid
- Liquid
- Gas at room temperature
- Human Body (top ten elements by weight)
- Earth's Crust (top eight elements by weight)
- Magnetic (ferromagnetic at room temperature)
- Noble Metals (corrosion-resistant)
- Radioactive (all isotopes are radioactive)
- Only Traces Found in Nature (less than a millionth percent of earth's crust)
- Never Found in Nature (only made by people)

The color of the symbol is the color of the element in its most common pure form.

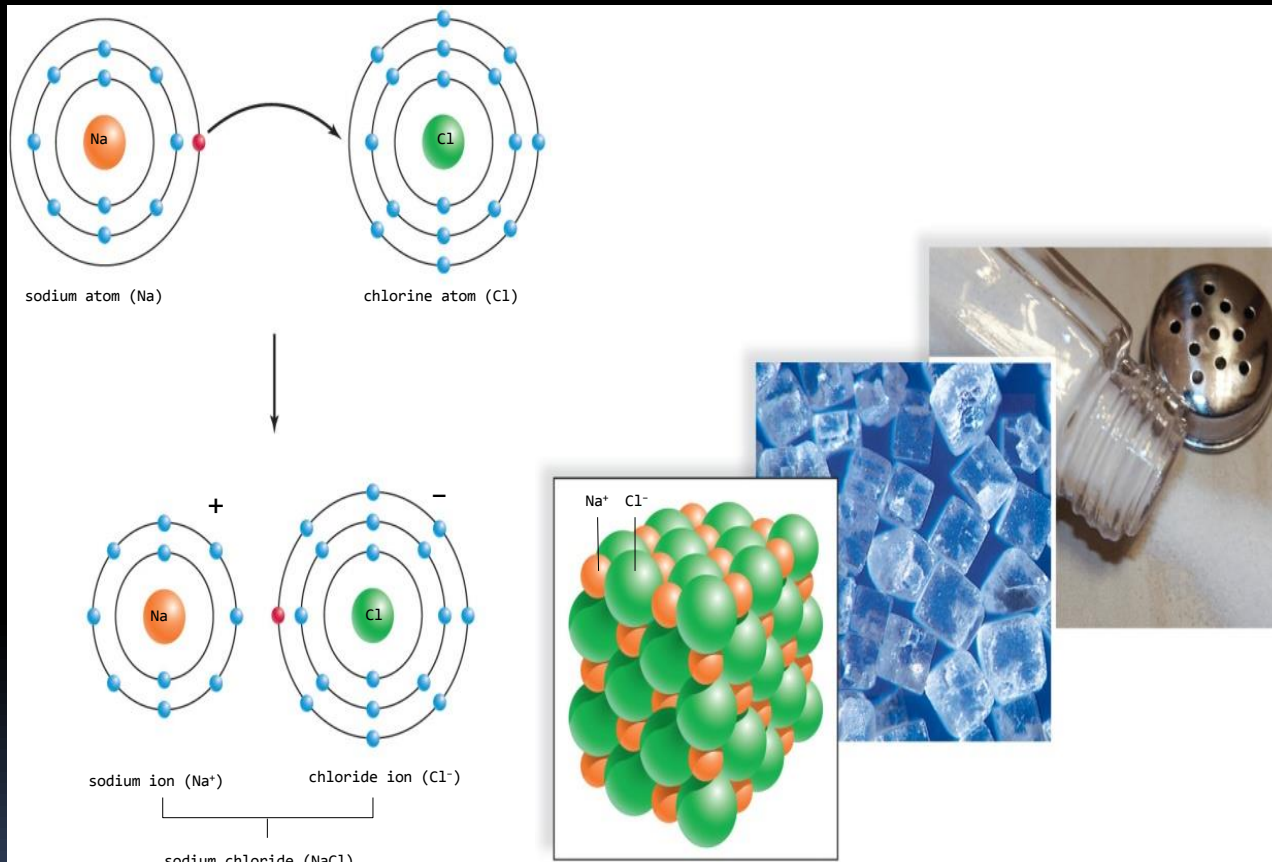
Examples: ■ metallic solid, ■ red liquid, ■ colorless gas

elements.wlonk.com

Redox Reactions



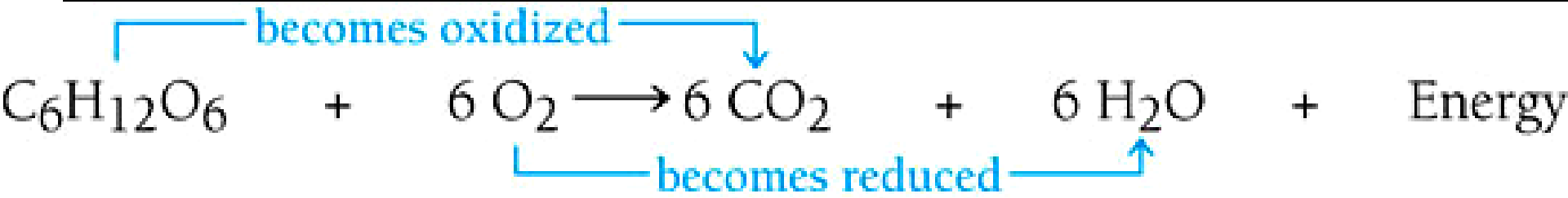
INORGANIC CHEMISTRY (CONT.)



Energy

- **Energy** is the capacity to cause change (“ability to do work”)
- Things tend to flow from high to low energy: High energy = unstable, low energy = stable
- Forms of Energy
 - **Kinetic:**
 - Energy of motion
 - Mechanical
 - **Potential:**
 - Stored energy
 - Chemical
- **Potential energy** is the energy that matter has because of its location or structure

Exergonic and Endergonic Reactions



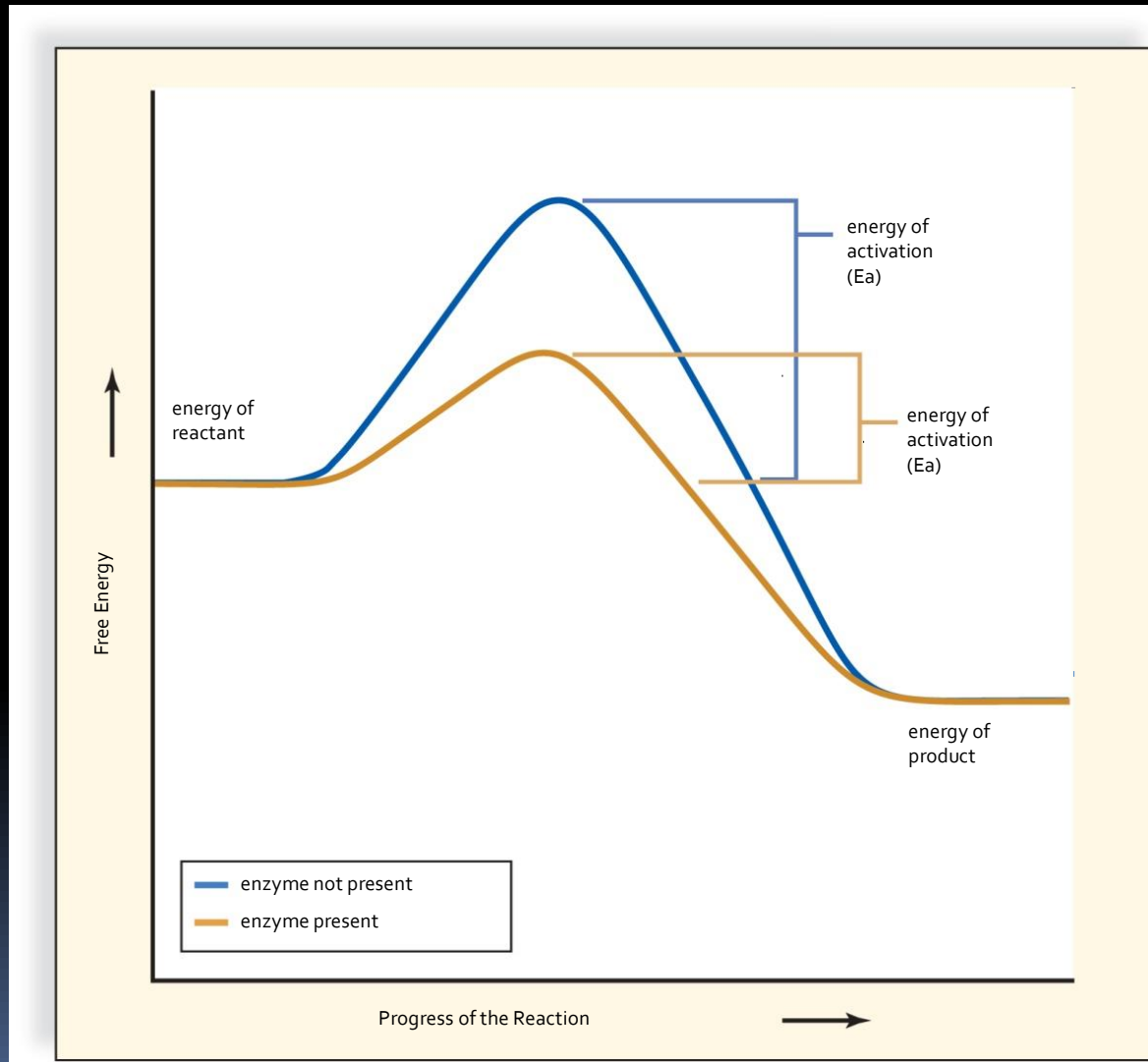
$$\Delta G = -686 \text{ kcal/mol} \text{ !!!!!!!!!}$$

- **Exergonic** Reactions - Products have *less* free energy than reactants => energy is released reaction is **spontaneous**
 - **Exothermic** – energy is released as heat
- **Endergonic** Reactions - Products have *more* free energy than reactants => Energy is necessary
 - **Endothermic** – energy is absorbed as heat

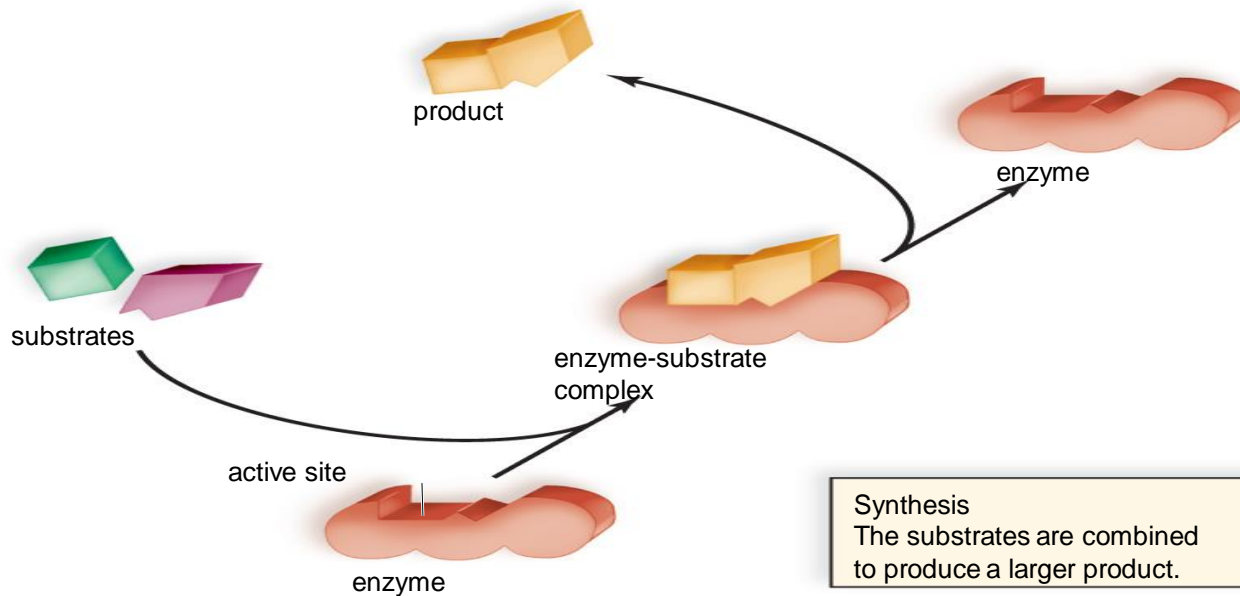
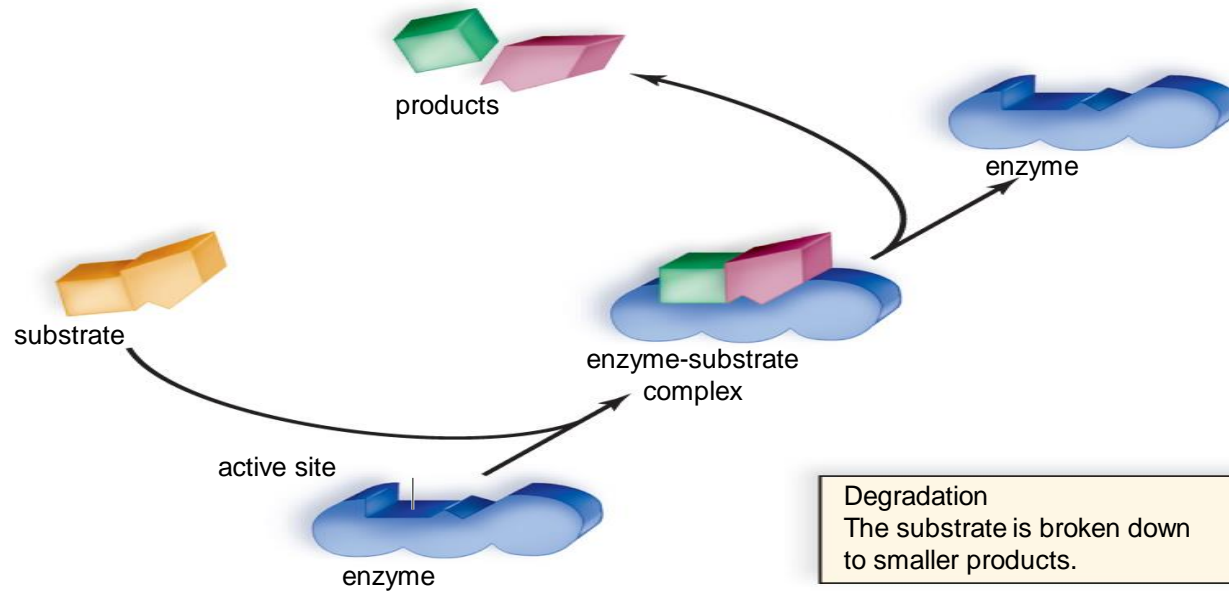
Energy of Activation and Enzymes

- Reactants often “reluctant” to participate in reaction
 - Energy must be added to at least one reactant to initiate the reaction
 - **Energy of activation (E_a)**
 - Catalysts operate by **lowering the energy of activation**
- **Enzymes:**
 - **are Organic Catalysts**
 - Enzyme Lower (E_a) by bringing the substrates into contact with one another

Energy of Activation



Enzymatic Actions



Atomic Symbols

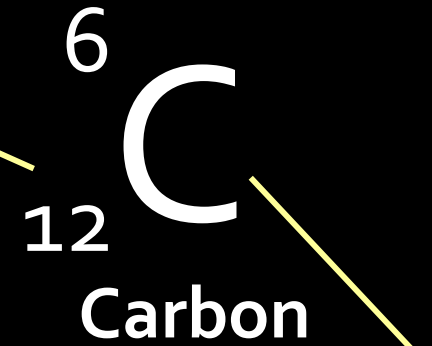
Atomic number = number of protons (${}_2\text{He}$)

Mass number = number of protons + neutrons (${}^4\text{He}$)

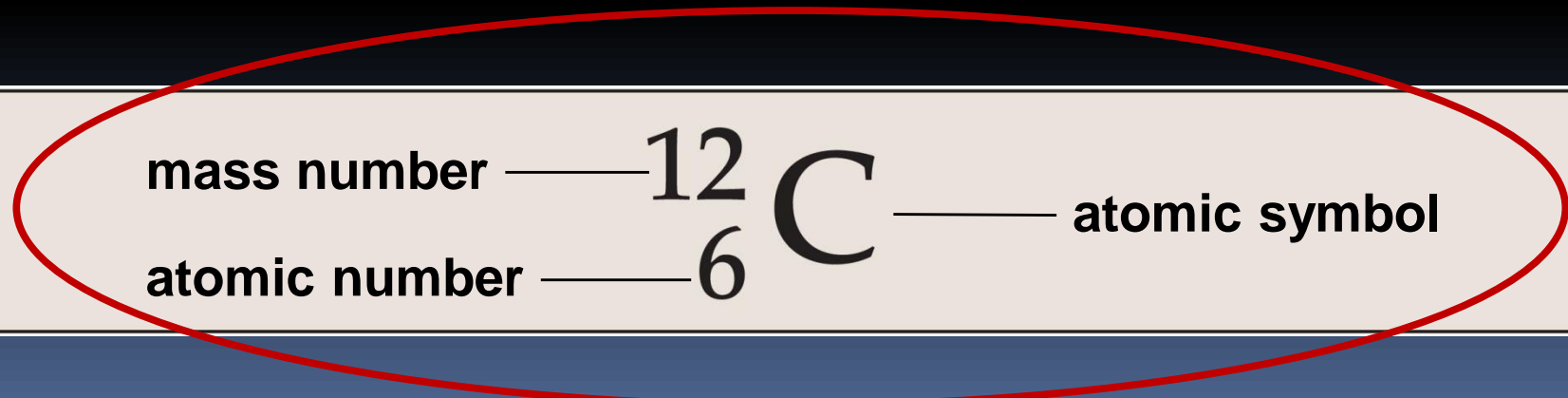
	1	II	III	IV	V	VI	VII	VIII
atomic number	1							2
atomic symbol	H							He
atomic mass	1.008							4.003
	3	4	5	6	7	8	9	10
	Li	Be	B	C	N	O	F	Ne
	6.941	9.012	10.81	12.01	14.01	16.00	19.00	20.18
	1	12	13	14	15	16	17	18
	Na	Mg	Al	Si	P	S	Cl	Ar
	22.99	24.31	26.98	28.09	30.97	32.07	35.45	39.95
	19	20	31	32	33	34	35	36
	K	Ca	Ga	Ge	As	Se	Br	Kr
	39.10	40.08	69.72	72.59	74.92	78.96	79.90	83.60

Mass Number

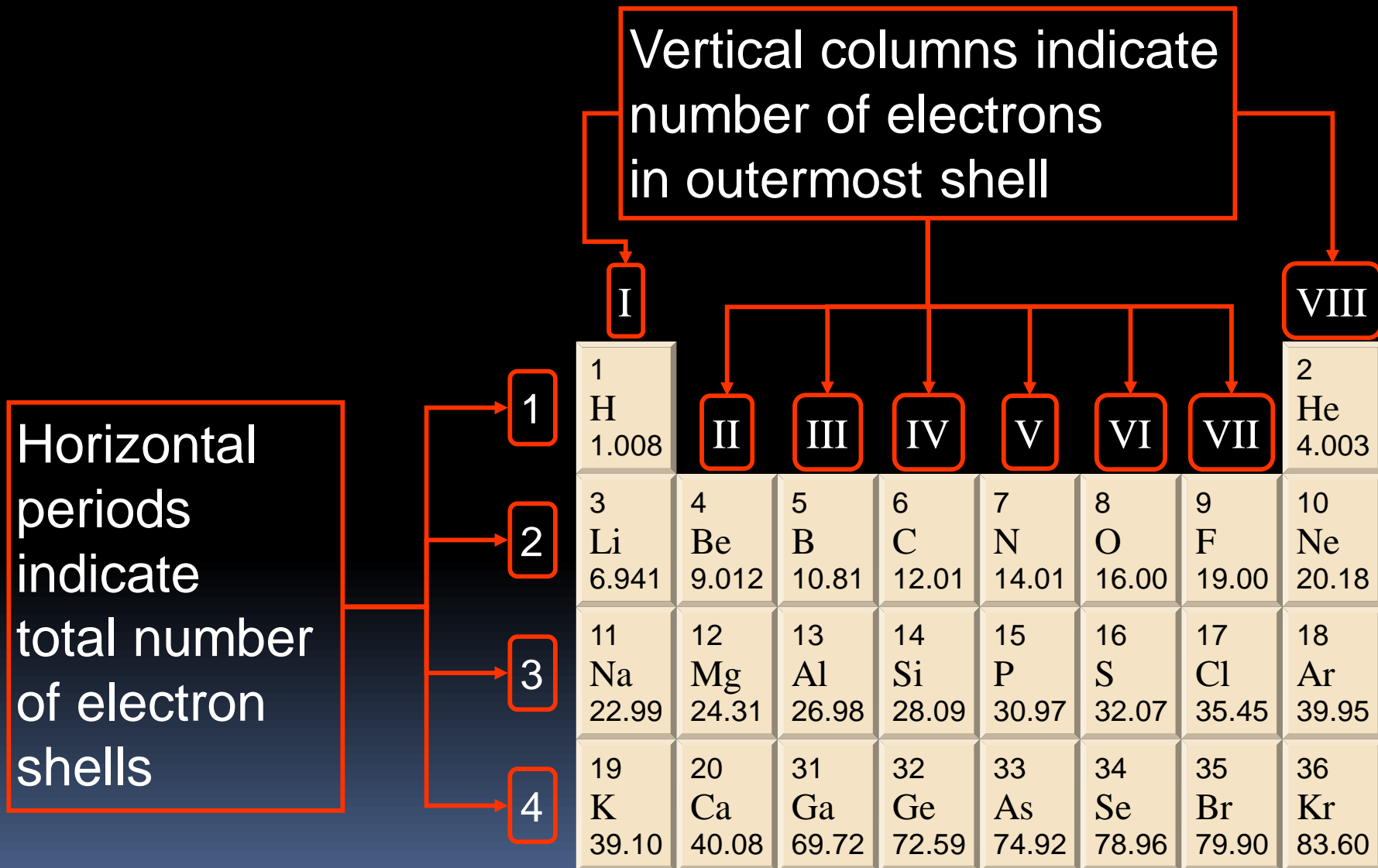
Atomic Number



Element Symbol

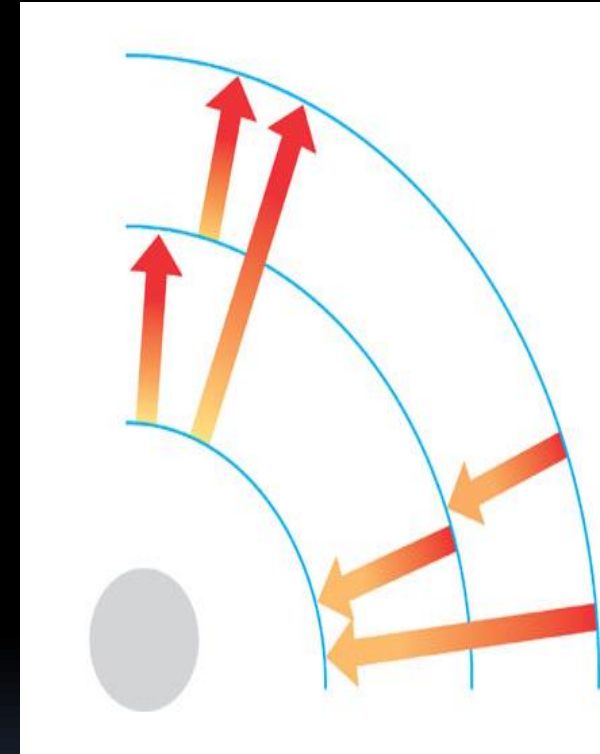


Periodic Table (Revisited)



Electrons Configuration

- 1st electron shell = capacity of 2 e⁻
- 2nd electron shell = capacity of 8 e⁻
- 3rd electron shell = capacity of 18 e⁻ (but only fills to 8)
- **VALENCE shell** = outer shell (valence = properties)
 - valence electrons: electrons in the outermost shell
 - Atoms “like” to have their valence shell filled (2 or 8)



Question (Test like)

Look at Magnesium ($^{25}_{12}\text{Mg}$). How many electron shells does it have? How many valence electrons?

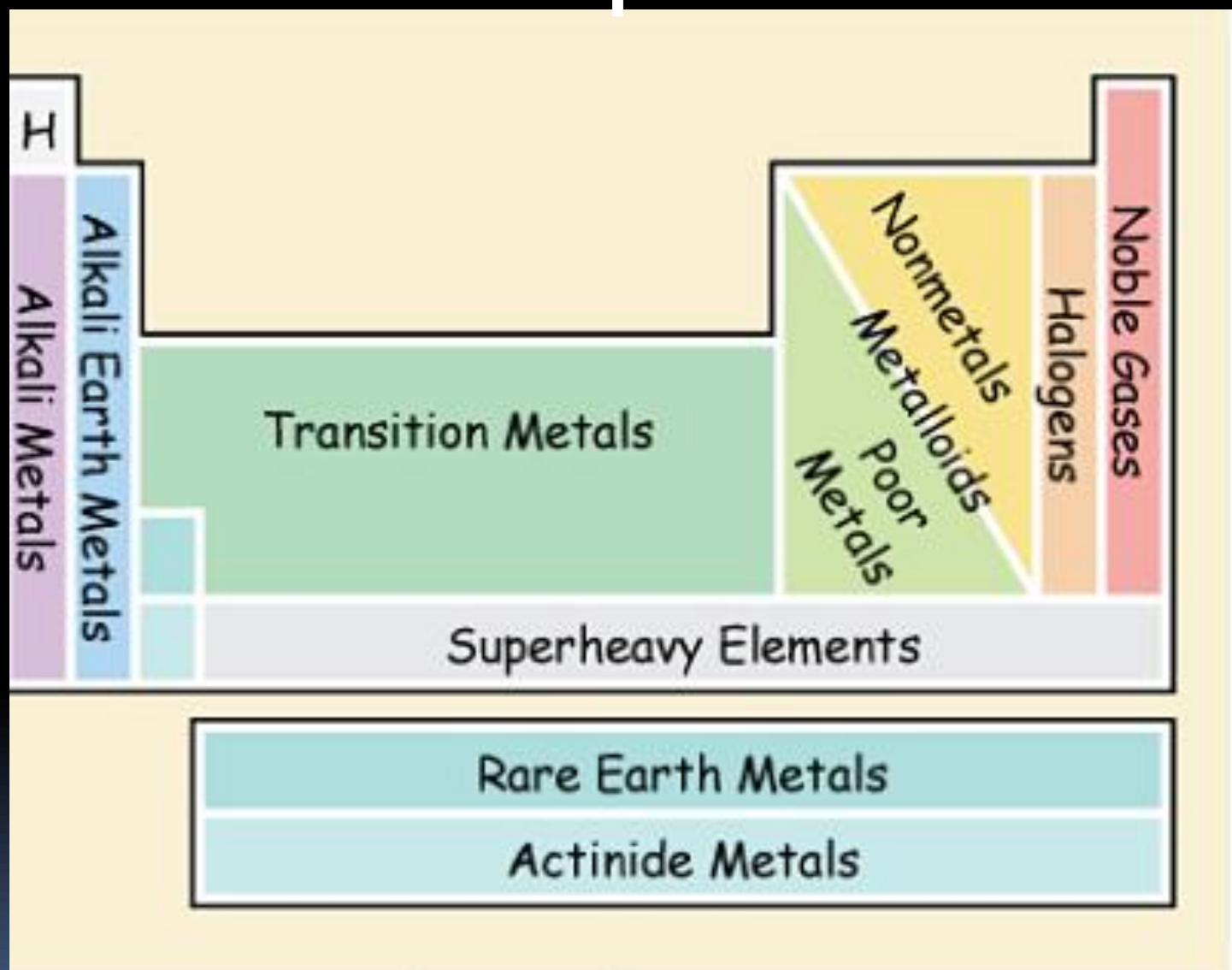
- A. 1 shell; 2 valence e-
- B. 12 shells; 3 valence e-
- C. 3 shells; 12 valence e-
- D. 3 shells; 2 valence e-



Electrons Configuration & Chemical Properties

- The periodic table of the elements shows the electron distribution of each element
- An atom's chemical properties are due to the configuration of its electrons
- The chemical behavior of an atom is mostly determined by the valence electrons

Chemical Properties:

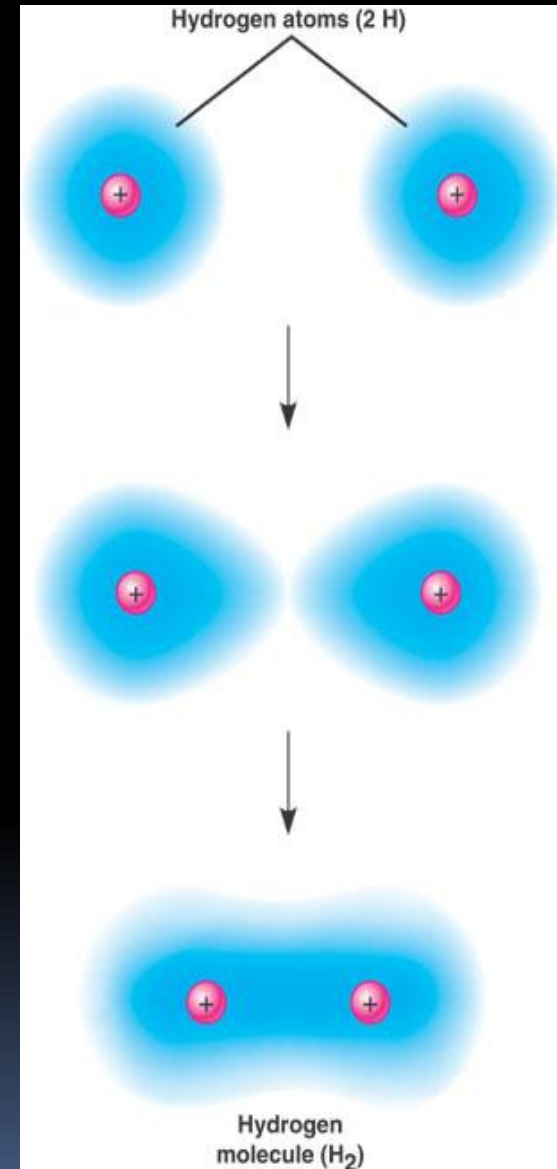


elements.wlonk.com

<https://www.youtube.com/watch?v=LcUNYGdNKIo>

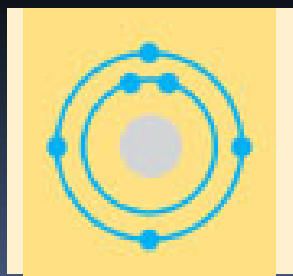
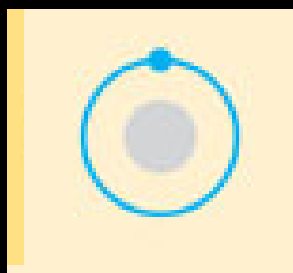
Chemical Bonding

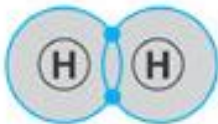

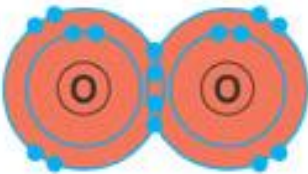

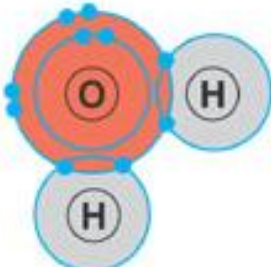

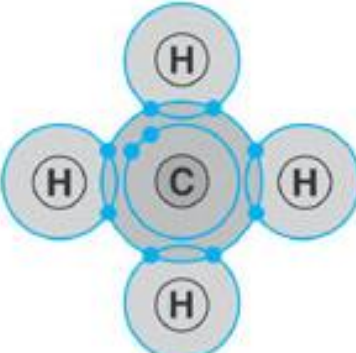

- Atoms are “bonded” together when their electrons interact in one of two ways...
- **Covalent Bonding**
 - Sharing of valence electrons between 2 atoms
 - If the atoms are different, it is a “compound”
 - Electrons are shared in pairs! One pair = single bond, two pairs = double bond, etc.
 - This forms a “molecule” (hydrogen atom vs. molecule)
- **Ionic Bonding**
 - Strong electrostatic attraction between two atoms due to transfer of electron(s) from one atom to the other.
- Atoms “want” to bond together in a way that will fill their valence shells. (Valence number = e^- needed)



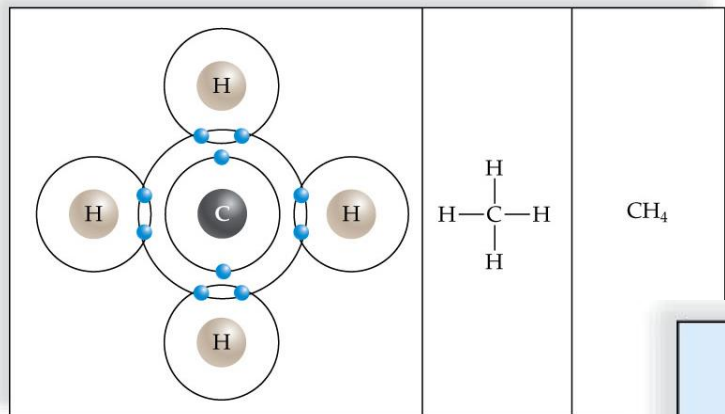
Covalent Bonding

Oxygen

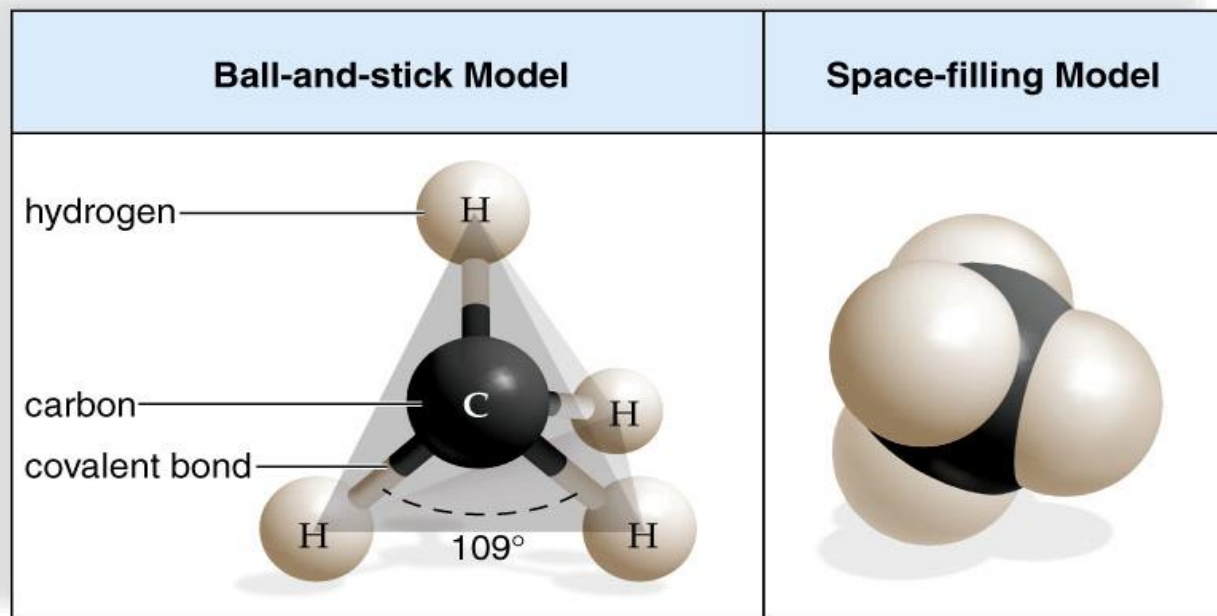


Name (molecular formula)	Electron-shell diagram	Structural formula	Space-filling model
(a) Hydrogen (H ₂)		H—H	
(b) Oxygen (O ₂)		O=O	
(c) Water (H ₂ O)		$\begin{array}{c} \text{O} - \text{H} \\ \\ \text{H} \end{array}$	
(d) Methane (CH ₄)		$\begin{array}{c} \text{H} \\ \\ \text{H} - \text{C} - \text{H} \\ \\ \text{H} \end{array}$	

Molecules are in three dimensions!



c. Methane



d. Methane—continued

When an electron pair is shared, the shape of the orbital changes. No longer a “dumbbell” around the nucleus, but in a cloud between the two bonded atoms

Electronegativity

- Electronegativity is an atom's attraction for the electrons in a covalent bond
- The more electronegative an atom, the more strongly it pulls shared electrons toward itself
- Remember, atoms to the RIGHT of the periodic table are more electronegative than atoms on the left.
- This means, when two atoms are bonded together in a covalent bond, the more electronegative atom will "pull" electrons more toward it and thus... it will have a partial negative charge

Electronegativity

Pauling Electronegativity Values

1 H 2.20																
3 Li 0.98	4 Be 1.57											5 B 2.04	6 C 2.55	7 N 3.04	8 O 3.44	9 F 3.98
11 Na 0.93	12 Mg 1.31											13 Al 1.61	14 Si 1.90	15 P 2.19	16 S 2.58	17 Cl 3.16
19 K 0.82	20 Ca 1.00	21 Sc 1.36	22 Ti 1.54	23 V 1.63	24 Cr 1.66	25 Mn 1.55	26 Fe 1.83	27 Co 1.88	28 Ni 1.91	29 Cu 1.90	30 Zn 1.65	31 Ga 1.81	32 Ge 2.01	33 As 2.18	34 Se 2.55	35 Br 2.96
37 Rb 0.82	38 Sr 0.95	39 Y 1.22	40 Zr 1.33	41 Nb 1.6	42 Mo 2.16	43 Tc 1.9	44 Ru 2.2	45 Rh 2.28	46 Pd 2.20	47 Ag 1.93	48 Cd 1.69	49 In 1.78	50 Sn 1.96	51 Sb 2.05	52 Te 2.1	53 I 2.66
55 Cs 0.79	56 Ba 0.89	57 La 1.1	72 Hf 1.3	73 Ta 1.5	74 W 2.36	75 Re 1.9	76 Os 2.2	77 Ir 2.20	78 Pt 2.28	79 Au 2.54	80 Hg 2.00	81 Tl 1.62	82 Pb 2.33	83 Bi 2.02	84 Po 2.0	85 At 2.2
87 Fr 0.7	88 Ra 0.9															

Non-polar vs. polar covalent bonds

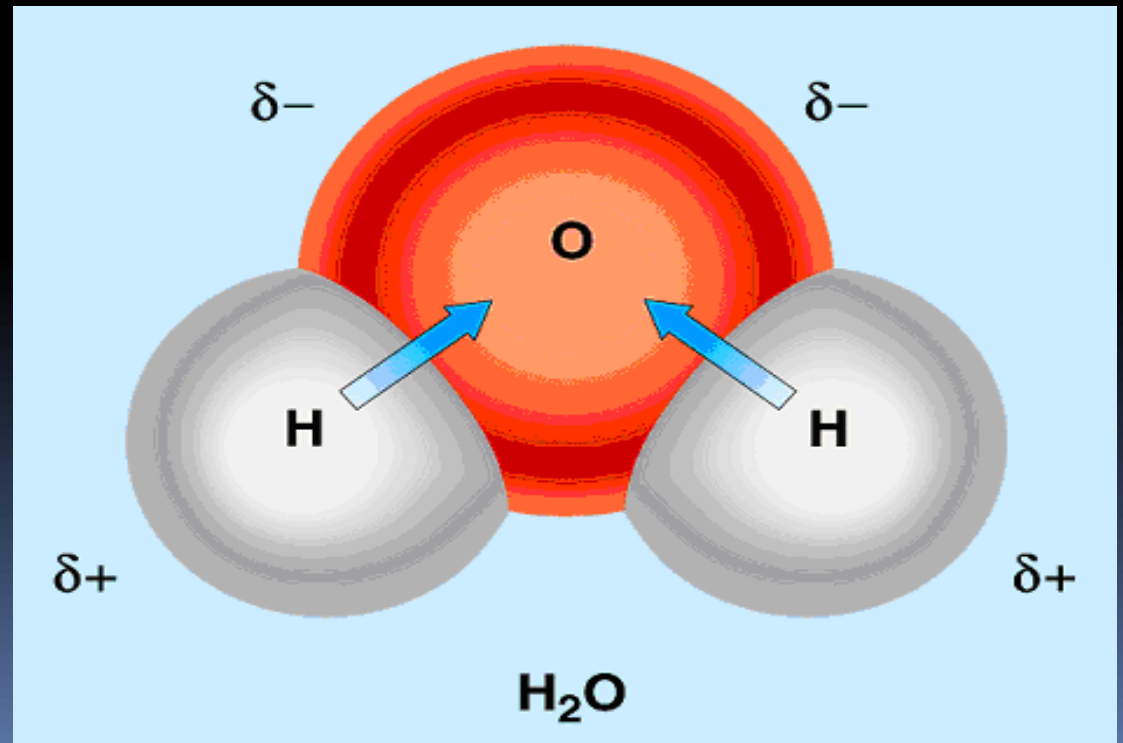
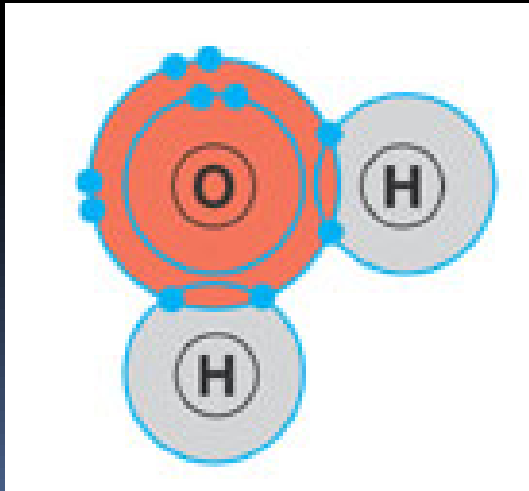
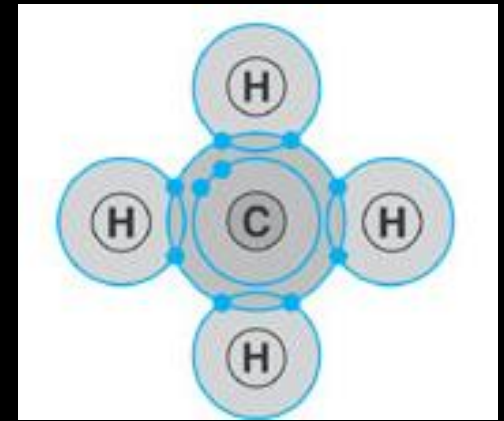
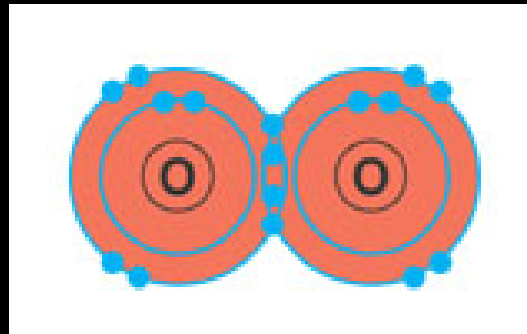
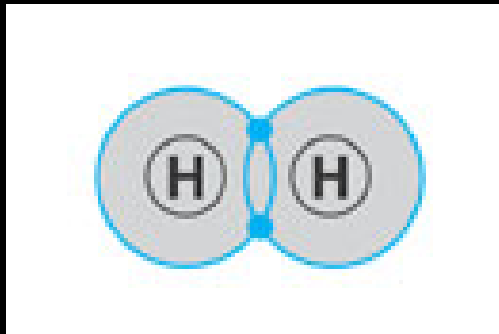
- **Non-polar covalent bonds**

- Electrons are shared equally between atoms

- **Polar covalent bonds**

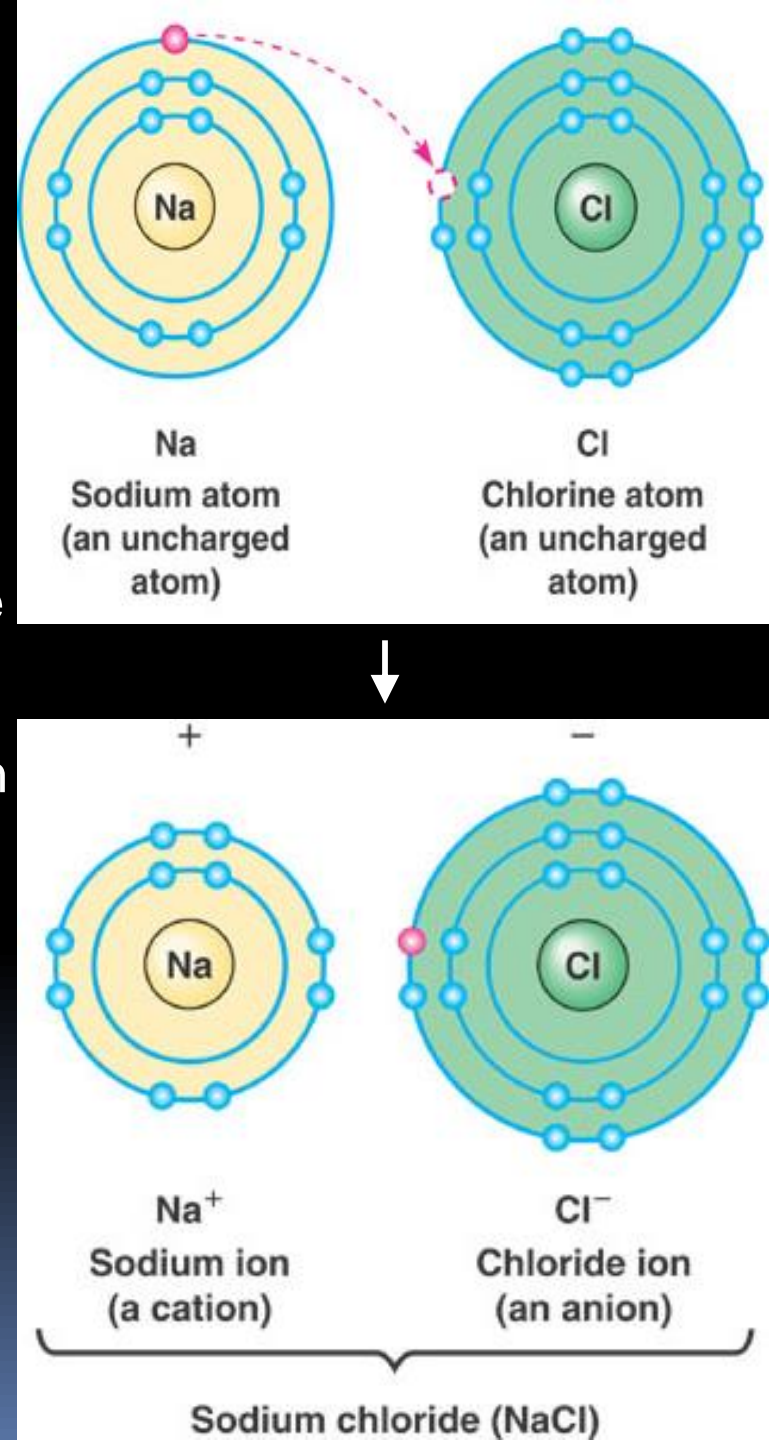
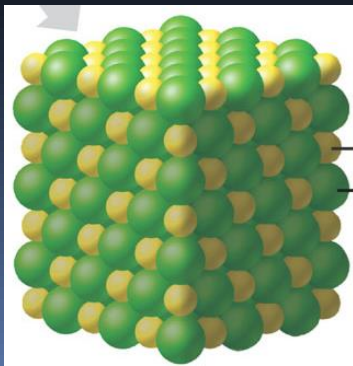
- Electrons are NOT shared equally
- This is because some atoms have higher “electronegativity”
 - This means they have a stronger attraction for electrons
 - **INCREASES** toward the **RIGHT** on the periodic table
- If there are differences in electronegativity that are not symmetrical, the molecule will be polar.
- The shape of the molecule determines where the partial poles will be.

Examples of polar and non-polar



Ionic bonds

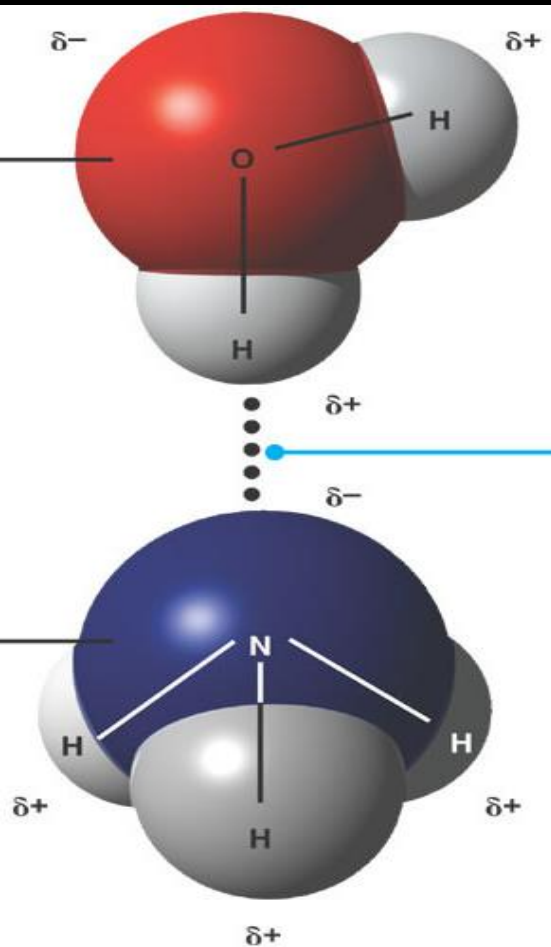
- This occurs when one atom actually **TAKES** an electron(s) from another
- (Just like with covalent bonds...) the goal is to end up with a **FULL** valence
- Both the **DONOR** and the **Receiver** will have full valences!
- Atoms that have an extra or missing electron are charged, called **IONS**. (+ = cation, - = anion)
- Two complimentary ions come together to form a **SALT**



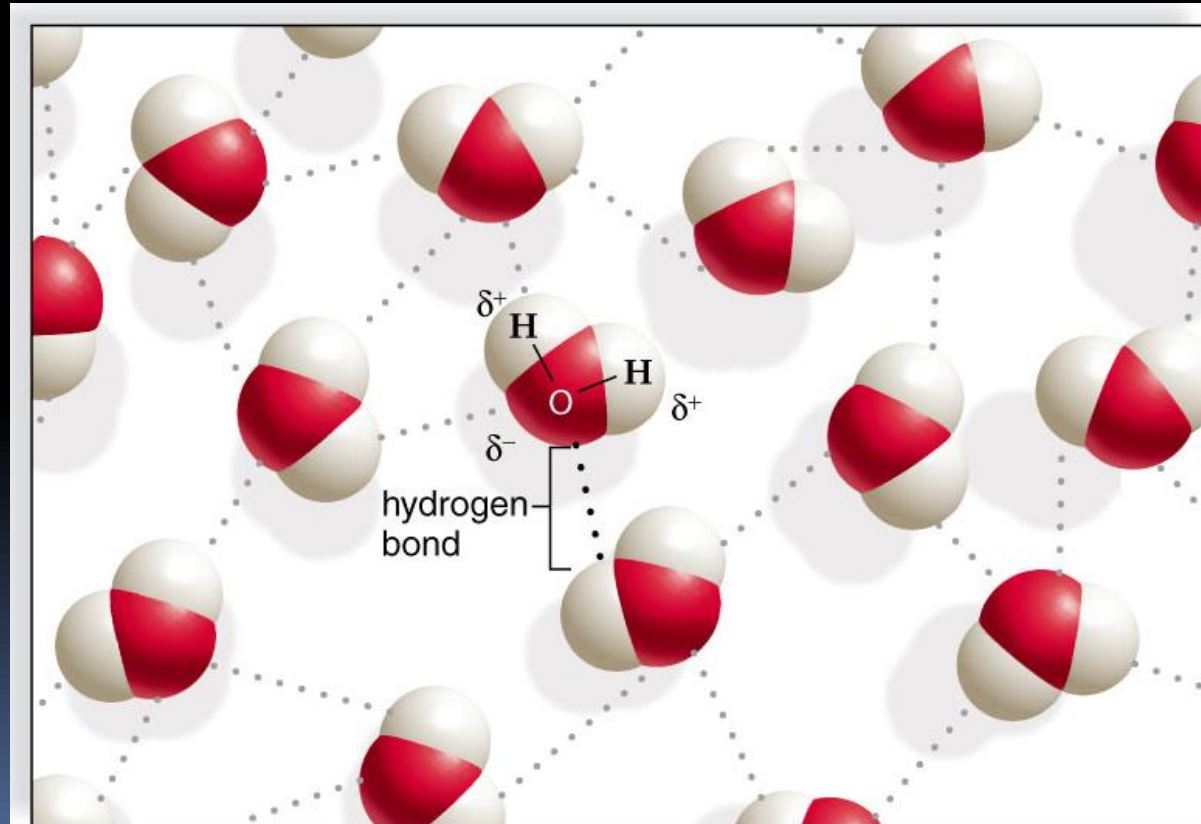
Weak Chemical Bonding

- Attraction between two molecules that is weak and transient (temporary), not a true “bond” because it can be easily broken without changing the chemical nature
- **Hydrogen bonding**
 - Hydrogen atoms are often bound to more electronegative atoms, and are thus slightly positively charged.
 - This slightly positive pole can then attract a negatively charged pole of another molecule.

Hydrogen Bonding



Hydrogen bond



b. Hydrogen bonding between water molecules

Weak Chemical Bonding

- **van der Waals Forces**

- Because electrons are in constant motion, a molecule can have short-lived “hot spots” of positive and/or negative charge.
- When molecules are VERY close together, this slight charges can result in attractive or repulsive forces
- Collectively, such interactions can be strong, as between molecules of a gecko’s toe hairs and a wall surface



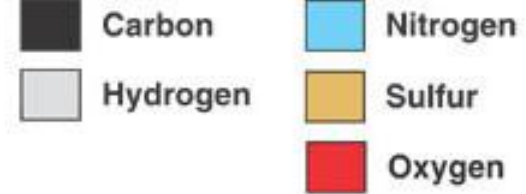
<https://www.youtube.com/watch?v=45yabrnryXk>

https://www.youtube.com/watch?v=wJ_rbsytjl

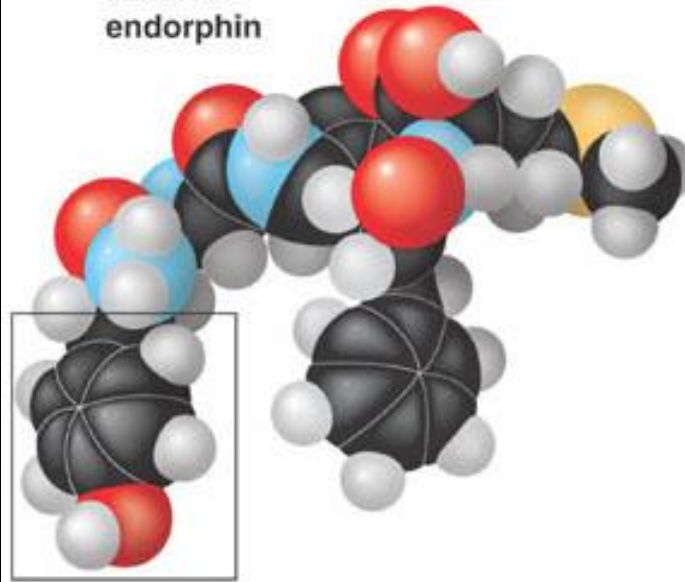
Molecular shape and function

- Most of the strongest bonds in organisms are covalent bonds that form a cell's molecules
- Weak chemical bonds, such as ionic bonds and hydrogen bonds, are also important:
these bonds reinforce shapes of large molecules and help molecules adhere to each other

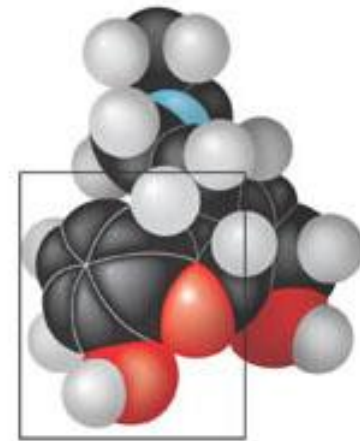
Shape = Function!



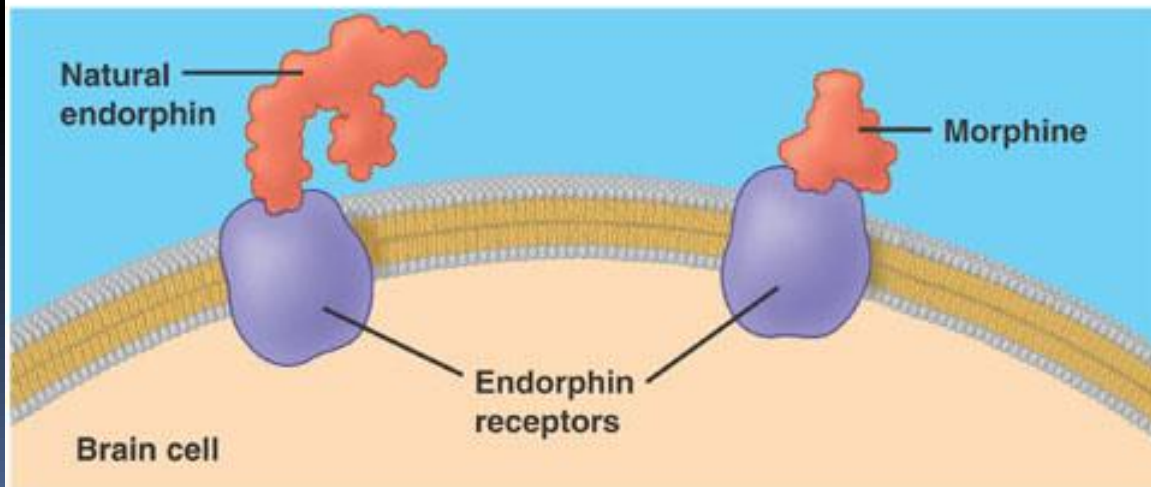
Natural
endorphin



Morphine



(a) Structures of endorphin and morphine



(b) Binding to endorphin receptors