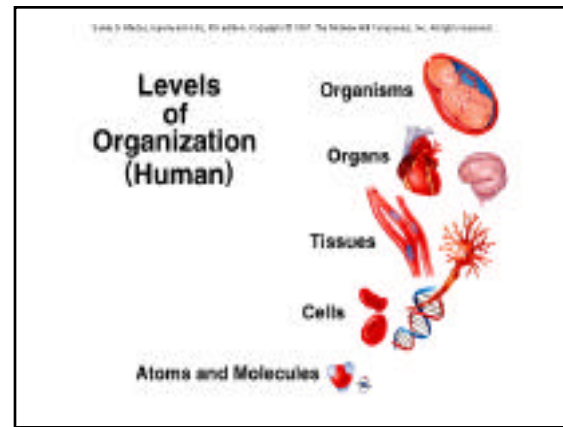


Chapter 2

Small Molecules: structure and behavior



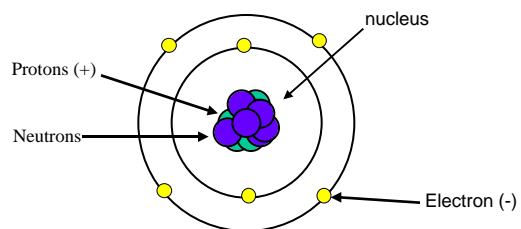
Chemical symbol
Atomic number
Atomic mass (average of all isotopes)

Lanthanide series
Actinide series

Atom, element, compound, and Mixture

- Atom (element)**: Oxygen (O)
 - Smallest unit that still has the properties of an element
- Molecule (element)**: Oxygen (O₂)
 - Stable assembly of two or more atoms
- Compound**: Water (H₂O) and Carbon dioxide (CO₂)
 - Substances forged in chemical reactions from two or more different elements
- Mixture**: Carbonated water
 - Different compounds combined together

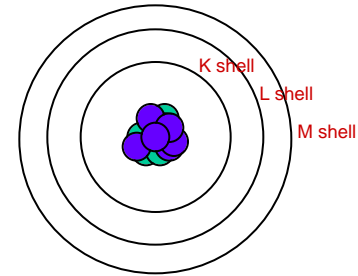
Atomic Structure



First three periods of the Periodic Table

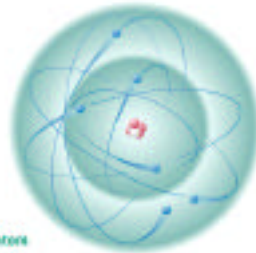
Diatomic symbol	Hydrogen H																	Helium He		
First shell	1																	2		
Atomic number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Element name	Lithium Li	Beryllium Be	Boron B	Carbon C	Nitrogen N	Oxygen O	Fluorine F	Neon Ne	Sodium Na	Magnesium Mg	Aluminum Al	Silicon Si	Phosphorus P	Sulfur S	Chlorine Cl	Argon Ar				Krypton Kr
Second shell	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Third shell	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Electrons are found in shells



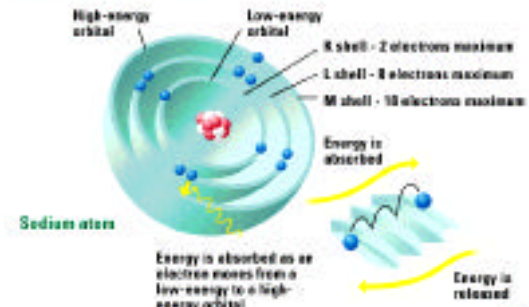
K shell - 2 electrons max/1 orbital
 L shell - 8 electrons max/4 orbitals
 M shell - 18 electrons max/9 orbitals

Structure of an atom



Carbon atom

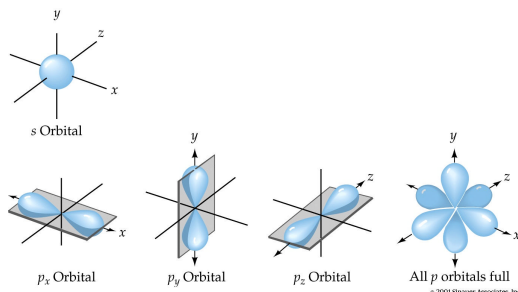
Structure of an atom



Sodium atom

Energy is absorbed as an electron moves from a low-energy to a high-energy orbital

Energy is released



Properties of an atom

mass number
 atomic number

Element

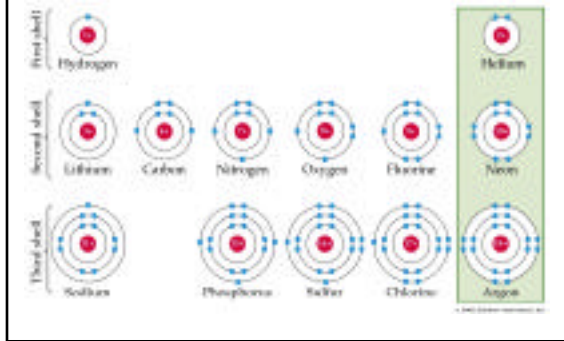
Number of proton + neutrons

Number of protons

$^{12}_6\text{C}$

Carbon

Shells of atoms



First three periods of the Periodic Table

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
First shell	Hydrogen (1)																	Helium (2)	
Second shell	Lithium (3)	Beryllium (4)	Boron (5)	Carbon (6)	Nitrogen (7)	Oxygen (8)	Fluorine (9)	Neon (10)											
Third shell	Sodium (11)	Magnesium (12)	Aluminum (13)	Silicon (14)	Phosphorus (15)	Sulfur (16)	Chlorine (17)	Argon (18)											

Molecular weight

- The molecular weight of a substance is the sum of the atomic mass units of atoms in the molecule.
- Water (H_2O) has *two* molecules of hydrogen ($amu = 1$) and *one* atom of oxygen ($amu = 16$).
 $2(1) + 1(16) = 18$;

So, **18 is the molecular weight of water**

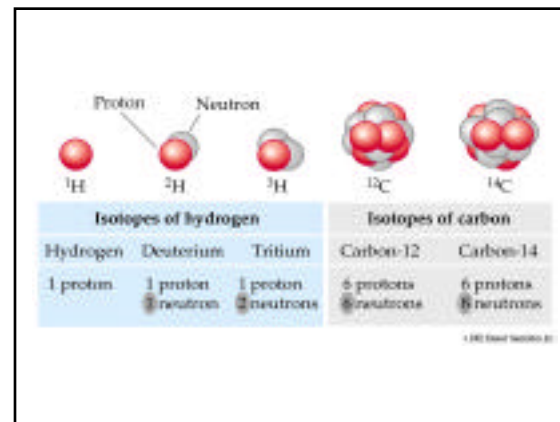
	Hydrogen	Carbon	Nitrogen	Oxygen
Molecular weights	1	12	14	16

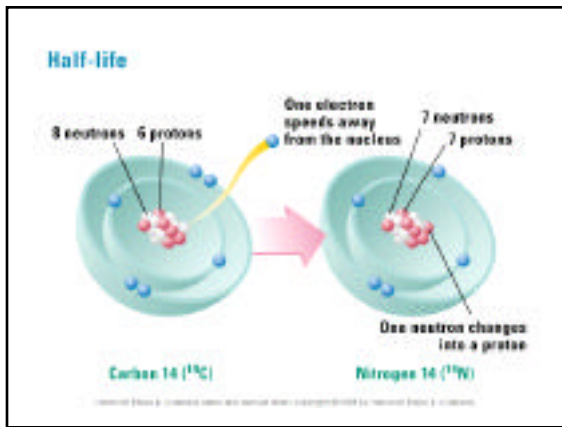
	Water	Alanine	Glucose
Molecular weights	18	89	180

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Isotopes

- Atoms that have the same number of protons but a different number of neutrons.
- All of these are isotopes of the element carbon.
 ${}^{12}_6\text{C}$ ${}^{13}_6\text{C}$ ${}^{14}_6\text{C}$





Octet Rule

- Atoms need to fill the outer shell with a maximum of 8 electrons to attain and maintain stability.

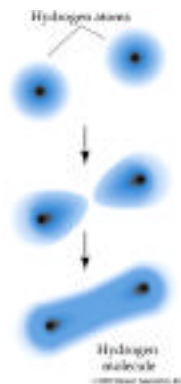
Chemical Bonds

- Atoms try to have full octet of electrons in the outer shell.
 - Strong bonds
 - Covalent bonds (50-110 Kcal/mol)
 - Sharing of electrons.
 - Ionic bonds (+/- the energy of covalent bonds)
 - Donating/accepting of electrons between two atoms
 - Weak bonds
 1. Hydrogen bonds (1-2 kcal/mol) - an attraction between molecules due to partial charges
 2. van der Waals - attraction between close molecules - very weak
 3. Hydrophobic interactions - similar to van der Waals

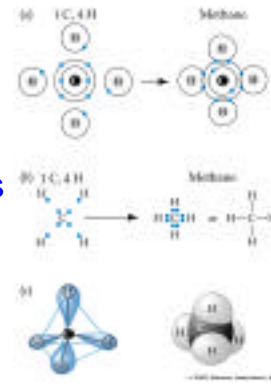
Covalent bonds

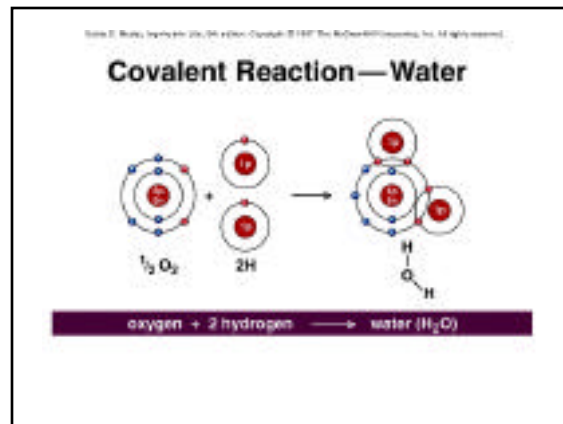
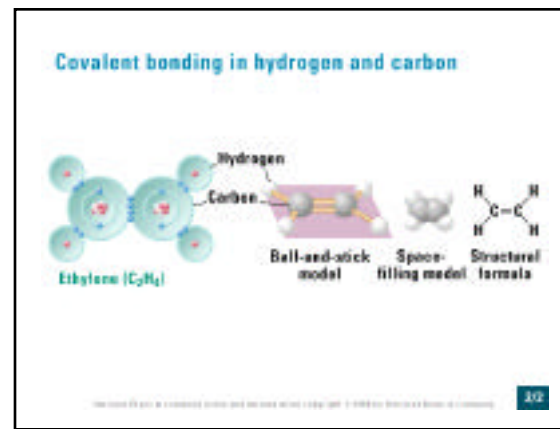
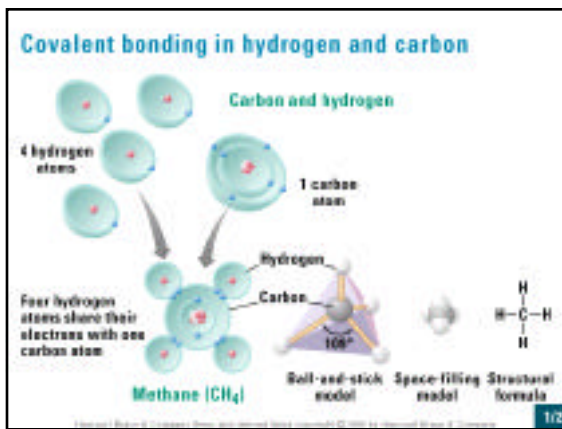
- Formed by the sharing of electrons.
- Two electrons are shared per covalent bond.
- Strong bond..
- SPONCH (sulfur, phosphorus, oxygen, nitrogen, carbon, hydrogen)

Covalent bond



Representing covalent bonds

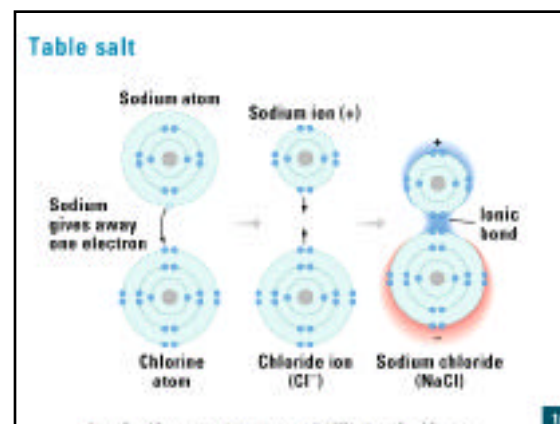


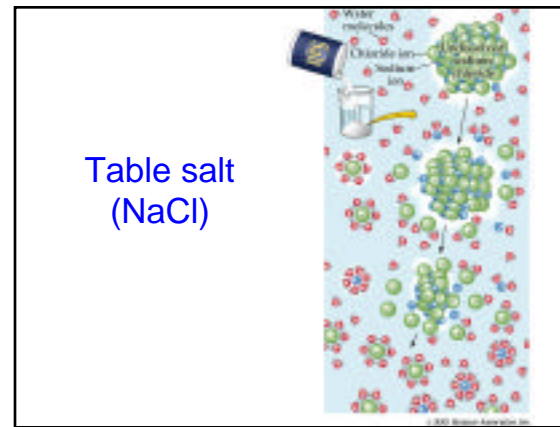
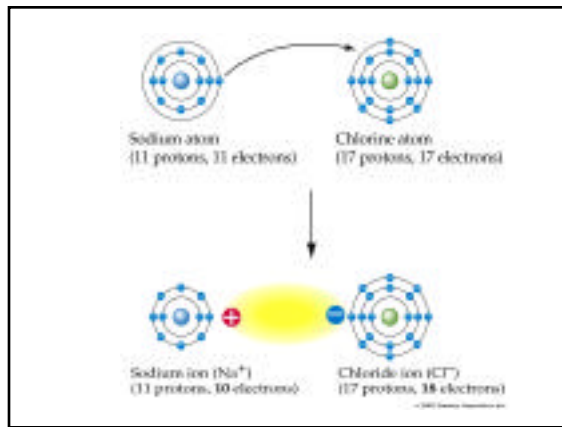


2.2 Covalent Bonding Capabilities of Some Biologically Important Elements

ELEMENT	NUMBER OF COVALENT BONDS
Hydrogen	1
Oxygen	2
Sulfur	2
Nitrogen	3
Carbon	4
Phosphorus	5

- ### Ionic Bond
- Formed by the donating and accepting of electrons by two atoms.
 - Strong bond.
 - Atoms that have nearly full or nearly empty shells tend to form ions.
 - Positively-charged ions are called cations.
 - Negatively-charged ions are called anions.



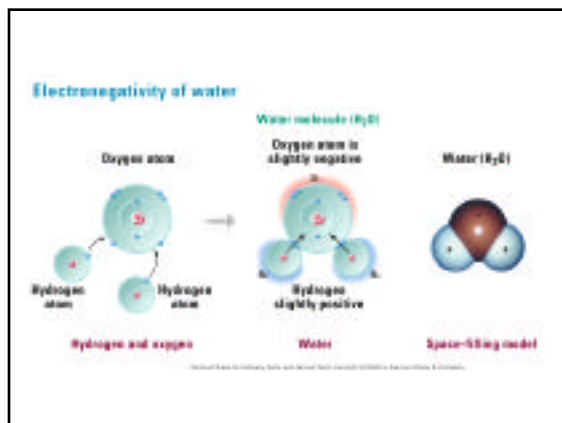


Electronegativity

- Tendency to gain electrons
 - Most electronegative
 - Oxygen
 - Chlorine
- Tendency to lose electrons
 - Least electronegative
 - Sodium
 - Potassium
 - Lithium

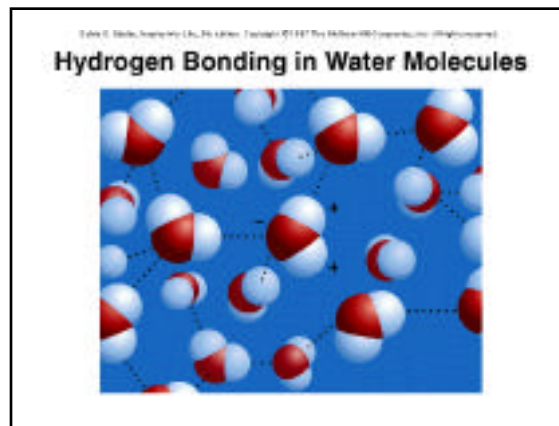
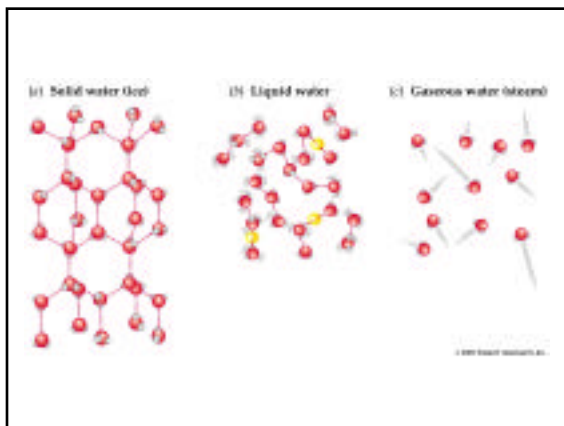
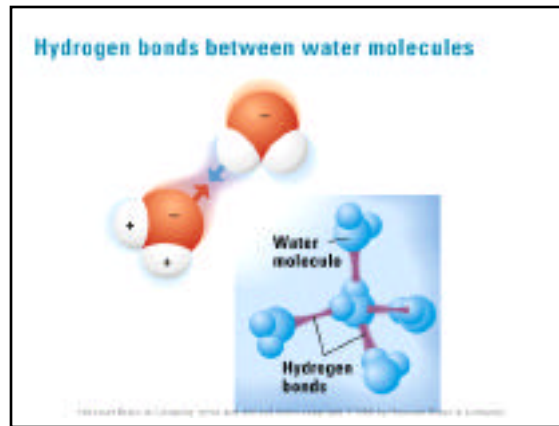
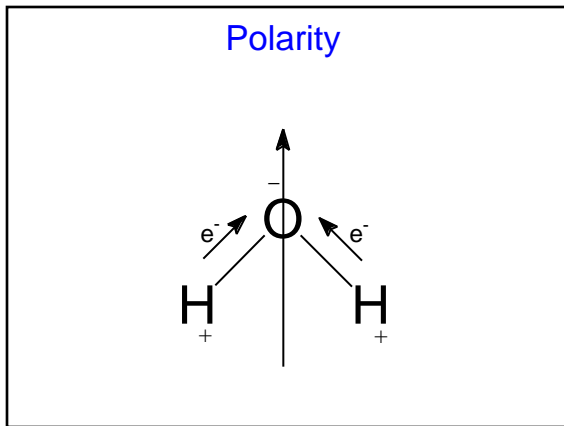
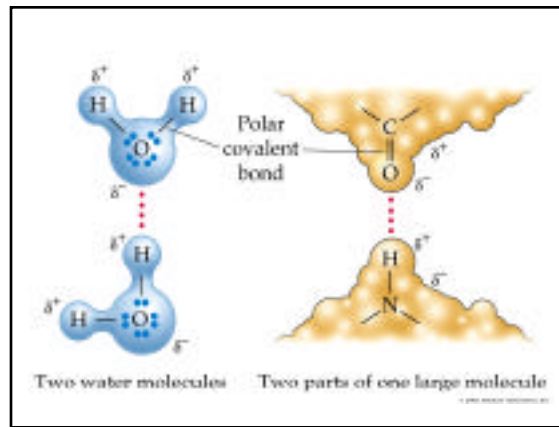
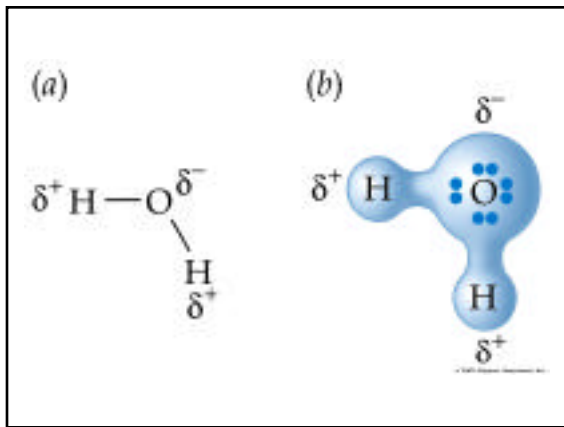
2.3 Some Electronegativities

ELEMENT	ELECTRONEGATIVITY
Oxygen	3.5
Chlorine	3.1
Nitrogen	3.0
Carbon	2.5
Phosphorus	2.1
Hydrogen	2.1
Sodium	0.9
Potassium	0.8



Hydrogen Bond

- Formed by partial positive (+) and partial negative (-) charges formed by electronegative atoms in two molecules
- Weak bond.



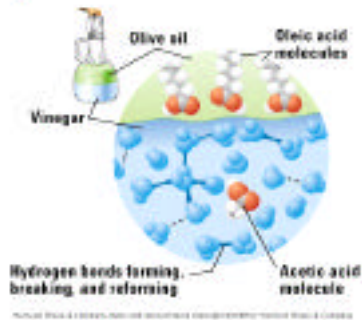
Properties of Water

- Denser as liquid than a solid (ice formation)
- High heat capacity
 - High boiling point
 - Good evaporative coolant
- Surface tension and cohesion
- Adhesion--sticks to everything
 - Capillary action
- Good solvent (polar medium)
 - Solutes (NaCl, sugars, etc.)

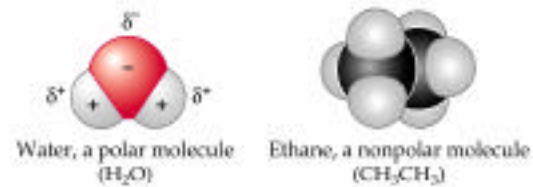
Pond life under winter ice



Hydrophobic interactions (water fearing)

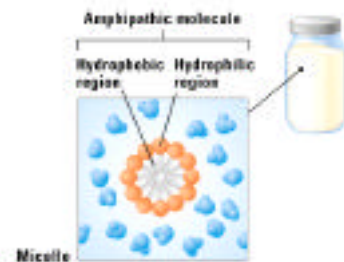


Polar and Nonpolar



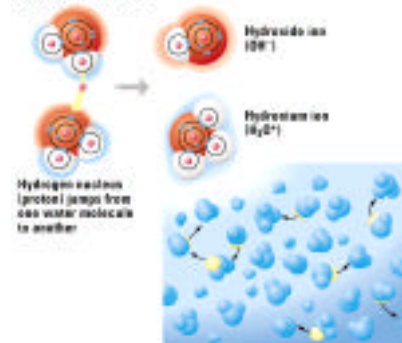
Amphipathic molecules contain a hydrophobic tail and hydrophilic head

(water loving)

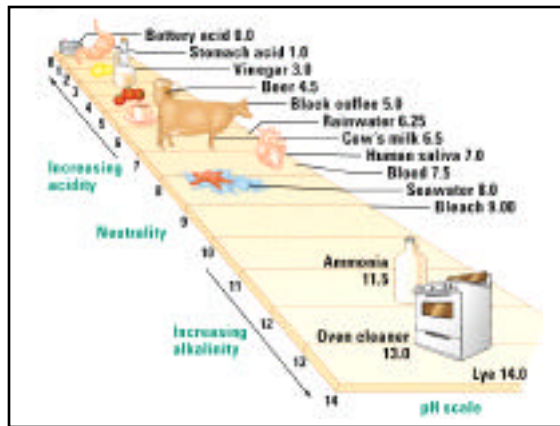
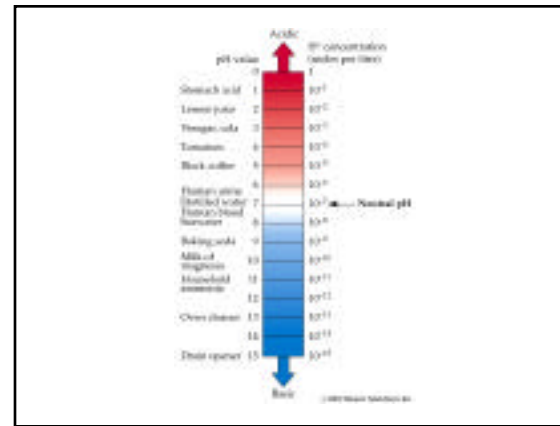
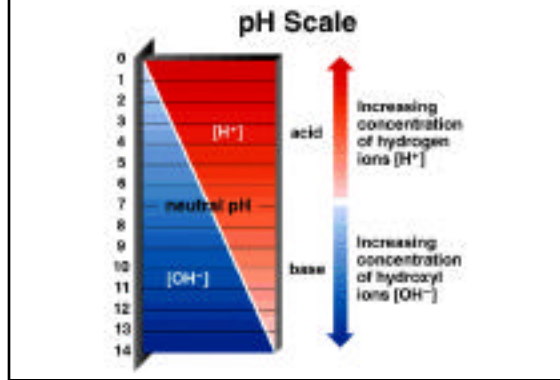


Juggling protons

Two water molecules

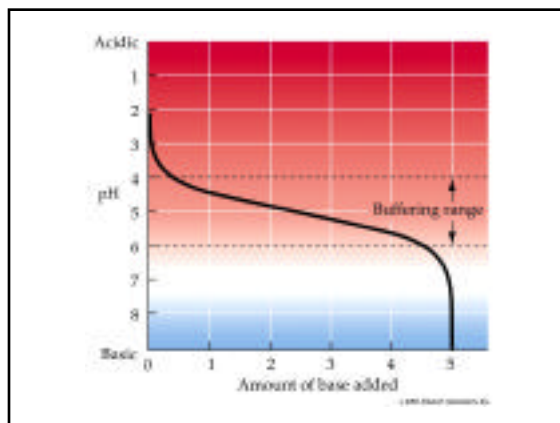
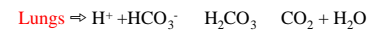


pH is a measure of the hydrogen ion concentration



Buffers

- ✓ Molecules that easily converts between acid and base forms
- ✓ Ex. Carbonic acid and bicarbonate in the blood



Functional group	Class of compounds	Structural formula	Example
Hydroxyl -OH	Alcohol	$\text{R}-\text{OH}$	Ethanol
Aldehyde -CHO	Aldehyde	$\text{R}-\text{CHO}$	Acetaldehyde
Keto -CO-	Ketone	$\text{R}-\text{C}(=\text{O})-\text{R}$	Acetone
Carboxyl -COOH	Carboxylic acid	$\text{R}-\text{COOH}$	Acetic acid

Functional group	Class of compounds	Structural formula	Example
Amino -NH ₂	Amino		 Methylamine
Phosphate -COO ²⁻	Optic phosphates		 3-Phosphoglyceric acid
Sulhydryl -SH	Thiol		 Methionine

