Chapter 2

Basic Chemistry

Introduction

- Chemistry – studies composition of substances and how they change or react
- Biochemistry –

Matter

- Matter – anything that occupies space & has mass (weight)
- Physical change – change in state
- Chemical change – alter the composition of a substance

Energy

- Energy – the ability to do work
- Kinetic energy –
- Potential energy –
  - Chemical
  - Electrical
  - Mechanical
  - Radiant

Composition of Matter

- Atoms – basic unit of matter
  - Building blocks of elements
- Elements – 92 naturally occuring
  - Each atom has 1 specific type of atoms
  - 96% of the body is made from 4 elements
    - C
    - O
    - H
    - N

Composition of Matter

- Remaining ~ 4% include
  - Ca
  - P
  - K
  - Na
  - Cl
- CHNOPS NaCl CaK
- Trace elements include Fe, I, ZN, Mg, Mn, Cu,

MULTIVITAMIN LABEL

Supplement Facts

Serving Size 1 Tablet
Servings Per Container 60

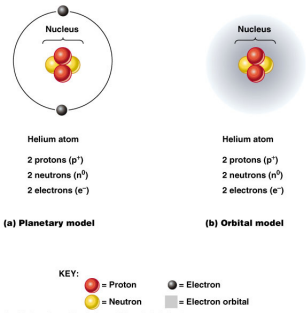
Amount Per Serving	% Daily Value	Amount Per Serving	% Daily Value
Vitamin A (4,000 IU as Vitamin A Palmitate and 10,000 IU as Beta-Carotene) 14,000 IU	280%	Magnesium (as Mg Apartate & Mg Oxide) 50 mg	13%
Vitamin C (as Ca Ascorbate & Ascorbic Acid) 300 mg	500%	Zinc (as Zn Aspartate & Zn Picolinate) 10 mg	67%
Vitamin D2 (as Ergocalciferol) 400 IU	100%	Selenium (as Se AAC) 20 mcg	29%
Vitamin E (as d-alpha tocopheryl succinate) 120 IU	400%	Copper (as Cu AAC) 0.25 mg	13%
Thiamin (as Thiamin Mononitrate) 60 mg	4000%	Manganese (as Mn Gluconate) 2 mg	100%
Riboflavin 60 mg	3529%	Chromium (as Cr Polynicotinate) 20 mcg	17%
Niacin (as Niacinamide) 60 mg	300%	Molybdenum (as Mo AAC) 10 mcg	13%
Vitamin B6 (as Pyridoxine HCl) 60 mg	3000%	Potassium (as K Citrate & K Aspartate) 30 mg	1%
Folic Acid 400 mcg	100%	Boron (as B AAC) 1 mg	*
Vitamin B12 (as Cyanocobalamin) 60 mcg	1000%	Choline (as Choline Bitartrate) 60 mg	*
Biotin 150 mcg	50%	Inositol 60 mg	*
Pantothenic Acid (ac Ca Pantothenate) 60 mg	600%	PABA (Para-aminobenzoic Acid) 60 mg	*
Calcium (as Ca Carbonate, Ca Ascorbate, Ca AAC & Ca Pantothenate) 100 mg	10%	Mixed Citrus Bioflavonoids 50 mg	*
Iron (as Fe Glycinate, Fe Aspartate, & Fe Fumerate) 10 mg	56%	Hesperidin 10 mg	*
Iodine (from kelp) 75 mcg	50%	Pectin 25 mg	*
		Betaine HCl 20 mg	*
		Alfalfa Leaf Powder 5 mg	*
		Chamomile Flower Powder 5 mg	*
		Rosehips 5 mg	*
		Red Raspberry Fruit Powder 5 mg	*
		Parsley Leaf Powder 5 mg	*

* Daily Value not established.

Other ingredients: stearic acid, microcrystalline cellulose, silica, vegetable stearate, guar gum, hydroxypropyl methylcellulose, talc.

Atomic Structure

- Nucleus
  - Protons ($^+$)
  - Neutrons (neutral)
- Outside of nucleus
  - Electrons (e^-)



Identifying Elements

- Atomic number
  - -
  - -
- Atomic mass number
  - -
  - Dalton – unit used to measure atomic mass (amu)
  - Mass of 1 P or N ~ 1 Dalton
  - Mass of 1 E ~ 1/2000th Dalton

Atomic Weight and Isotopes

- Atomic weight
  - Close to mass number of most abundant isotope
- Isotopes
  - Have the same number of protons but neutrons vary

Isotopes of Carbon

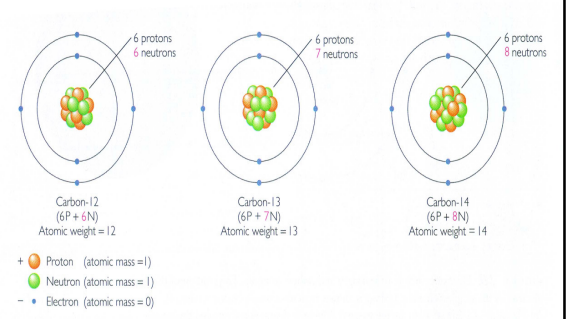


FIGURE 2.3 These three carbon isotopes all have the same number of protons and thus the same atomic number, 6. Their atomic masses differ, however, because they have slightly different numbers of neutrons. The atomic mass of any element is the average of the weighted sum of the atomic masses of its various isotopes. One isotope of an element—for example, carbon-12—is

Radioactivity

- Radioisotope
  - Tend to be unstable isotopes
  - Decomposes to more stable isotope
- Radioactivity
  - Process of spontaneous atomic decay
  - Rate is constant – C_{14} half life is 5740 yrs.
  - Used to date fossils
  - Medical tracing of chemicals in body

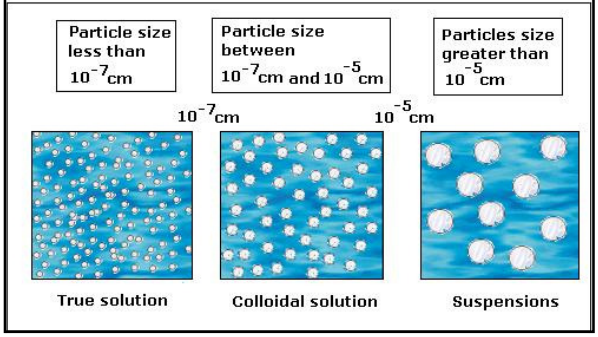
Molecules & Compounds

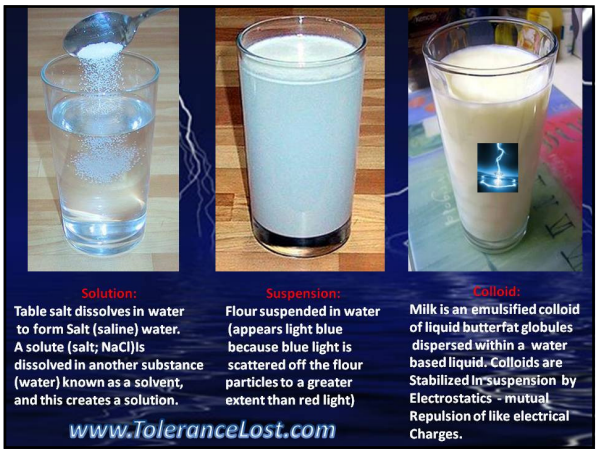
- Molecule –
- Compound –
- Mixture –

Mixtures

- Three types of mixtures
  - Solutions – homogenous mixture of 2 or more particles (Sweet tea)
    - Solute –
    - Solvent –
  - Suspensions - particles are larger than those found in solutions. Particles can be evenly distributed by a mechanical means, but will settle out. EX.
  - Colloids – Particles intermediate in size between those found in solutions and suspensions; remain evenly distributed without settling out. EX.

Mixtures are based on particle size





Chemical Reactions

- Atoms are joined by chemical bonds to form compounds
- Elements on left side are
- Elements on right side are

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

(reactants) (products)

- Conservation of Mass states mass of reactants = mass of products

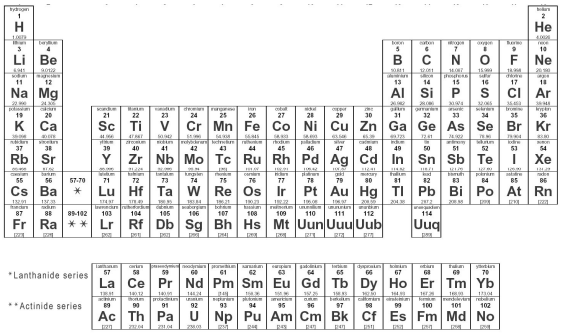
Electrons and Bonding

- Electrons occupy energy levels called electron shells
- Electrons closest to the nucleus are most strongly attracted
- Each shell has distinct properties
  - Shells closest to nucleus fill first
  - 1st has
  - 2nd has
  - 3rd has

Electrons and Bonding

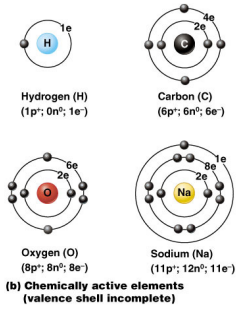
- Bonding involves interactions between electrons in the outer shell (valence shell)
- Full valence shells do not form bonds (Noble Gases)
- Atoms with same # of valence electrons have similar chemical behaviors (Groups)
- Energy required to break chemical bonds

Identify groups, oxidation numbers, who loses or gains electrons



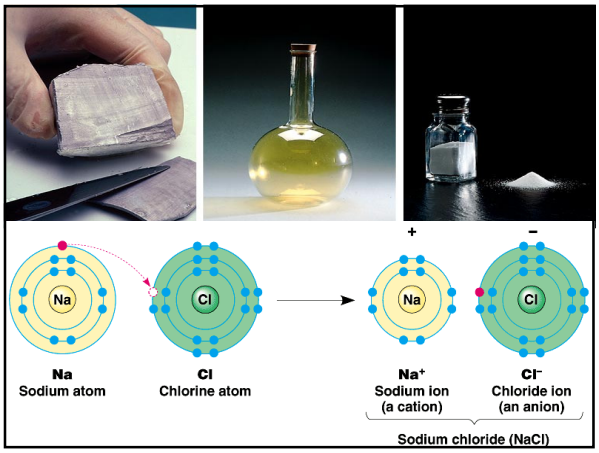
Reactive Elements

- Valence shells that are not full & are unstable
- Tend to gain, lose, or share electrons
- Needs full shell to be stable
- Group I bonds with Group 7. Group 2 bonds w/ Group 6



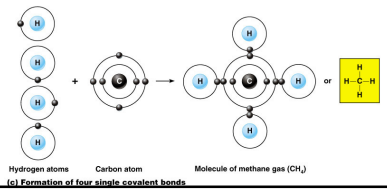
Chemical Bonds

- Ions –
  - Atoms that gain electrons are negative & called
  - Atoms that lose electrons are positive & called
- Ionic Bonds
  - Form when electrons are transferred from one atom to another; one is + and other is –
  - Example is NaCl

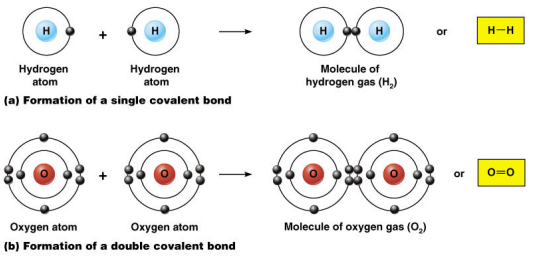


Chemical Bonds

- Covalent Bonds
  - -
  - -
  - -

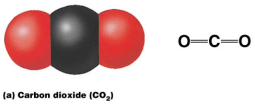


Examples of Covalent Bonds

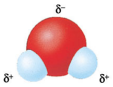


Polarity

- Describes how electrons are shared between atoms of molecules
- Some are non-polar
  - Equal sharing of electrons
  - Electrically neutral
- Some are polar
  - Unequal sharing of electrons
  - Have a positive & negative side



O═C═O

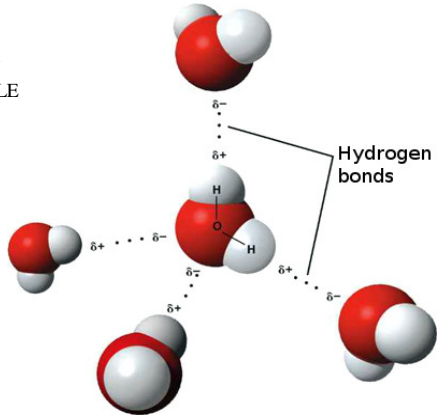


Chemical Bonds

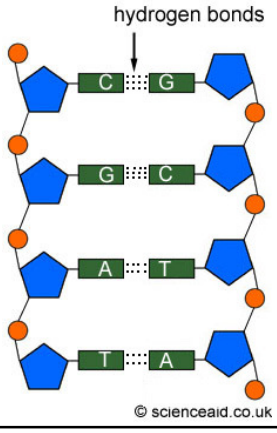
- Hydrogen bonds
  - 1 of the most important bonds
  - Weak chemical bonds
  - Hydrogen is attracted to negative portion of polar molecule
  - Provides attraction between 2 or more molecules
  - H bonds water molecule and bases of DNA chain

WATER

MOLECULE



DNA



Patterns of Chemical Reactions

- Synthesis reaction (A+B→AB)
  - -
  - -
- Decomposition reaction (AB→A+B)
  - -
  - -

Synthesis and Decomposition Reactions

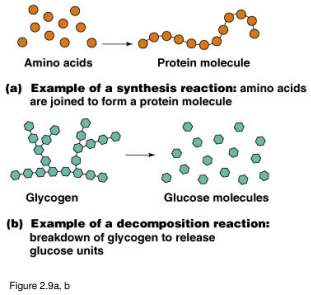


Figure 2.9a, b

Chemical Reactions

- All chemical reactions are either exergonic or endergonic
  - Exergonic reactions—
    - Catabolic reactions
  - Endergonic reactions—
    - Anabolic reactions

Rates of Chemical Reactions

- Rate of reaction is influenced by:
  - ↑ temperature → ↑ rate
  - ↓ particle size → ↑ rate
  - ↑ concentration of reactant → ↑ rate
- Catalysts: ↑ rate without being chemically changed
  - Enzymes are biological catalysts

Biochemistry: Essentials for Life

- Organic compounds
  - Contain carbon – associated with life
  - Covalently bonded (most)
  - Ex:
- Inorganic compounds
  - Not of biological origin
  - Tend to be simpler compounds
  - Ex:

Important Inorganic Compounds

- Water
  - Most abundant compound
  - End product of respiration
  - Vital properties
    - High heat capacity
    - Polarity/solvent properties
    - Chemical reactivity
    - Cushioning

Important Inorganic Compounds

- Salts
  - Vital to many body functions
  - Includes electrolytes which conduct electrical currents
- Acids –
- Bases –
- Neutralization reaction
  - Acids & bases react to form water & salt

pH

- Measures conc. of H^+ ions
  - pH 7 = neutral
  - pH below 7 = acidic
  - pH above 7 = basic
  - Buffers
    - Chemicals that can regulate pH change

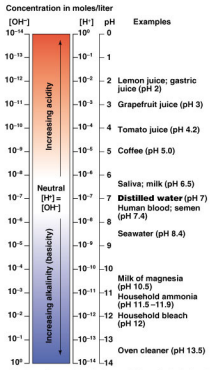


Figure 2.11

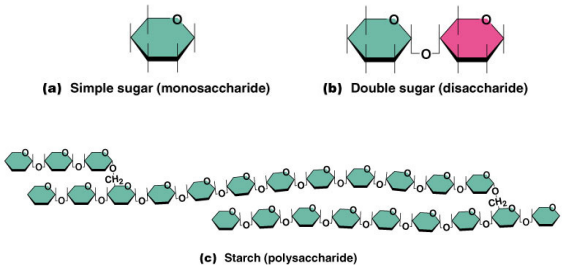
4 Major Macromolecules of Life

- Carbohydrates –
- Lipids –
- Proteins –
- Nucleic Acids –

Important Organic Compounds

- Carbohydrates
  - Contain C, H, & O (1:2:1 ratio) $C_6H_{12}O_6$
  - Include sugars & starches
  - Classified according to size
    - Monosaccharides – simple sugars
    - Disaccharides – 2 simple sugars joined by dehydration synthesis
    - Polysaccharides – many long branching chains of simple sugars

Carbohydrates



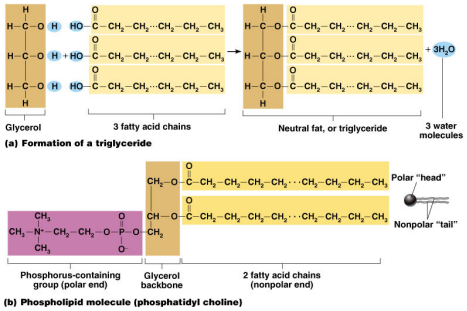
Important Organic Compounds

- Lipids
  - Contain C, H, and O
    - C & H outnumber O
- Insoluble in water
- Source of stored energy

Important Organic Compounds

- Common lipids in the body
  - Triglycerides - Composed of fatty acids & glycerol
  - Phospholipids - Form cell membranes
  - Steroids
    - Includes cholesterol, bile salts, vitamin D, & some hormones

Lipids

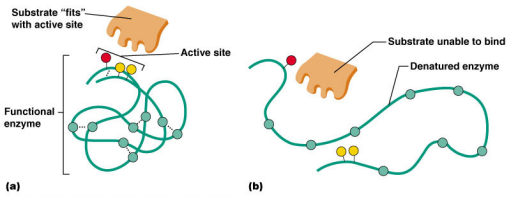


Important Organic Compounds

- Proteins
  - Made of amino acids
  - Contain C, O, H, N, and sometimes S
  - Provides for construction of all body tissues
  - Act as enzymes, intercellular signaling, & antibodies

Enzymes

- Act as biological catalysts
  - -

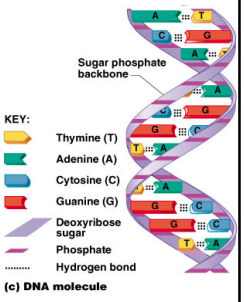


Important Organic Compounds

- Nucleic Acids
  - Provide blueprint of life
  - Nucleotide bases
    - A = Adenine
    - G = Guanine
    - C = Cytosine
    - T = Thymine
    - U = Uracil
  - Make DNA & RNA

Important Organic Compounds

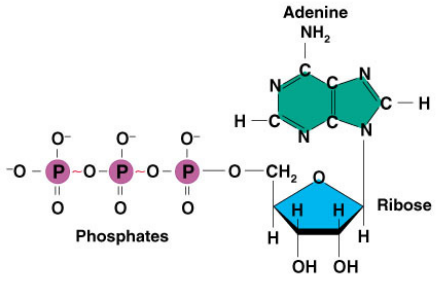
- Deoxyribonucleic acid (DNA)
  - complimentary bases form double helix
    - A-T
    - C-G
  - Replicates before cell division (interphase)
  - Provides instruction for every protein in the body; codons determine amino acids



Important Organic Compounds

- Adenosine triphosphate (ATP)
  - Chemical energy used by all cells
  - Energy is released by breaking high energy phosphate bond
  - ATP is replenished by oxidation of food fuels

Adenosine Triphosphate (ATP)



(a) Adenosine triphosphate (ATP)