Ch. 3 - Chemical Compounds

chemical bonds - an attractive force between two atoms holding them together

molecular compound(covalent compound) - two or more different elements combined into an independent unit

-"share" electrons

molecular formula - representation of the composition of a molecular compound

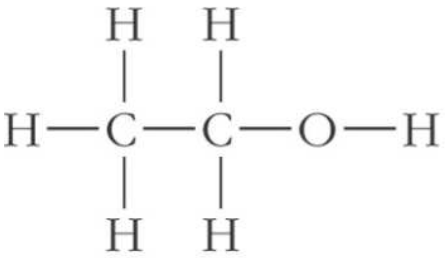
inorganic compounds - do not contain C, except for CO & CO_2

organic compounds - contain C & usually H, can include O, N, P, S

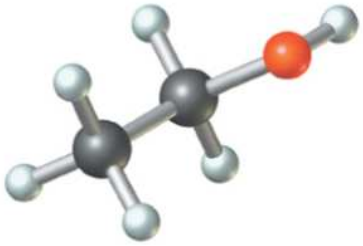
- must abundant of all compounds - millions - vary in structure and function

-all livings things are made of organics

-reason for such variability is due to C ability to form four bonds to other C or atoms



Structural formula



Ball-and-stick model

Space-filling model

structural formula - shows exactly how the atoms are connected
ball and stick model
space filling model

condensed formula - emphasis the atoms or groups of atoms bonded to each carbon

TABLE 3.2 Prefixes Used in Naming Chemical Compounds

Prefix	Number
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Nona-	9
Deca-	10

TABLE 3.3 Examples of Binary Compounds

Molecular Formula	Name	Use
CO	Carbon monoxide	Steel manufacturing
NO_2	Nitrogen dioxide	Preparation of nitric acid
N_2O	Dinitrogen oxide	Anesthetic; spray can propellant
N_2O_5	Dinitrogen pentoxide	Forms nitric acid
PBr_3	Phosphorus tribromide	Forms phosphorous acid
PBr_5	Phosphorus pentabromide	Forms phosphoric acid
SF_6	Sulfur hexafluoride	Transformer insulator
P_4O_{10}	Tetraphosphorus decoxide	Drying agent

functional groups - distinctive groups of atoms that characterize the organic compound

alkyl - R
alcohol - OH; R-OH
halides - halogens; R-X

Binary molecular compounds - contain only two types of elements

-use latin prefixes: mono - 1 tetra - 4 hepta - 7 deca - 10
di - 2 penta - 5 octa - 8
tri - 3 hexa - 6 nona - 9

ex./CO_2 - carbon dioxide; SO_3 - sulfur trioxide;
P_4O_{10} - tetraphosphorous decoxide

-when hydrogen and a nonmetal: use hydrogen and nonmetal name drop ending and add -ide

ex./HCl - hydrogen chloride; H_2S - hydrogen sulfide

-some were named before the systematic naming rules were developed

Hydrocarbons - organic cpds composed only of hydrogen and carbon
- simplest class of organic cpds.

-three major classes:
-alkanes - C_nH_{2n+2}
-alkenes - C_nH_{2n}
-alkynes - C_nH_{2n-2}

-using organic prefixes: meth -1 but- 4
eth - 2 then latin as before
prop - 3

Isomers - two or more compounds with the same molecular formula but different arrangements of atoms; can differ in physical and chemical properties

-structural isomers (constitutional isomers) - differ in order in which their atoms are bonded together

-functional isomers - differ in how the functional group is bonded

-positional isomers - differ in where the functional group is bonded

-geometric isomers - differ in orientation around a double bond

-straight chain vs. branched chain isomers hydrocarbons - pg.87-Table 3.5

straight chain - the C atoms are arranged in a line

branched chains - the C atoms are attached to the central atoms; not on end of chain

-the branched group is named using -yl ending

TABLE 3.5 Some Common Alkyl Groups

Name	Condensed Structural Representation
Methyl	$CH_3—$
Ethyl	$CH_3CH_2—$
Propyl	$CH_3CH_2CH_2—$
Isopropyl	$CH_3CH(CH_3)—$ or $(CH_3)_2CH—$
Butyl	$CH_3CH_2CH_2CH_2—$
sec-Butyl	$CH_3CH_2CH(CH_3)—$
t-Butyl	$(CH_3)_3C—$ or $CH_3—C(CH_3)_2—$

TABLE 3.6 Alkane Isomers

Molecular Formula	Number of Isomers	Molecular Formula	Number of Isomers
CH_4	1	C_9H_{20}	35
C_2H_6	1	$C_{10}H_{22}$	75
C_3H_8	1	$C_{12}H_{26}$	355
C_4H_{10}	2	$C_{15}H_{32}$	4347
C_5H_{12}	3	$C_{20}H_{42}$	366,319
C_6H_{14}	5	$C_{30}H_{62}$	4,111,846,763
C_7H_{16}	9	$C_{40}H_{82}$	62,491,178,805,831
C_8H_{18}	18		

Ionic Compound Properties - ionic solids are held in a crystal lattice structure
-cations and anions surround each other to maximize attraction and minimize repulsion
-the greater the attraction between ions the higher the melting point
-solids do not conduct electricity but do when melted
-liquid ionic cpds. contain ions that are free to move about
-cations migrate to neg. electrode; anions move to the pos. electrode
-stable valence shell achieved by bonds

Binary ionic compounds - positive ion first; negative ion second-Figure 3.2
-positive ion uses usually metal name; negative ion uses nonmetal name, drop ending, add -ide
ex./NaCl - sodium chloride; $MgCl_2$ - magnesium chloride

Ternary ionic compounds - contain at least one polyatomic ion (pos. or neg.); use above rules and polyatomic ion name; -pg.91-Table 3.7

ex./Na_3PO_4 - sodium phosphate

Molecular vs. Ionic Cpds. - pg.99-Table 3.9

Ionic Cpds. in Aqueous Solution - many are soluble in water; dissociates

-conduct electricity called electrolytes

-if they do not dissolve; no conduction - non-electrolyte

Hydrates - compounds with water chemically trapped within the crystal lattice

-water of hydration

TABLE 3.8 Names of Some Common Ionic Compounds

Common Name	Systematic Name	Formula
Baking soda	Sodium hydrogen carbonate	$NaHCO_3$
Lime	Calcium oxide	CaO
Milk of magnesia	Magnesium hydroxide	$Mg(OH)_2$
Table salt	Sodium chloride	$NaCl$
Smelling salts	Ammonium carbonate	$(NH_4)_2CO_3$
Lye	Sodium hydroxide	$NaOH$
Blue vitriol	Copper(II) sulfate pentahydrate	$CuSO_4 \cdot 5\ H_2O$

TABLE 3.9 Properties of Molecular and Ionic Compounds

Molecular Compounds	Ionic Compounds
Many are formed by combination of nonmetals with other nonmetals or with some metals	Formed by combination of reactive metals with reactive nonmetals
Gases, liquids, solids	Crystalline solids
Brittle and weak or soft and waxy solids	Hard and brittle solids
Low melting points	High melting points
Low boiling points (−250 to 600 °C)	High boiling points (700 to 3500 °C)
Poor conductors of heat and electricity	Good conductors of electricity when molten; poor conductors of heat and electricity when solid
Many insoluble in water but soluble in organic solvents	Many soluble in water
Examples: hydrocarbons, H_2O, CO_2	Examples: NaCl, CaF_2

Moles of Compounds - we use the mole concept to manipulate quantities of compounds; molar mass

molecular cpds. mass - molecular wt.

ionic cpds. mass - formula wt.

Gram-Mole Conversions -

Molar mass of a hydrate - must include the mass of the water of hydration

Percent Composition - also called mass percent of the cpd
-mass of each element/mass of total cpd. X 100

Empirical Formula - lowest whole no. ratios of atoms in a molecule

Biological Periodic Table - pg.109-Fig. 3.7

-dietary minerals - essential elements other than C, H, O, N
-major minerals - 28 found in qty. > 0.01%
-trace elements - minimal qtys.

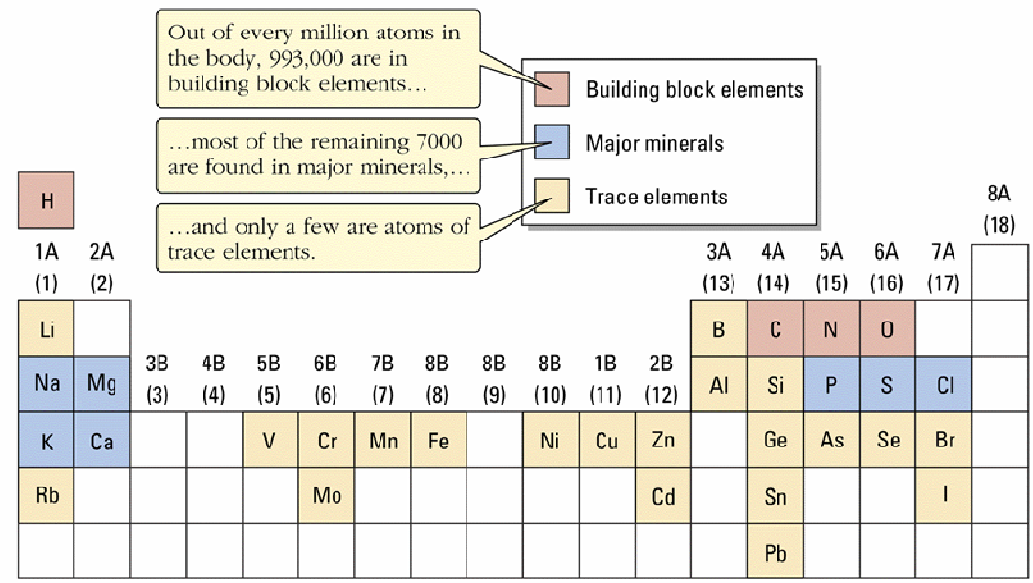
Biomolecules:
lipids - a component of plants or animal tissue that is insoluble in water but soluble in solvents of low polarity
-includes fats and oils(triglycerides), cholesterol, sex hormones, some vitamins (A,D,E,K), phospholipids in cell membrane (amphipathic)

carbohydrates - supply energy needs of our bodies
-monosaccharides - simple sugars; glucose, fructose
-disaccharides - two sugars, sucrose (glucose+fructose), lactose (glucose +galactose)
maltose (glucose + glucose)
-polysaccharides - more than two sugars; cellulose, starches, amylose

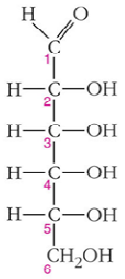
proteins - molecules with 50 or more amino acids
-amino acids are made of R-$CHNH_2$-COOH
-20 different aa serve as monomers for the protein polymers
-essential amino acids - must be obtained from our diet

nucleic Acids - DNA and RNA
-made of sugar, phosphate and nitrogenous bases A,T,G,C (U not T in RNA)
-base pairing in the middle of the DNA helix ; A-T, G-C
-make up our genes which we replicate, transcribe and translate

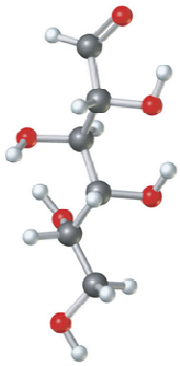
Biological Periodic Table

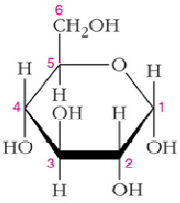


Glucose

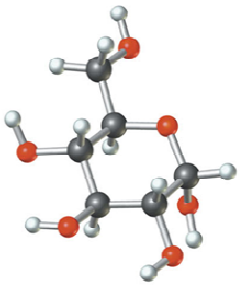


Chain structural formula and ball-and-stick molecular model for glucose

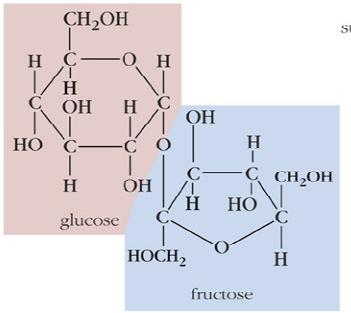




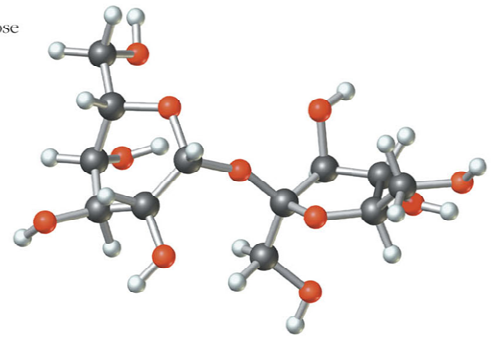
Ring structural formula and ball-and-stick molecular model for glucose



Sucrose

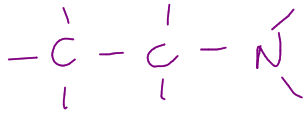


sucrose



For practice naming compounds go to:

http://fsc.fernbank.edu/chemistry/nomen.html

(3) b.  C_2H_7N

(6) d. C_6H_{14} hexane C_nH_{2n+2} -ane

C_nH_{2n} -ene

C_nH_{2n-2} -yne

(9) d. $C_{15}H_{32}$

(32) Ca^{2+} NO_3^- $Ca(NO_3)_2$

K^+ Cl^- KCl

Ba^{2+} PO_4^{3-}

$Ba_3(PO_4)_2$

Extra Practice:

① Find emp. form. of a cpd. given the following: 7.22g Ni, 2.53g P, 5.25g O

$7.22\text{g Ni} \left|\frac{1\text{ mol}}{58.71\text{ g}}\right| = \frac{0.123\text{ mol}}{0.082} = \frac{1.5}{1} \times \frac{3}{2}$ Ni P

$2.53\text{g P} \left|\frac{1\text{ mol}}{30.97\text{ g}}\right| = \frac{0.082\text{ mol}}{0.082} = \frac{1}{1}$

$5.25\text{g O} \left|\frac{1\text{ mol}}{16.00\text{g}}\right| = \frac{0.33\text{ mol}}{0.082} = \frac{4}{1}$

~~$Ni_3P_2O_8$~~

$Ni_3(PO_4)$

② Find emp. form. of a hydrate cpd.

2.94g $Sn(NO_3)_2$

4.37g H_2O

$Sn(NO_3)_2 \cdot 20H_2O$

$2.94\text{g} \left|\frac{1\text{ mol}}{242.71\text{ g}}\right| = 0.012\text{ mol}$

$4.37\text{g} \left|\frac{1\text{ mol}}{18.02\text{g}}\right| = \frac{0.243\text{ mol}}{0.012} = 20$

③ A hydrated sodium salt containing 39.7% H_2O is analyzed as follows: sodium 16.9%, carbon 17.7%, hydrogen 6.67%, oxygen 58.8%. Find the emp. form.

$39.7\text{g } H_2O \left|\frac{1\text{ mol}}{18.02\text{g}}\right| = \frac{2.2}{.74} = \frac{3}{1}$

$16.9\text{g Na} \left|\frac{1\text{ mol}}{23.00\text{g}}\right| = \frac{0.74}{0.74} = \frac{1}{1}$

$17.7\text{g C} \left|\frac{1\text{ mol}}{12.01\text{g}}\right| = \frac{1.47}{0.74} = \frac{2}{1}$

$NaC_2H_3O_2 \cdot 3H_2O$

$6.67\text{g H} \left|\frac{1\text{ mol}}{1.01\text{g}}\right| = \frac{6.60}{0.74} = \frac{9}{1}$ 3 left after water

$58.8\text{g O} \left|\frac{1\text{ mol}}{16.00\text{g}}\right| = \frac{3.70}{0.74} = \frac{5}{1}$ 2 left after water

~~$NaC_2H_9O_2$~~