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Chemistry

Chemistry

- Chemistry is the study of the smallest forms of matter and their interactions.
- Matter is anything that has mass and takes up space.
- Generally, chemistry deals with the study of matter known as atoms and molecules.

Atoms

Atoms

- are the smallest units of matter that have unique properties
- are extremely small
- are composed of smaller components called subatomic particles
- exist in roughly 90 different naturally-occurring varieties known as elements

Elements

Elements

- are the names given to the 90 or so types of atoms around us
- in addition to a name, each element has a chemical symbol assigned to it
- each have unique properties that distinguish them from the other elements
- certain elements are more common in the human body than others
- are arranged and organized into a Periodic Table of Elements

The Periodic Table of the Elements

1 H Hydrogen 1.00794																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (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)

Atomic Structure

Atoms are composed of smaller forms of matter called subatomic particles:

- protons
- neutrons
- electrons

Atomic Structure

Protons

- located in a cluster at the center of the atom, called its nucleus
- carry a positive electrical charge
- have a mass of 1 atomic mass unit (a.m.u. or just unit)

Atomic Structure

Neutrons

- found clustered in the nucleus of the atom
- have no electrical charge (neutral)
- have a mass of 1 a.m.u.

Atomic Structure

Electrons

- orbit the nucleus at specific distances at the speed of light
- have a negative electrical charge
- have such an insignificant mass that it is effectively zero (no significant mass)

Properties of Atoms

Atomic Number

- number of protons in the nucleus. This also determines what type of element it is. All atoms of the same element have the same number of protons.

Atomic Mass

- the mass of the atom
- number of protons plus the number of neutrons.

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Electron Location

Electrons orbit the atom's nucleus at specific distances called **energy levels**.

- each level is numbered 1–7 from the closest to the nucleus to the furthest
- electrons prefer to orbit in the lowest energy level possible (closest to the nucleus as they can get)
- each level can only hold a certain maximum number of electrons before forcing additional ones to orbit in higher levels:
  - Level 1: 2 electrons maximum
  - Levels 2–8: 8 electrons maximum

Valence Electrons

An atom's valence electrons are only the ones found in the outermost energy level of the atom.

They are important in determining an atom's behavior with other atoms.

Neutrality

An atom is considered neutral if it has no overall electrical charge.

An atom is neutral if it has an equal number of protons and electrons.

Stability

An atom is considered stable if its outermost energy level is full.

Atoms have a strong desire to become stable if they are not already by either completing a current energy level by gaining electrons or by eliminating a current energy level by losing electrons.

Atoms can become stable by taking electrons away from other atoms, by allowing electrons to be taken away by other atoms, or by sharing electrons with other atoms.

Ions

Ions are atoms that have an overall positive or negative charge.

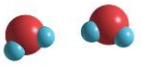
They become this way by gaining or losing electrons to achieve stability.

Positive ions = cations
Negative ions = anions

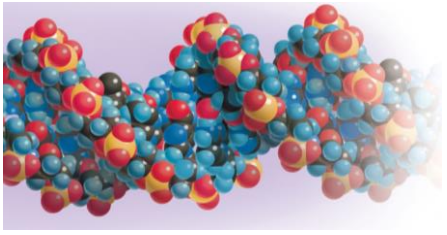
Molecules

Sometimes atoms become bonded to other atoms. A combination of two or more atoms bonded together is called a molecule.

Molecules can be small:



or large:



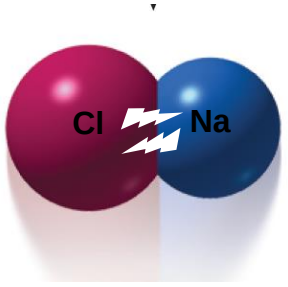
Bonds

A bond is any attractive force between two atoms.

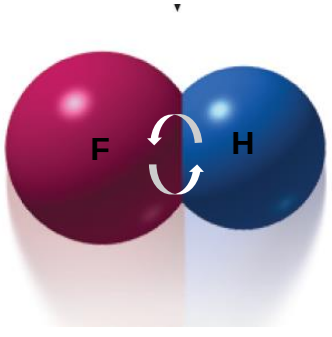
There are three main types of bonds that hold atoms together:

- Ionic bond
- Covalent bond
- Hydrogen bond

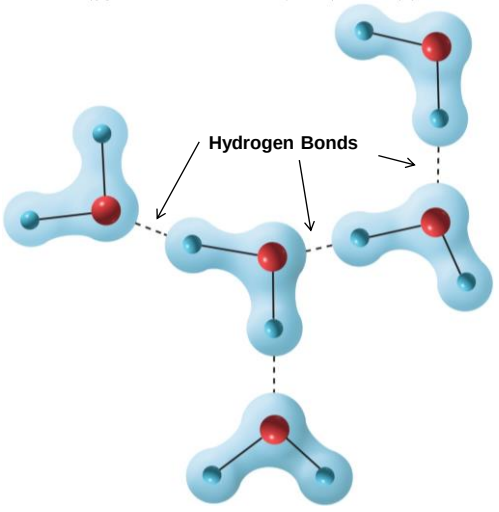
Ionic Bond



Covalent Bond



Hydrogen Bond



Solutes, Solvents, and Solutions

Solutes are small particles of a substance placed into and mixed with a fluid.

Solvents are the fluids that solutes are placed into.

A solution is mixture of a very small-sized solute mixed in a solvent until the solute is evenly mixed and suspended within the solvent without any settling.

Electrolytes

- A molecule that breaks into ions when placed into water.
- Essential for nerve and muscle functions.
- Most common ions are Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, Cl^{-}.

Acids and Bases

- 2 really important types of electrolytes:
  - Acids: electrolytes that releases a hydrogen ion (H^{+}) when placed into water. Also called hydrogen donors.
  - Bases: electrolytes that accept hydrogen ions when placed in water.

pH Scale

- Used to measure relative acidity.
- Measures amount of H^+
- Read on a scale of 0 – 14. 0 being extremely acidic, 14 being extremely basic, and 7 is neutral.

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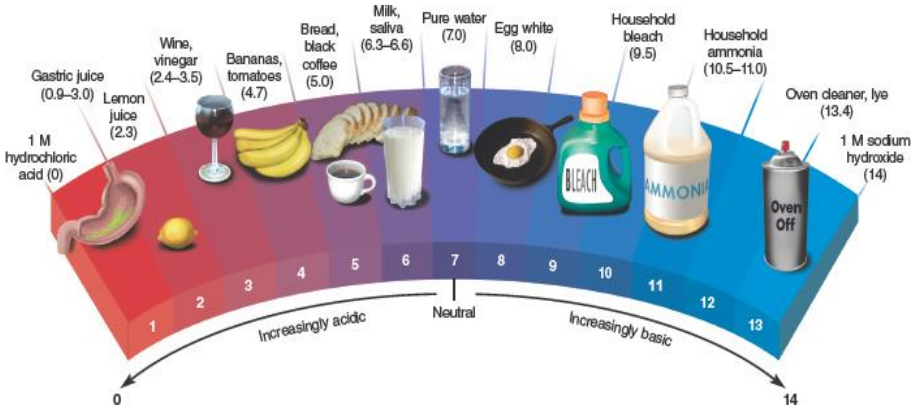


Organic vs. Inorganic

- Organic molecules
  - Composed primarily of the element carbon
  - Lipids, proteins, carbohydrates, nucleic acids, etc.
- Inorganic molecules
  - Do not contain carbon
  - Example: water, salt, etc.

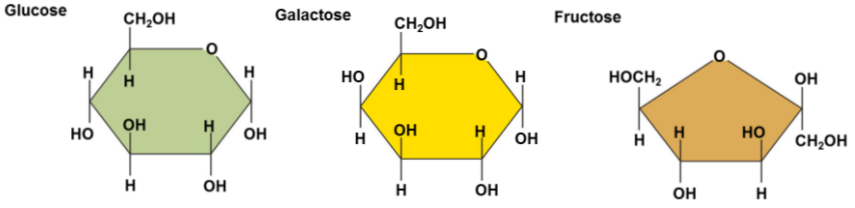
Carbohydrates

- Most commonly known as sugars and starches.
- Many end in "-ose".
- Primarily used by the body for energy
- Composed of carbon, hydrogen, and oxygen atoms
- The basic building block for carbohydrates is a ring-like structure with 6 carbons, 12 hydrogens, and 6 oxygens. $C_6H_{12}O_6$

Monosaccharides

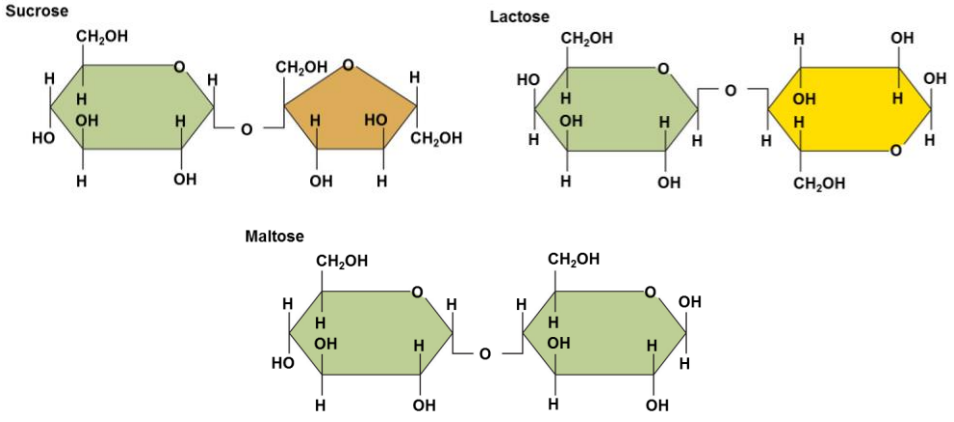
Monosaccharides are the simplest forms of carbohydrates.

They are used for energy and as building blocks (monomers) of larger carbohydrates.



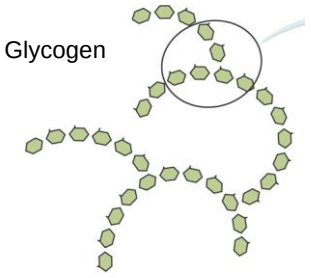
Disaccharides

- two monosaccharides bonded together
- sucrose, lactose, maltose



Polysaccharides

- long chains of monosaccharides
- used by plants for structure (cellulose) and energy storage (starch)
- used by animals for energy storage (glycogen)



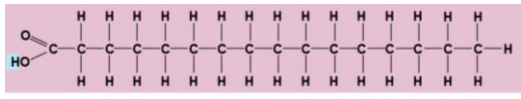
Lipids

- composed of carbon, hydrogen, and oxygen atoms
- many atoms of carbon and hydrogen, very few of oxygen
- frequently exist as linear carbon chains, others are four rings of carbon bonded together
- hydrophobic
- variety of functions in the body, depending on the type of lipid

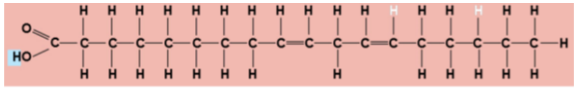
Lipids

1. Fatty Acids

- single chain of four or more carbon atoms surrounded by hydrogen atoms and with an acid group on one end
- can be saturated or unsaturated
- used for energy and for building more complex lipids



Palmitic acid (saturated)
$CH_3(CH_2)_{14}COOH$



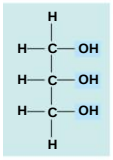
Linoleic acid (unsaturated)
$CH_3(CH_2)_4\ CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$

Lipids

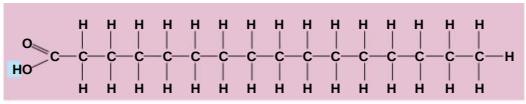
2. Triglycerides

- group of three fatty acids attached to a glycerol molecule
- used to store fatty acids in adipose (fat) tissue for energy
- in substantial quantities, triglycerides provide thermal insulation and cushioning

Lipids



Glycerol



Palmitic acid (saturated)
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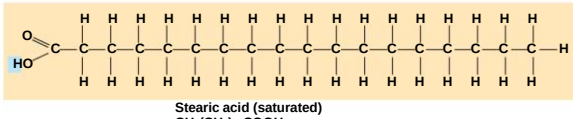
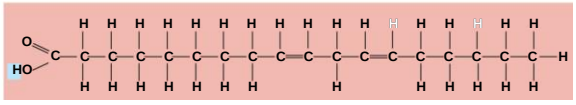


Stearic acid (saturated)
$CH_3(CH_2)_{16}COOH$



Linoleic acid (unsaturated)
$CH_3(CH_2)_4\ CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$

Lipids

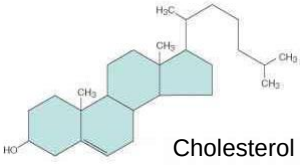
3. Phospholipids

- two fatty acids attached to a phosphate molecule
- phosphate end (head) is hydrophilic
- fatty acids (tails) are hydrophobic
- used to create membranes around cells and organelles

Lipids

4. Steroids

- four rings of carbon atoms bonded together
- cholesterol is used to stabilize plasma membranes around cells and to create the other types of steroids
- other steroid molecules are used as hormones (chemical messengers) for communication from cell to cell.



Cholesterol

Proteins

- composed of carbon, hydrogen, oxygen and nitrogen atoms
- have a wide range of functions

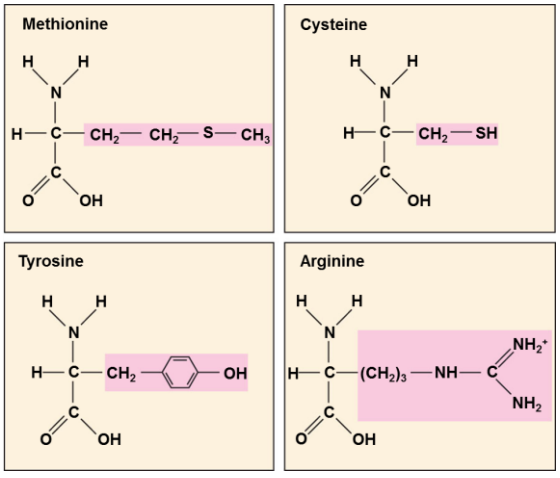
Proteins

Amino Acids

- 20 different kinds of amino acids
- some are essential (need to be eaten), some are not (can be made within us)
- assembled using peptide bonds
- peptides are chains of fewer than 50 amino acids; proteins have 50 or more

Proteins

An example of 4 amino acids



Proteins

Functions

- structure
- communication
- membrane transport
- catalysis
- recognition
- protection
- movement
- cell adhesion

Nucleic Acids

- large molecules involved in the process of how to make proteins
- DNA
- RNA

Adenosine Triphosphate

- molecule consisting of an adenosine bonded to three phosphate groups.
- stores energy released from the breakdown of carbohydrates and other compounds
- used by all of the cells for their available energy