MOLECULES OF LIFE

Matter, Energy, and Life

- Living things are composed of **matter** and carry out processes that involve use of **energy**

- **Matter**: anything that has mass and takes space

  Difference between mass and weight?

  (mass refers to amount of matter; weight refers to amount of force with which an object is attracted by gravity)

- **Energy**: ability to do work or cause things to move

ENERGY

- From where do living things get their energy?
- Two different types of energy:
  Kinetic: energy of motion
  Potential: energy not doing work, i.e. energy in chemicals
- Potential energy can be converted to kinetic energy

LAW OF ENERGY CONSERVATION

- Energy is never created or destroyed

  energy can be converted from one form to another, but total energy remains constant.

  Ex: object on mountain contains "energy of position". Ex: spring in ballpoint

Energy forms

There are 5 forms and each can be kinetic or potential

- Mechanical: ex athlete (potential and kinetic)
- Nuclear: from reactions in matter (in atomic nucleus)
- Electrical: flow of charged particles
- Radiant: heat, light, microwave
- Chemical: internal potential energy stored in matter and can be released as kinetic , ex: cellular respiration

Matter

- **Atoms** are the smallest units of matter that can exist alone.
- Atoms are constructed of : neutrons, protons, and, electrons

Neutron: heavy subatomic particle with *no charge* located in central core (atomic nucleus)

Proton: heavy subatomic particle with *positive charge* located in atomic nucleus

Electron: light subatomic particle with negative electrical charge that moves in energy levels outside the atomic nucleus. Number of electrons atom has determines the space or volume that atom takes up

Subatomic Particles

Particle	Symbol	Charge	Relative Mass
Electron	**e^-**	**-1**	**0**
Proton	**p^+**	**+1**	**1**
Neutron	**n**	**0**	**1**

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- **Element**: collection of only 1 kind of atom. Ex: hydrogen, oxygen
- Overall electrical charge of element is zero with number of electrons equal to protons.
- All atoms of an element have same number of protons. Number of protons determines the element **identity.** Ex: C → 6; O → 8
- **Atomic number** of element: number of protons in an atom of that element; each element has unique atomic number.
- Mass of proton= 1 atomic mass unit (AMU)

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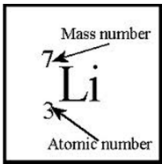
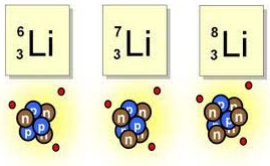
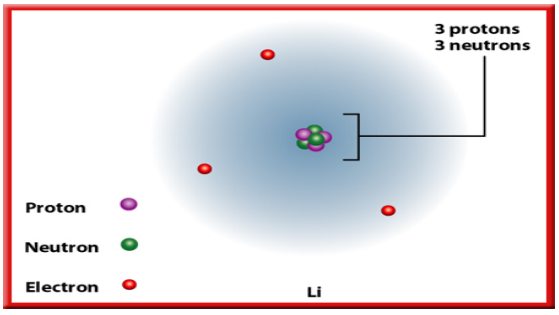
- **Isotope**: atom of same element with different number of neutrons
- **Atomic weight**: average of all isotopes present in mixture.
- **Mass number**: sum of number of protons and neutrons, ex: hydrogen, deuterium (2), tritium (3)





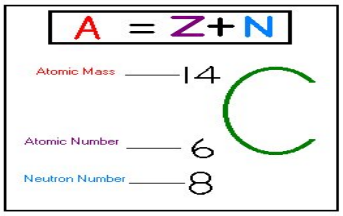


- Electrons fill energy levels according to the octet rule: first energy level full with 2, second level 8, energy level 3 also is full with 8 electrons.
- All atoms tend to be stable through chemical reaction.
- Why Helium, Neon , Argon are called noble??
- For any element:

Number of Protons = Atomic Number

Number of Electrons = Number of Protons = Atomic Number

Number of Neutrons = Mass Number - Atomic Number



MOLECULES

- Smallest particle of chemical compound that is a definite and distinct, electrically neutral group of bonded atoms. Ex. **Diatomic:** Two atoms of oxygen combine to form a molecule of oxygen [O_2]. One atom of carbon combines with two atoms of oxygen to form a molecule of carbon dioxide [CO_2].
- A molecule is formed when atoms of the same or different elements combine. A molecule is the smallest particle of a substance that can normally exist independently.
- **Compound** is chemical substance made up of atoms of two or more elements combined in specific ratio. The attractive force that holds atoms of molecule together is **chemical bond**

Molecules and kinetic energy

- Temperature is the measure of average kinetic energy of molecules making up substance.
- The higher the temperature, the greater the kinetic energy of molecules (ex. perfume diffusion)
- Heat is the quantity of energy (calories), it is the total internal kinetic energy of molecules.
- Calorie is the amount of heat necessary to raise the temperature of 1 gram of water 1 degree celsius.
- Temperature deals with comparative hotness or coldness (Celsius or Fahrenheit)
- Heat depends on size of object while temperature doesn't.

Phases of matter

- Solid: molecules with strong attractive forces and low kinetic energy. Molecules vibrate in place with fixed distances from one another.
- Liquid: molecules with enough kinetic energy to overcome the attractive forces that holds molecules together. Molecules are slightly further apart than solid.
- Gas: molecules with great deal of kinetic energy. Molecules move faster than that of solids and liquids, their collision tends to push them further apart, so gas expand to fill its container

In chemical reaction, interacting atoms may become attached by

ionic or covalent bond

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IONIC BOND

- Charged atom or molecule is called ion.
- Ionic bonds are formed when atoms transfer electrons to achieve a full outermost energy level
- Electrons are donated or received forming stable group which has orderly arrangement and is a crystalline solid
- The force of attraction between oppositely charged ions forms ionic bonds and results in ionic compounds. Ex NaCl

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- Cations: positively charged ions
- Anions: negatively charged ions
- Oppositely charged ions with attractive force between them forms ionic bond.
- Electrolyte: substance that dissociates into ions in water and allows conduction of electric current

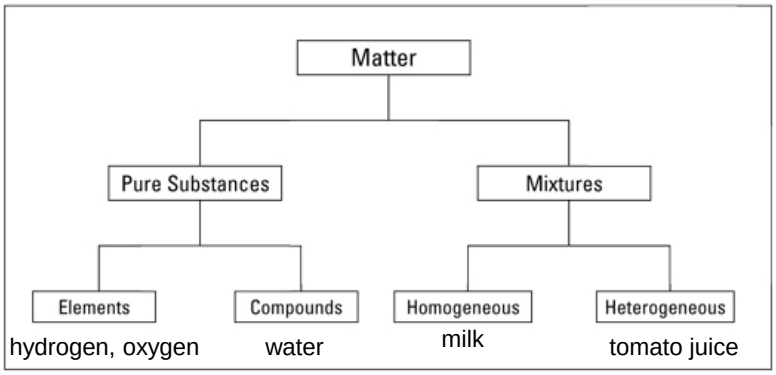
COVALENT BONDS

- Substances with no properties of ionic compounds. Ex: hydrogen atoms with chemical bond formed by sharing of a pair of electrons.
- When single pair of electrons is shared by 2 atoms, it is called **single bond**
- **Double bond** is formed when 2 pairs of electrons are shared by 2 atoms, ex: Carbon
- **Triple bond** when 3 pairs of electrons are shared by two atoms, ex: Nitrogen

WATER

- Two atoms of hydrogen and 1 atom of oxygen joined by covalent bond. Because there are more protons in the oxygen than in the hydrogen, electrons tend to be attracted more to the oxygen and are not equally shared. This type of covalent bond is called: **polar covalent bond**
- **Hydrogen bond:** occur between hydrogen and oxygen or between hydrogen and nitrogen.

- Mixture: matter that contains 2 or more substances that are not in set proportions
- Solution: liquid mixture of ions or molecules of 2 or more substances. Ex: salt water
- Homogeneous mixture: components of mixture are distributed equally
- Solvent is the component present in large amount
- Solute is the component that dissolves in solvent.



- Aqueous solution is solution of a solid, liquid, or gas in water.
- Relative amounts of solute and solvent are described by the concentration of a solution
- Large amount of solute, then it is concentrated
- Less solute, then diluted.

CHEMICAL REACTIONS

- Elements stay the same, but compounds and their properties change when the elements are bounded in new combination
- Energy is absorbed to produce new chemical substances with more potential energy
- Energy is released when new chemical substances are produced with less potential energy
- In a chemical reaction, reactants change to products with balanced elements on both sides of the equation

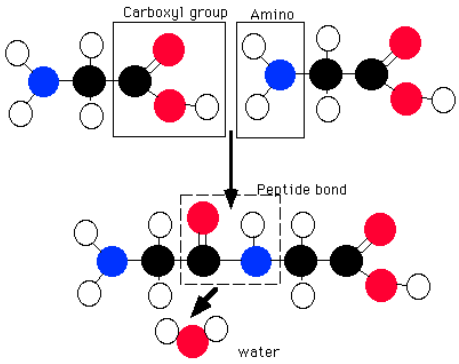
OXIDATION-REDUCTION REACTION

- Chemical change in which electrons are transferred from one atom to the other end with energy contained in its electrons
- Oxidation: part of reaction where atom loses electron
- Reduction is the other part where atom gains electron. Ex. Cellular respiration equation

$C_6H_{12}O_6 + 6O_2 \dashrightarrow 6CO_2 + 6H_2O + \text{energy}$

Dehydration synthesis reaction

- Reaction where water is released and large molecule synthesized from smaller less complex parts



Hydrolysis Reactions

- Opposite to dehydration.
- Water used to break reactants into smaller less complex molecules. Ex. Digestion

$$CH_3CONH_2 + H_2O + H^+ \longrightarrow CH_3COOH + NH_4^+$$

Phosphorylation reaction

- When phosphate group is added to another molecule
- Important reaction because bond between phosphate and another atom contains the potential energy that is used by cells to power activities

Acid-Base reactions

- Ions from acid react with ions from base to form salt and water.
- H from acid becomes chemically bound to the OH of the base.
- Acids and bases neutralize one another thus protect organisms from damage

$$HCl + NaOH \rightarrow H_2O + NaCl$$

Acids, Bases, and Salts

- Acids release hydrogen ions in solution
- Acid donates hydrogen to a solution; proton without electron. Ex : HCl, $H_3PO_4^-$

$$HCl \rightarrow H^+ + Cl^-$$

$$H_2SO_4 \rightarrow H^+ + HSO_4-$$

- Base when dissolves in water, it removes hydrogen from solution. Ex: NaOH

$$NaOH \rightarrow Na^+ + OH^-$$

$$OH^- + H^+ \rightarrow H_2O$$

- PH=7, neutral solution; equal H^+ and OH^-
- PH less than 7; it is acidic; more H^+
- PH more than 7; it is basic, more OH^-
- Salts are ionic compounds that don't release H^+ or OH^- when dissolves in water, but they are the result from reaction of acid and base in a *neutralization* reaction

$$HCl + NaOH \longrightarrow NaCl + H_2O$$