MAMMOTH

SCIENCE

Unit 1 - Chemistry of Life - Atomic Basics, Matter, & Water

Student Expectations:

- *Describe the structure of atoms; including masses, electrical charges, and locations, of protons and neutrons in the nucleus and electrons in the electron cloud.*
- *Relate the physical and chemical behavior of an element, including bonding and classification, to its placement on the Periodic Table*
- *Analyze States of Matter and be able to read and understand a phase-change diagram*
- *Describe energy changes within a reaction and interactions within the environment*
- *Determine whether an activation energy diagram is exothermic or endothermic*
- *Understand the properties and interactions of water. Distinguish between polar and nonpolar molecules.*
- *Define acids and bases, and have a clear understanding of the pH scale.*

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Menu

Standards

- Composition of Matter
- Periodic Table
- Properties of Matter
- Bonding
- States of Matter
- Energy of Reactions
- Properties of Water
- Cohesion / Adhesion
- Acids & Bases - pH

Standards

Texas TEK Standards -

- **Bio 9** The student knows the significance of various molecules involved in metabolic processes and energy conversions that occur in living organisms. The student is expected to:
  - **A)** *compare the structures and functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids*
  - **C)** *identify and investigate the role of enzymes*

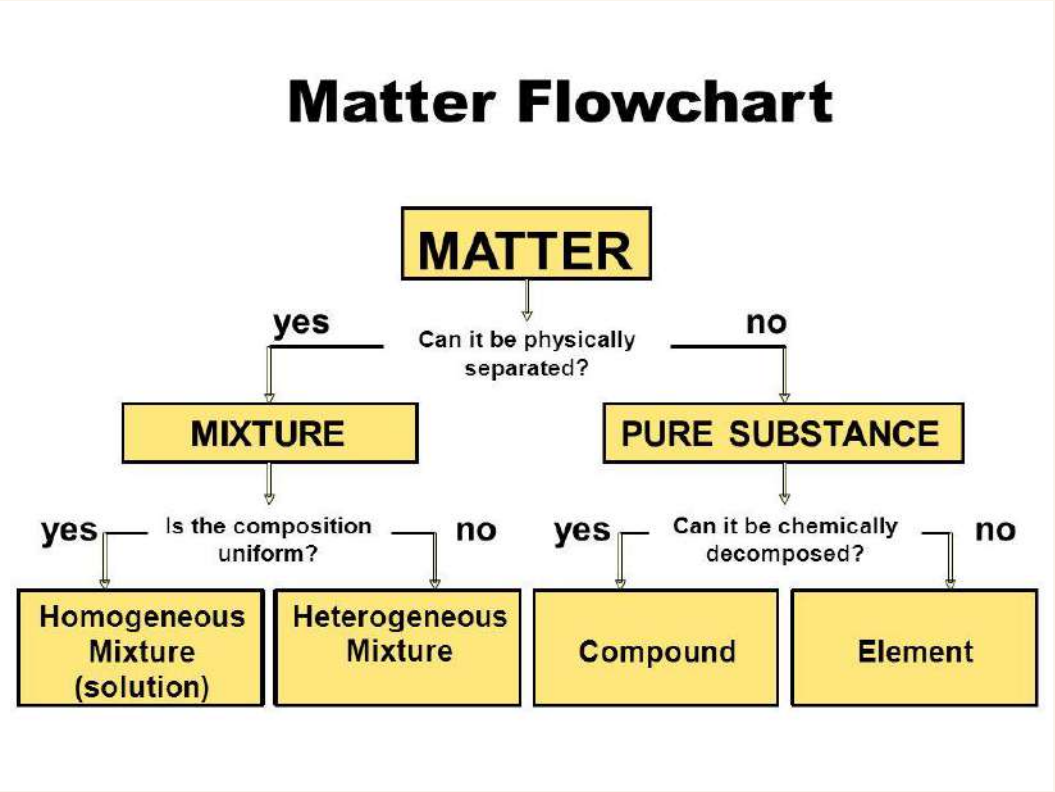
National Next-Gen Standards -

- **HS-PS1-1.** *Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms*
- **HS-LS1-6.** *Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.*

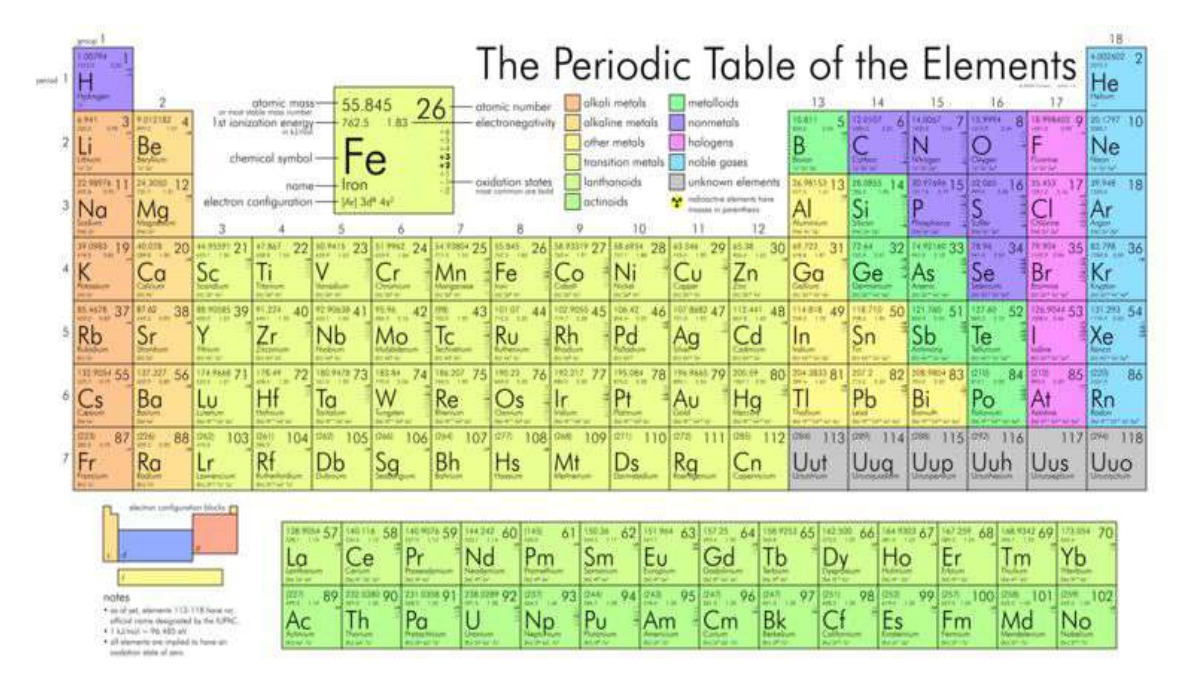
Composition of Matter

Composition of Matter

- **Matter** - is anything that occupies space or has mass.
- Everything in universe is composed of matter.
- **Mass** – quantity of matter an object as.
- **Weight** – pull of gravity on an object.



Composition of Matter



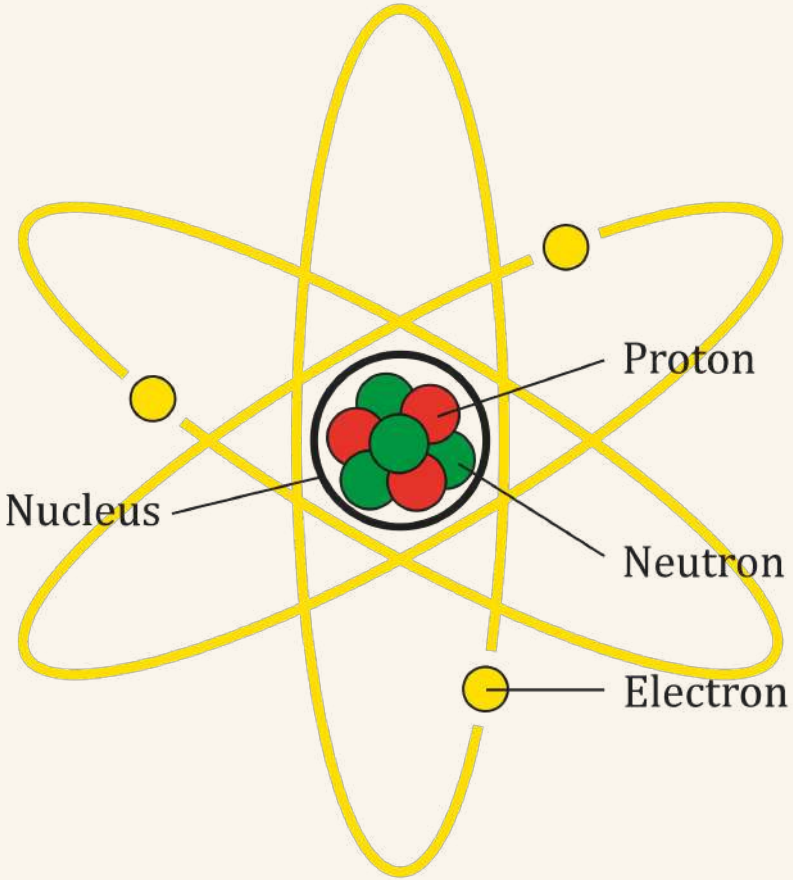
Elements

- Pure substances that cannot be broken down chemically into simpler kinds of matter.
- More than 100 elements (92 naturally occurring).

Composition of Matter

Atoms

- The simplest particle of an element that retains all the properties of that element.
- Properties of atoms determine the structure and properties of the matter they compose.
- Our understanding of the structure of atoms based on scientific models, not observation.



The Atom

Proton

(+)

- All atoms of a given element have the same number of protons.
- Number of protons called the atomic number.
- Number of protons balanced by an equal number of negatively charged electrons.

Neutron

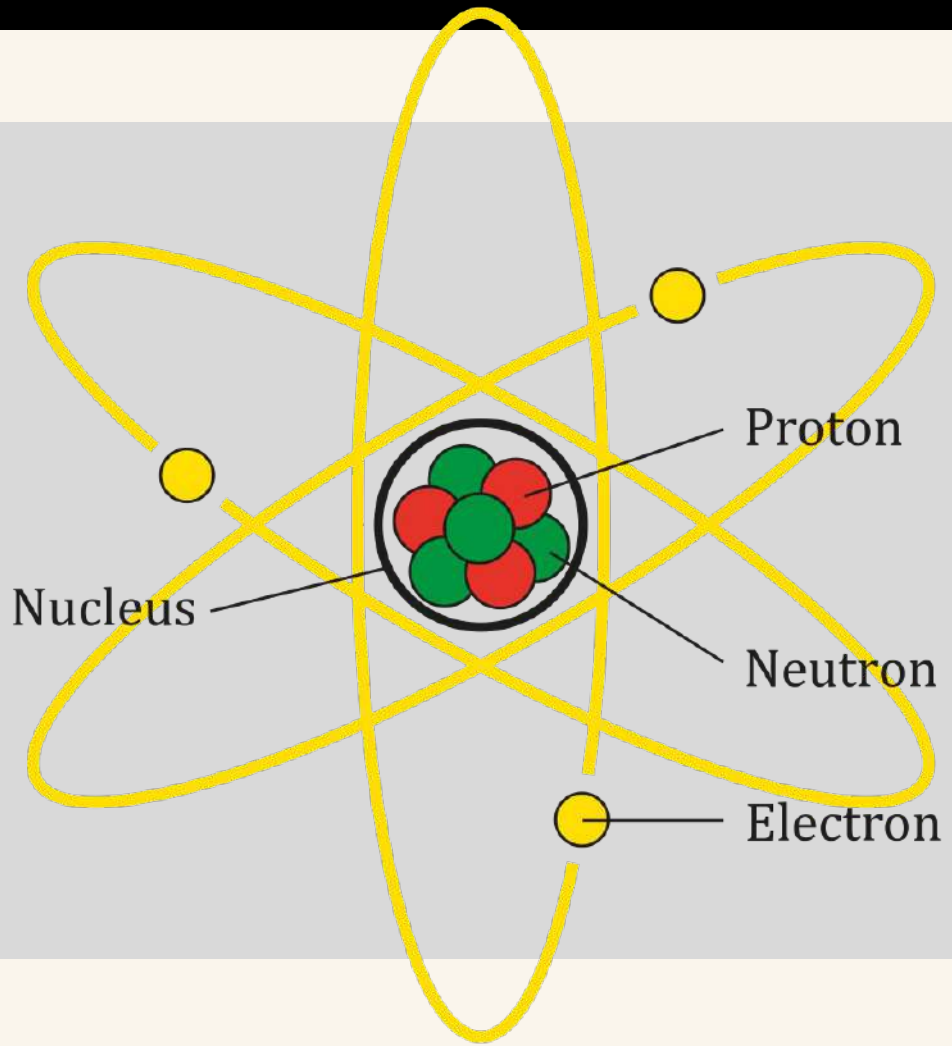
(0)

- The number varies slightly among atoms of the same element.
- Different number of neutrons produced isotopes of the same element.

The Nucleus

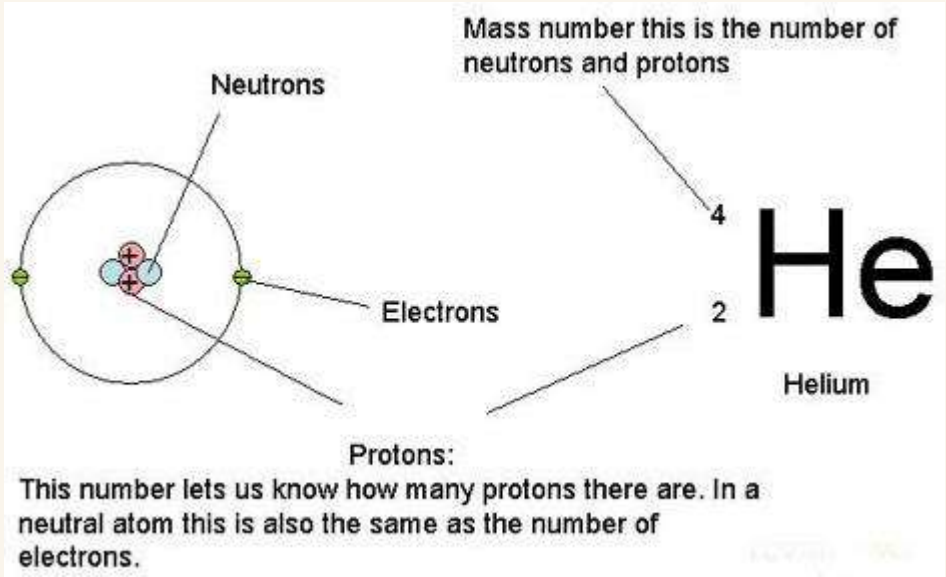
- Central core, consists of positively charged protons and neutral neutrons, positively charged, contains most of the mass of the atom.

The Atom



Atomic Mass

- Protons & neutrons are found in the nucleus of an atom.
- Protons and neutrons each have a mass of 1 amu (atomic mass unit).
- The mass number of an atom is found by rounding the decimal point
- The mass number tells you the number of protons and neutrons in the atom.



The Electron

Energy Levels

(-)

- Electrons in the same energy level are approximately the same distance from the nucleus.
- Outer energy levels have more energy than inner levels.
- Each level holds only a certain number of electrons (2, 8, 18...)

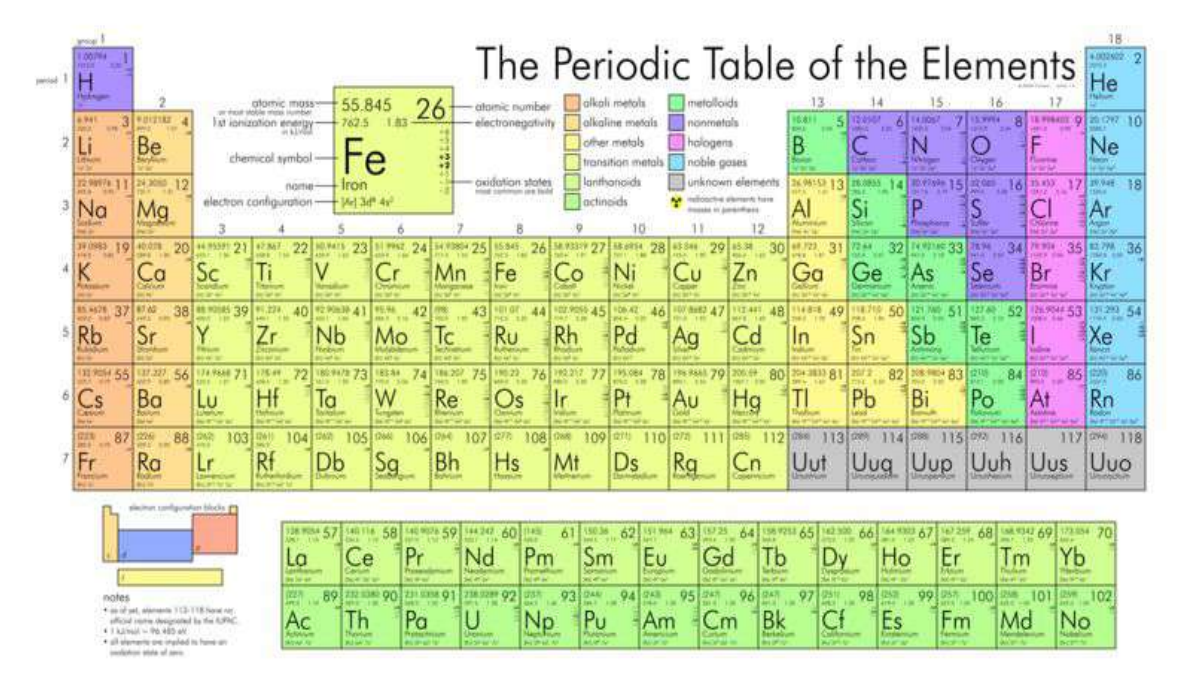
Valence

- Outermost Electrons that are responsible for how the atom reacts

Defined

- Negatively charged high energy particles with little or no mass.
- Travel at very high speeds at various distances (energy levels) from the nucleus.

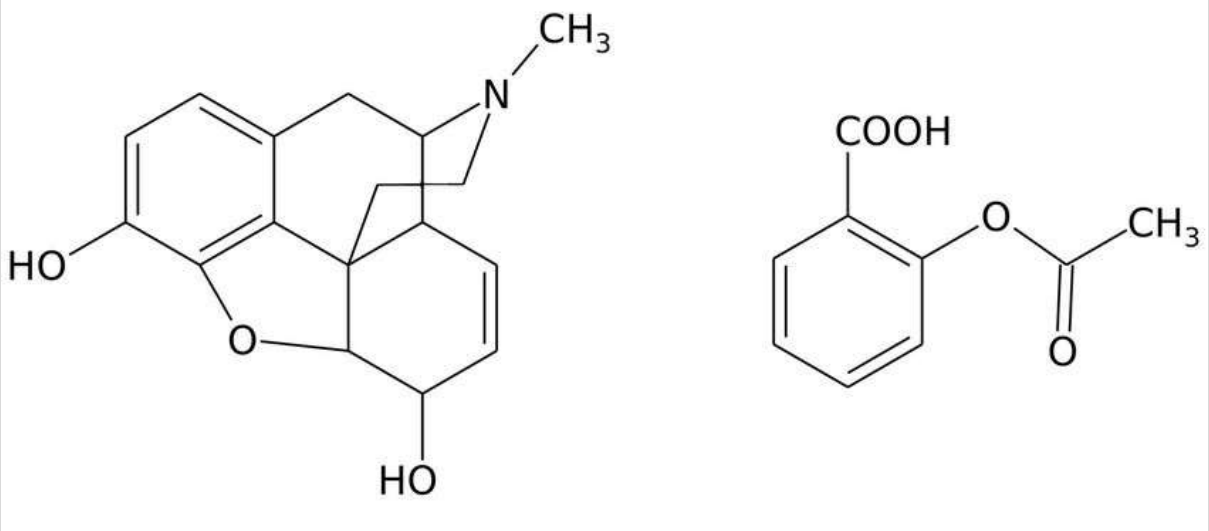
Periodic Table



Elements

- Elements are arranged by their atomic number on the Periodic Table.
- The horizontal rows are called Periods.
- Vertical groups are called Families & tell the outermost number of electrons (valence electrons).

Combinations



Morphine

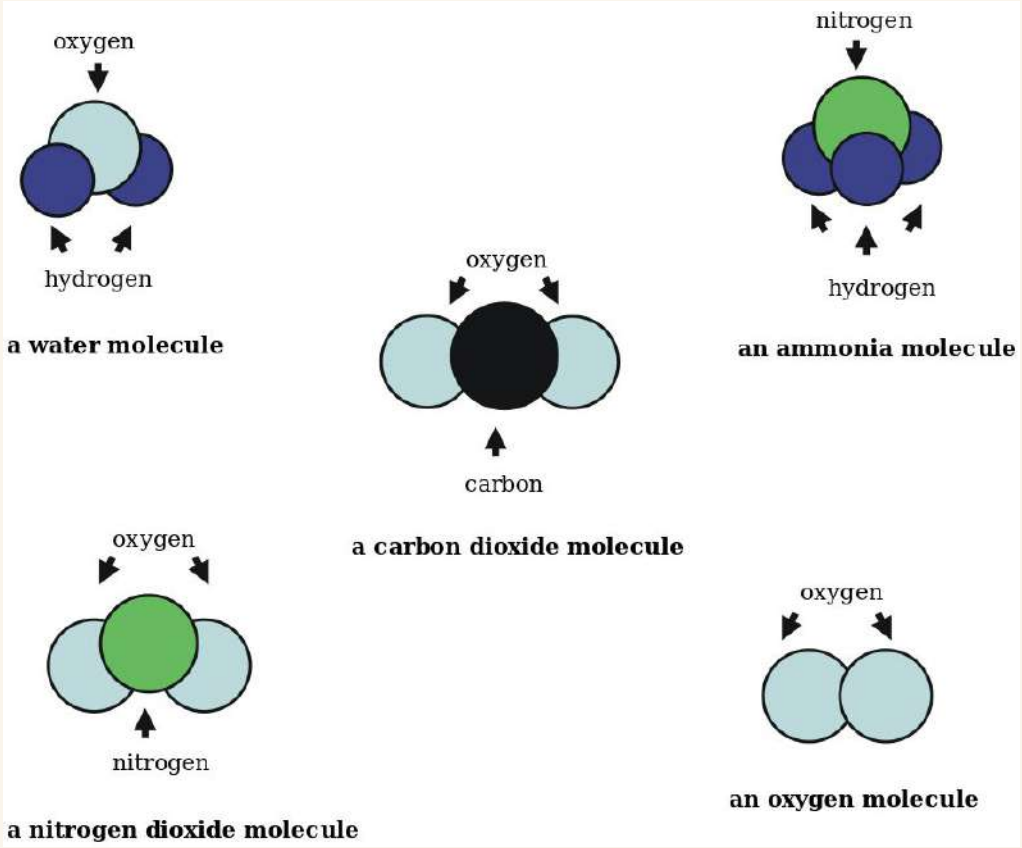
Aspirin

Elements

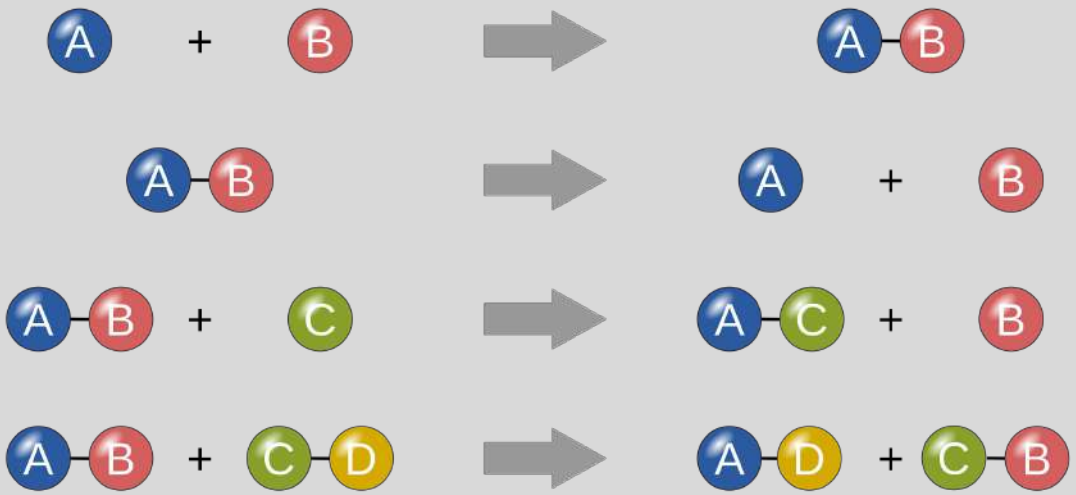
- Most elements do not exist by themselves.
- They readily combine with other elements in a predictable fashion.
- A compound is a pure substance made up of atoms of two or more elements.
- The proportion of atoms are always fixed.
- Chemical formula shows the kind and proportion of atoms of each element that occurs in a particular compound.
- The tendency of elements to combine and form compounds depends on the number and arrangement of valence electrons in their outermost energy level.
- Atoms are most stable when their outermost energy level is filled.

Molecules

- Molecules are the simplest part of a substance that retains all of the properties of the substance and exists in a free state.
- Some molecules are large and complex.



Chemical Formulas



- Subscript after a symbol tell the number of atoms of each element.
- H2O has 2 atoms of hydrogen & 1 atom of oxygen.
- Coefficients before a formula tell the number of molecules.
- 3O2 represents 3 molecules of oxygen or (3x2) or 6 atoms of oxygen.

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

Properties of Matter

Stability

- Most atoms are not stable in their natural state.
- Tend to react (combine) with other atoms in order to become more stable (undergo chemical reactions).
- In chemical reactions bonds are broken; atoms rearranged and new chemical bonds are formed that store energy.

Chemical Reaction

- a process in which one or more substances, the reactants, are converted to one or more different substances, the products. Substances are either chemical elements or compounds. A chemical reaction rearranges the constituent atoms of the reactants to create different substances as products.

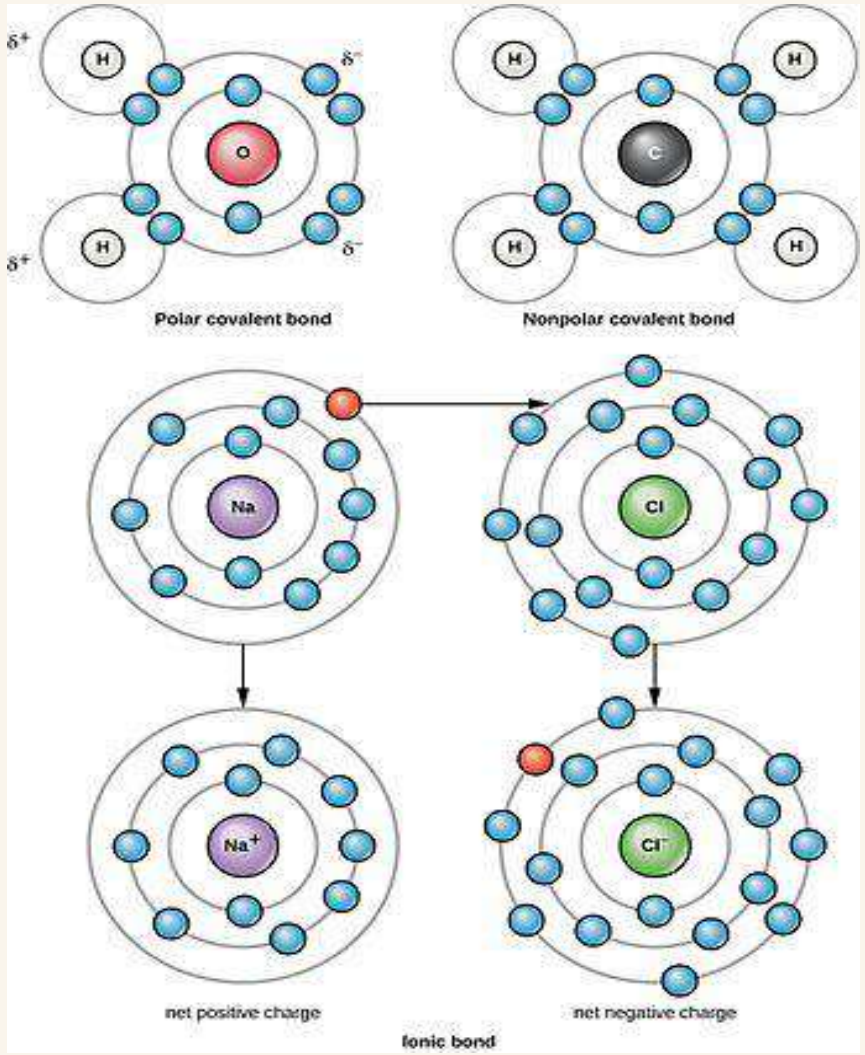
Properties

- The physical and chemical properties of a compound differ from the physical and chemical properties of the individual elements that compose it.

Bonding

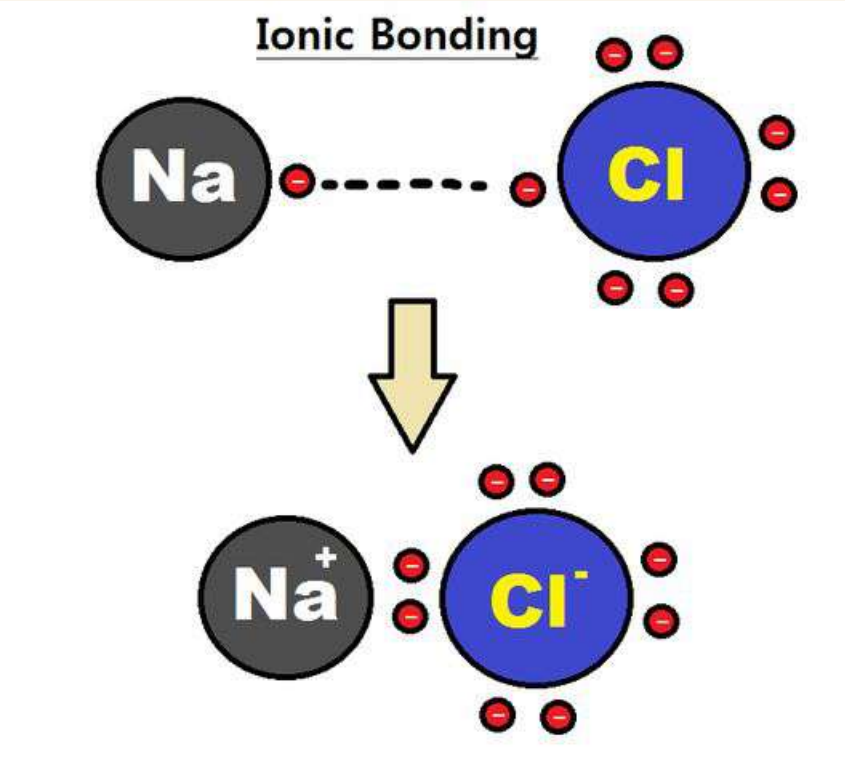
Covalent Bonding

- Formed when two atoms share one or more pairs of electrons.
- Usually form between two nonmetals.
- **Polar covalent**: occurs when atoms are shared unequally in a covalent bond.
- **Nonpolar covalent**: Equal sharing of electrons



Ionic Bonds

- Some atoms become stable by losing or gaining electrons.
- Atoms that lose electrons are called positive ions or cations.
- Atoms that gain electrons are called negative ions or anions.
- Because positive and negative electrical charges attract each other ionic bonds are formed.



States of Matter

Atoms are in constant motion. The rate at which atoms or molecules in a substance move determines its state.

Liquid

- Molecules not as tightly linked as a solid.
- Maintain fixed volume.
- Able to flow and conform to shape of container.

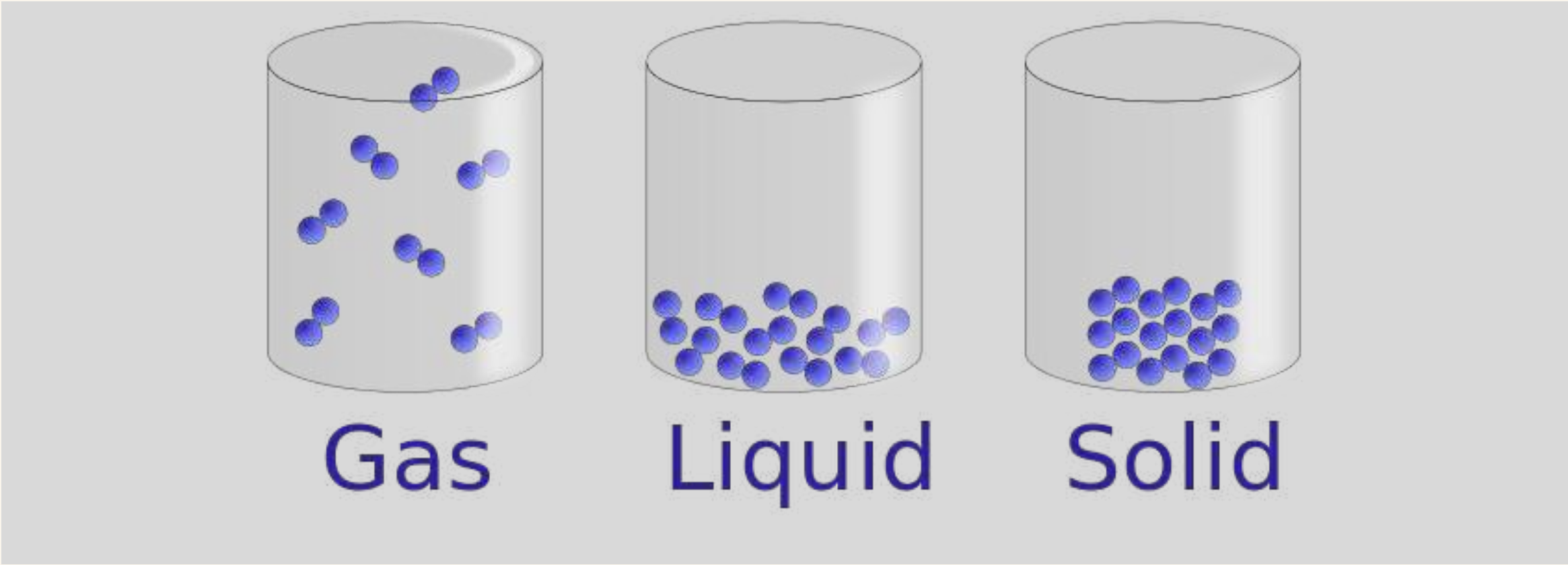
Gas

- Molecules have little or no attraction to each other.
- Fill the volume of the occupied container.
- Move most rapidly.

Solid

- Molecules tightly linked together in a definite shape.
- Vibrate in place.
- Fixed volume and shape.

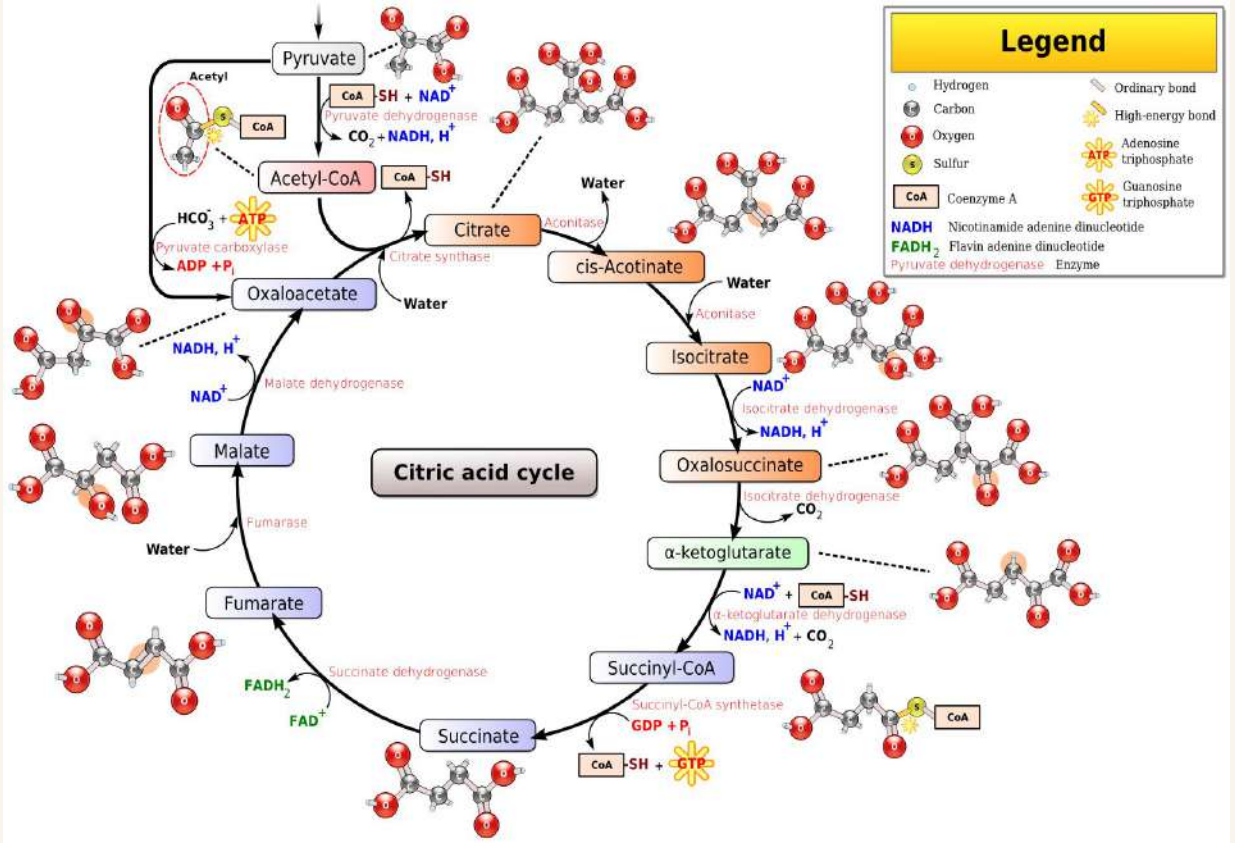
States of Matter



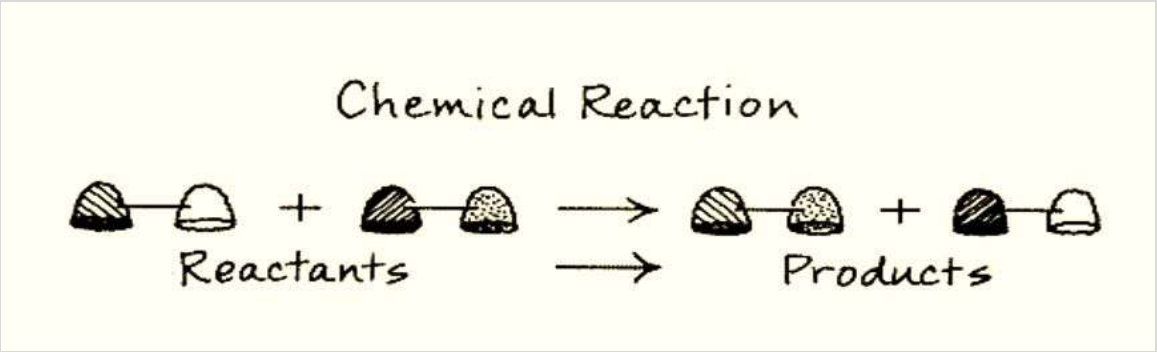
Energy & Chemical Reactions

Biochemical Pathways

- Living things undergo thousands of chemical reactions as part of the life process.
- Many are very complex involving multi-step sequences called biochemical pathways.

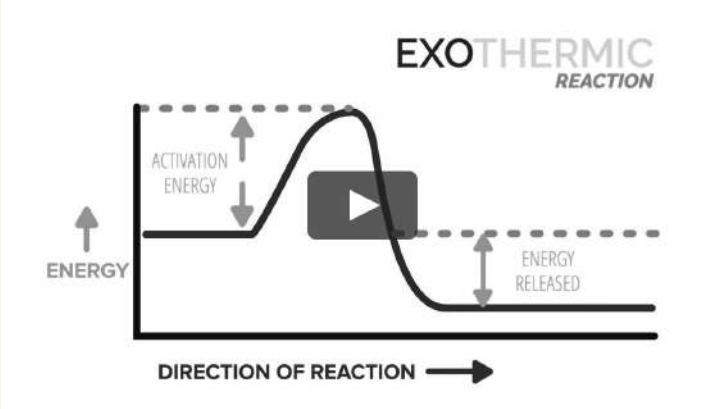


Energy & Chemical Reactions Continued



- Chemical equations represent chemical reactions.
- Reactants are shown on the left side of the equation.
- Products are shown on the right side.

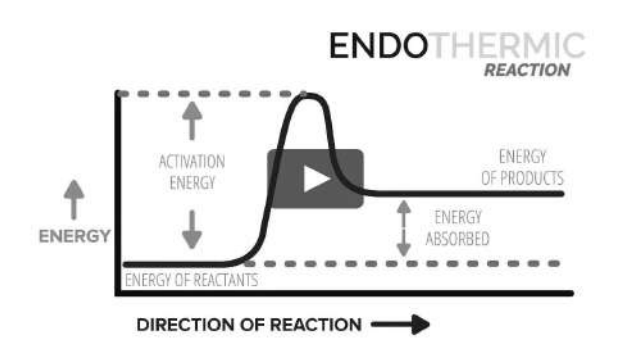
Energy Changes



Exothermic / Exergonic

Much of the energy organisms need is provided by sugar (food)

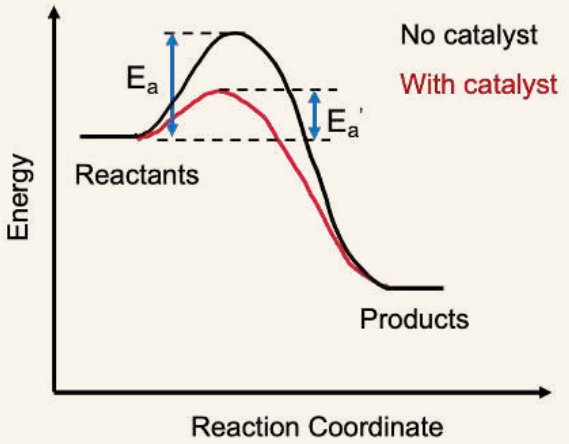
The net release of free energy is called an exergonic (exothermic) reaction



Endothermic / Endergonic

Reactions that involve a net absorption of free energy are called endergonic (endothermic) reactions.

Most reactions in living organisms are endergonic; therefore living organisms require a constant source of energy.



Activation Energy

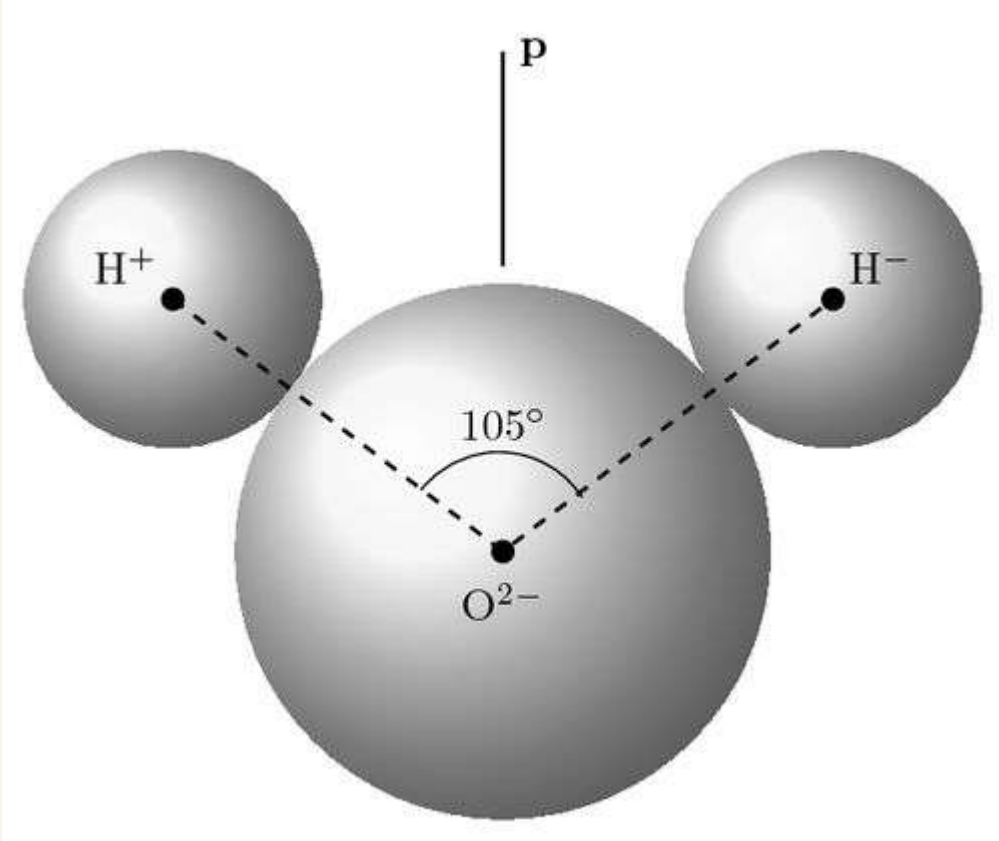
Most chemical reactions require energy to begin.

The amount of energy needed to start the reaction is called activation energy.

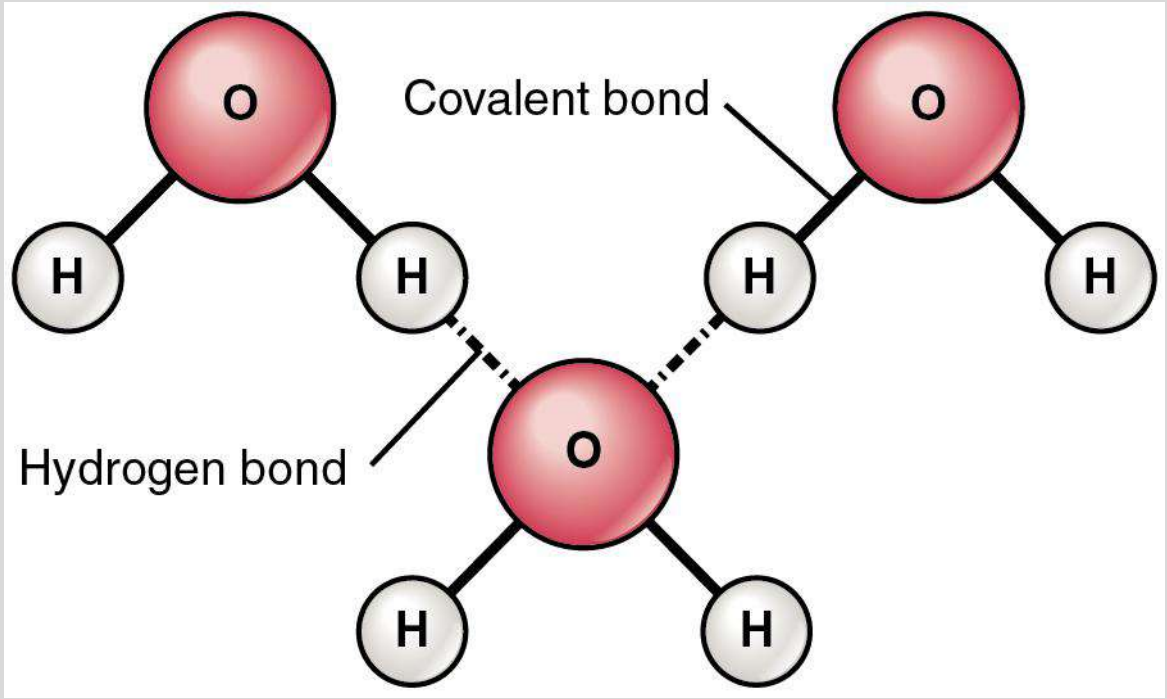
Properties of Water

Dihydrogen Monoxide

- A water molecule (H_2O), is made up of three atoms --- one oxygen and two hydrogen.
- In each water molecule, the oxygen atom attracts more than its "fair share" of electrons.
- The oxygen end “acts” negative.
- The hydrogen end “acts” positive.
- Causes the water to be polar. However, water is neutral.



Water is Polar



- Hydrogen Bonds Exist Between Water Molecules
- Formed between a highly Electronegative atom of a **polar** molecule and a Hydrogen
- One hydrogen bond is weak , but many hydrogen bonds are strong

Cohesion & Adhesion

Cohesion - Attraction between particles of the same substance (why water is attracted to itself).

- Results in **Surface tension** (a measure of the strength of water's surface).
- Produces a surface film on water that allows insects to walk on the surface of water.

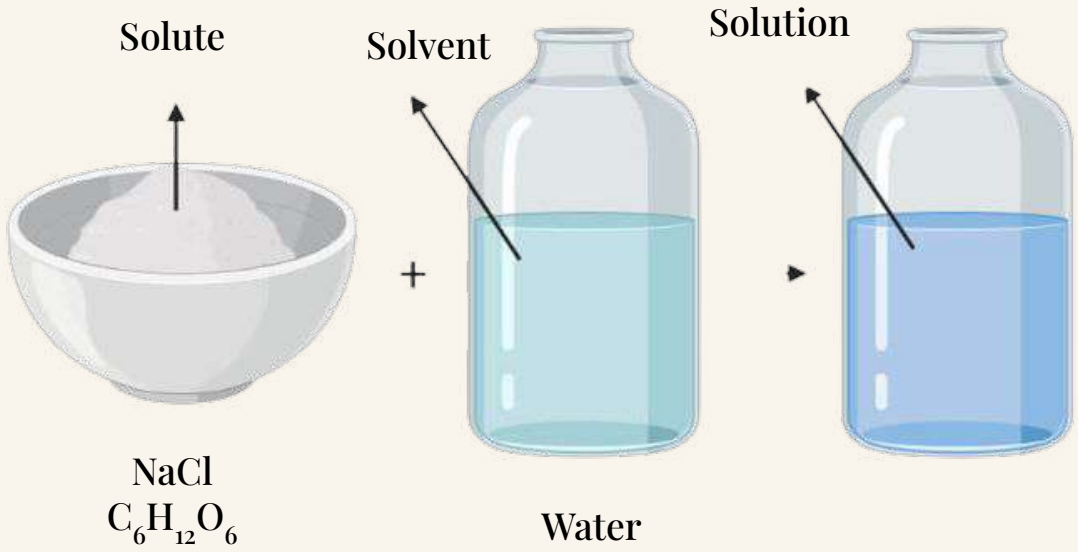
Adhesion - Attraction between two different substances.

- Water will make hydrogen bonds with other surfaces such as glass, soil, plant tissues, and cotton.
- **Capillary action**-water molecules will pull each other along when in a thin glass tube.
- **Example**: **transpiration** process which plants and trees remove water from the soil, and paper towels soak up water.

Cohesion

Adhesion

Solutions



- A **solution** is a **homogeneous** mixture of two or more substances. A solution may exist in any phase.
- A solution consists of a **solute** and a **solvent**. The **solute** is the substance that is dissolved in the **solvent**. The amount of solute that can be dissolved in solvent is called its solubility. For example, in a saline solution, salt is the solute dissolved in water as the solvent.

Properties of Water

High Specific Heat

- **High Specific Heat**-Amount of heat needed to raise or lower 1g of a substance 1° C.
  - ❏ Water resists temperature change, both for heating and cooling.
  - ❏ Water can absorb or release large amounts of heat energy with little change in actual temperature.
  - ❏ This causes temperature stabilization

High Heat of Vaporization

- **High Heat of Vaporization**-Amount of energy to convert 1g or a substance from a liquid to a gas
  - ❏ In order for water to evaporate, hydrogen bonds must be broken.
  - ❏ As water evaporates, it removes a lot of heat with it.
  - ❏ Water vapor forms a kind of global "blanket" which helps to keep the Earth warm.
  - ❏ Heat radiated from the sun warmed surface of the earth is absorbed and held by the vapor.

Density

Water Density

- Less Dense as a Solid
- Water is Less Dense as a Solid.
- Ice is less dense as a solid than as a liquid (ice floats)
- Liquid water has hydrogen bonds that are constantly being broken and reformed.
- Frozen water forms a crystal-like lattice whereby molecules are set at fixed distances.

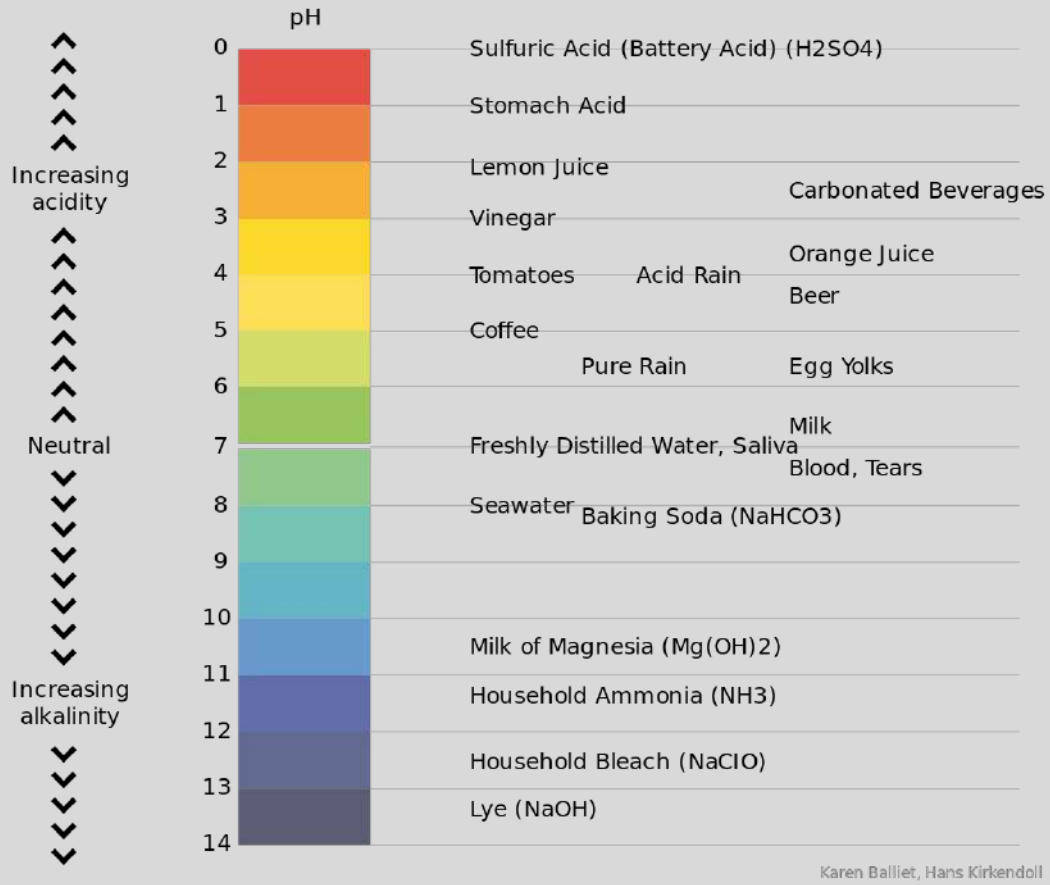
Acids, Bases, & pH

- One water molecule in 550 million naturally dissociates into a Hydrogen Ion (H+) and a Hydroxide Ion (OH-)

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

Hydrogen ion Hydroxide Ion

pH Scale



- Indicates the concentration of H+ ions.
- Ranges from 0 – 14.
- pH of 7 is neutral.
- pH 0 (strongest) up to 6.9 (weakest) is acid … H+ .
- pH above 7.1 (weakest) – 14 (strongest) is basic… OH- .
- Each pH unit represents a factor of 10X change in concentration.
- pH 3 is 10 x 10 x 10 (1000) stronger than a pH of 6.

Buffers & Neutralization

- **Neutralization**: Weak acids or bases that react with strong acids or bases to prevent sharp, sudden changes in pH.
- Produced naturally by the body to maintain homeostasis.

Thank you!

Do you have any questions?

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