Chemistry of Life

Atoms

- The basic unit of matter is called an Atom
- Atoms are incredibly small, but despite its extremely small size, an atom contains subatomic particles that are even smaller
- Three subatomic particles:
    - Proton
    - Neutron
    - Electron

Atoms

Particle	Charge	Location in Atom
Proton	Positive (+)	Nucleus
Neutron	Neutral (0)	Nucleus
Electron	Negative (-)	Constant motion surrounding the nucleus

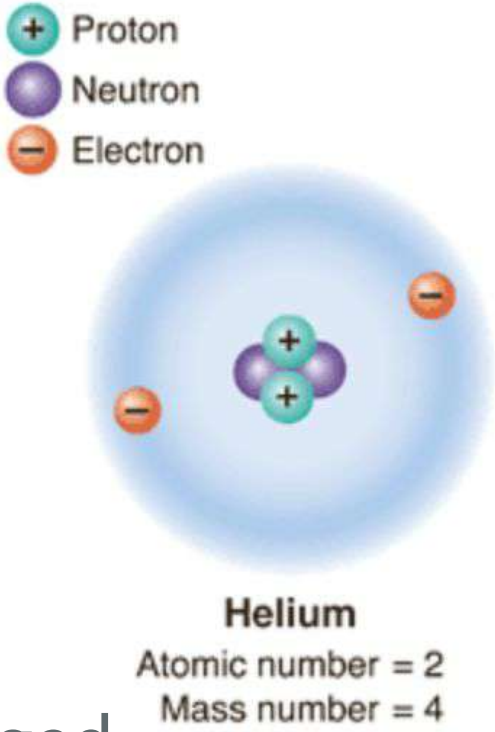
Atoms

- Nucleus:

  - Center of the atom that contains the protons and neutrons

- Electrons move around the nucleus in orbitals

- Atoms are neutral even with the charged particles because it has an equal number of both electrons (-) & Protons (+)



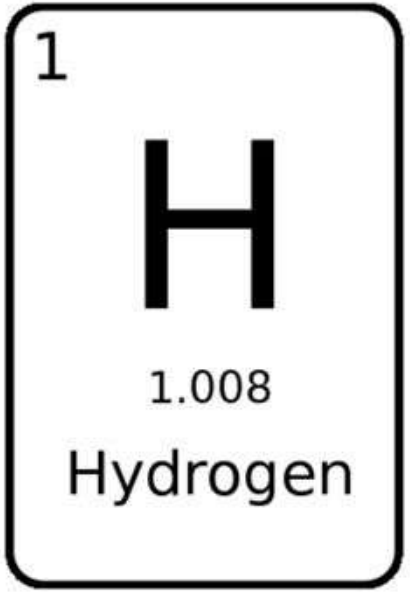
Elements

- Element:

  - Pure substance that consists entirely of one type of atom

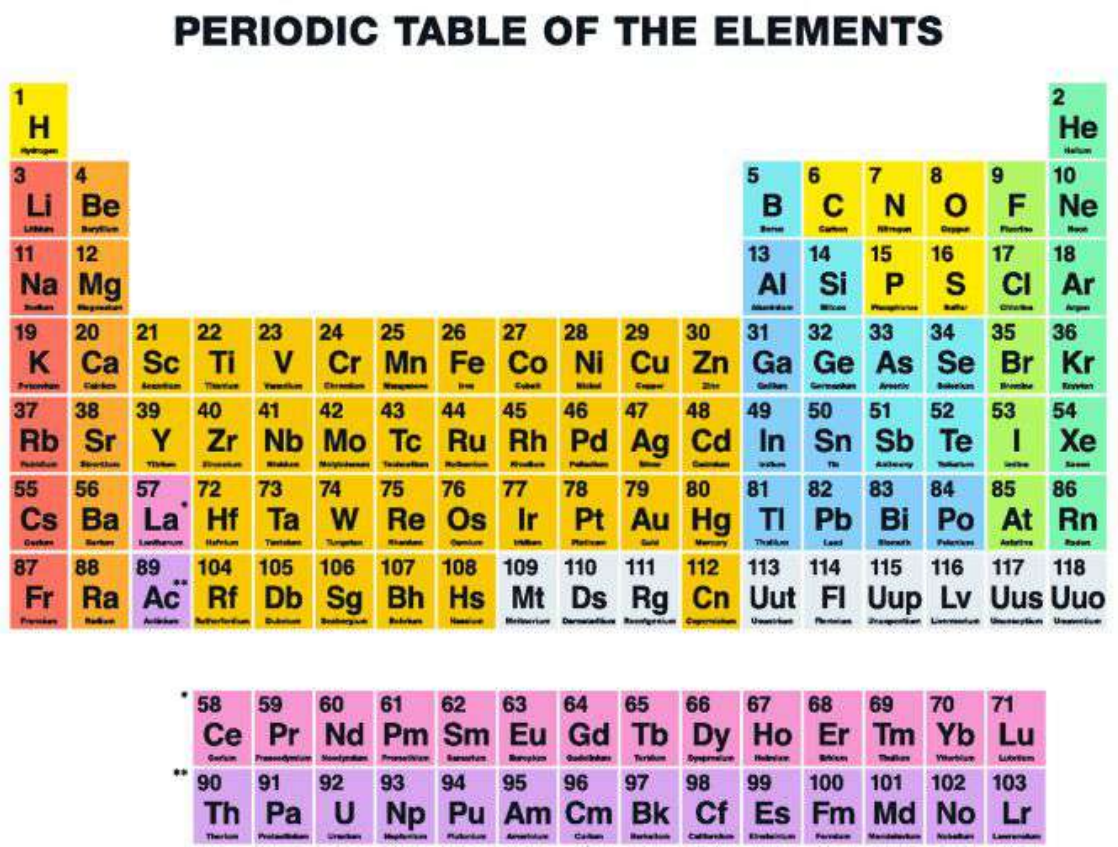
- More than 100 elements are known, but only about two dozen are commonly found in living organisms

- Elements are represented by a one- or two-letter symbol



Elements

- The number of protons in an atom of an element is the element's atomic number



Chemical Compounds

- Chemical Compound/Molecule:

  - substance formed by the chemical combination of two or more elements in definite proportions

- In nature, most elements are found combined with other elements in compounds

- Scientists show the composition of compounds by a kind of shorthand known as a chemical formula.

Chemical Compounds

- Water, H_2O (Chemical Formula)

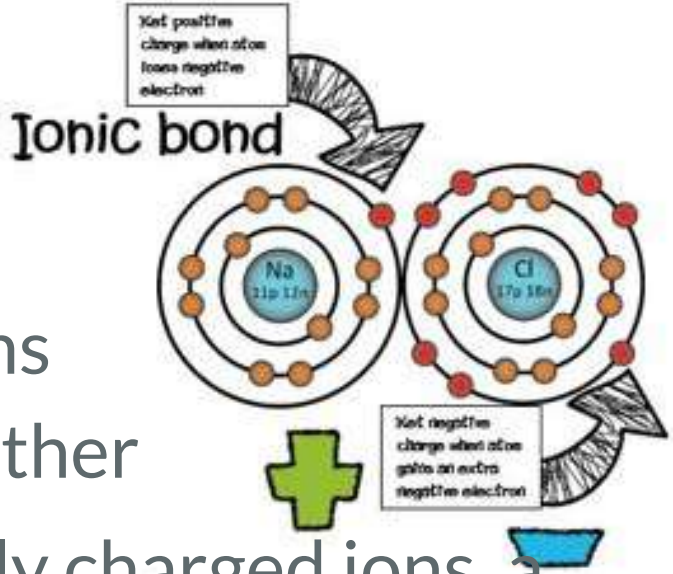
  Contains two atoms of hydrogen for each atom of oxygen

- Table Salt: NaCl (Chemical Formula) 1:1 Ratio
- Hydrogen Peroxide: H_2O_2 (Chemical Formula)
- Carbon Dioxide: CO_2 (Chemical Formula)

Chemical Bonds

- Chemical Bonds:
    - link that holds together atoms in compounds
- Bond formation involves the electrons that surround each atomic nucleus
- The main types of chemical bonds are ionic bonds and covalent bonds

Chemical Bonds



- Ionic Bond:

formed when one or more electrons are transferred from one atom to another

- Strong attraction between oppositely charged ions, a positive ion and a negative ion come together

- Ions are positively and negatively charged atoms

Think of the MVP Award: One player gets the trophy

Chemical Bonds

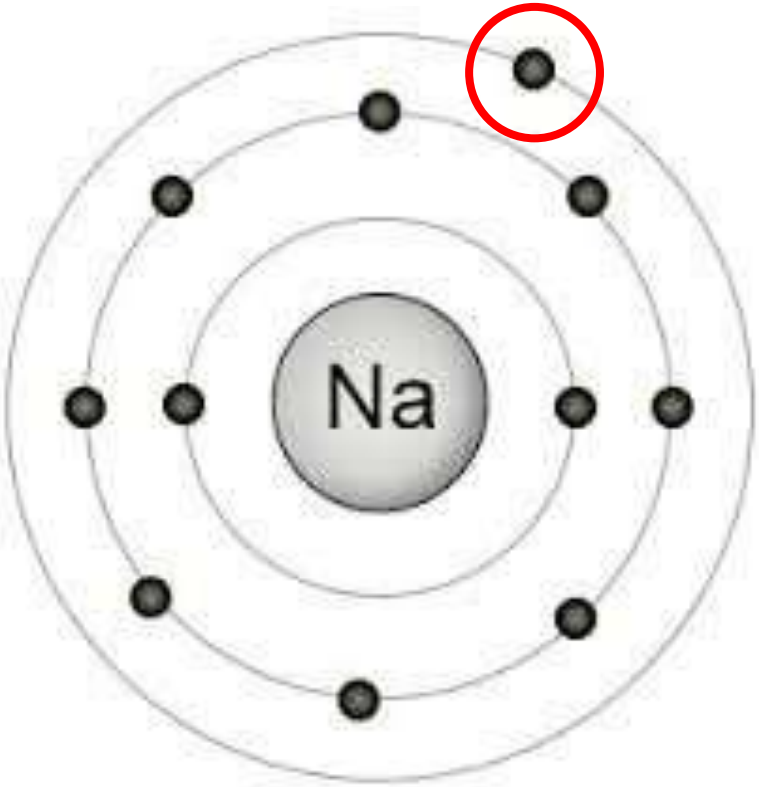
- Sodium (Symbol Na) is a chemical element.

  Chlorine (Symbol Cl) is a chemical element.

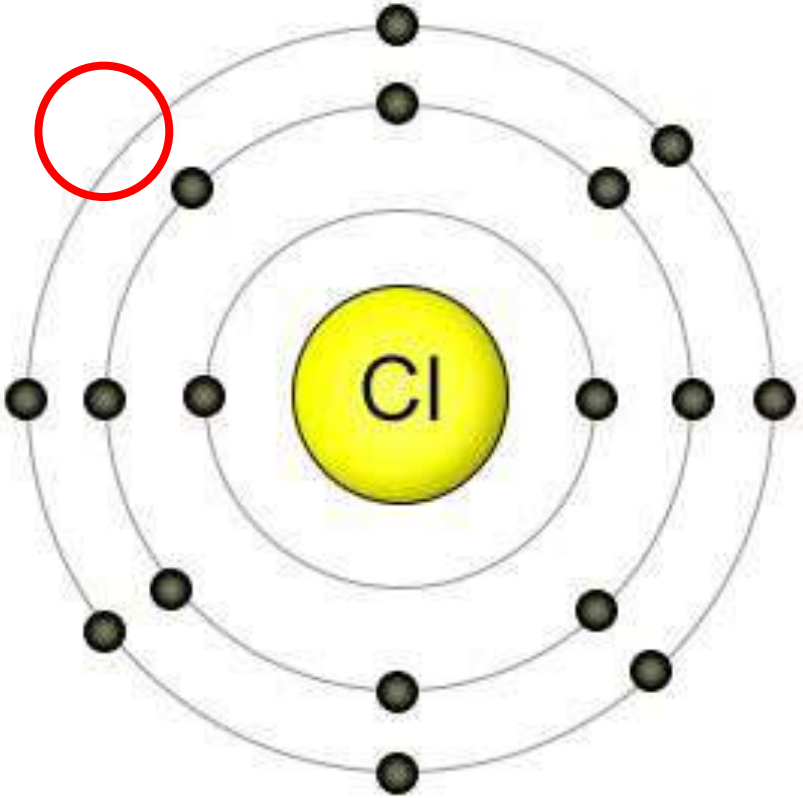
- When 1 sodium atom & 1 chlorine atom bond together (Symbol NaCl) they form the compound Sodium Chloride

- This is commonly known as Table Salt

Chemical Bonds



11 Electrons

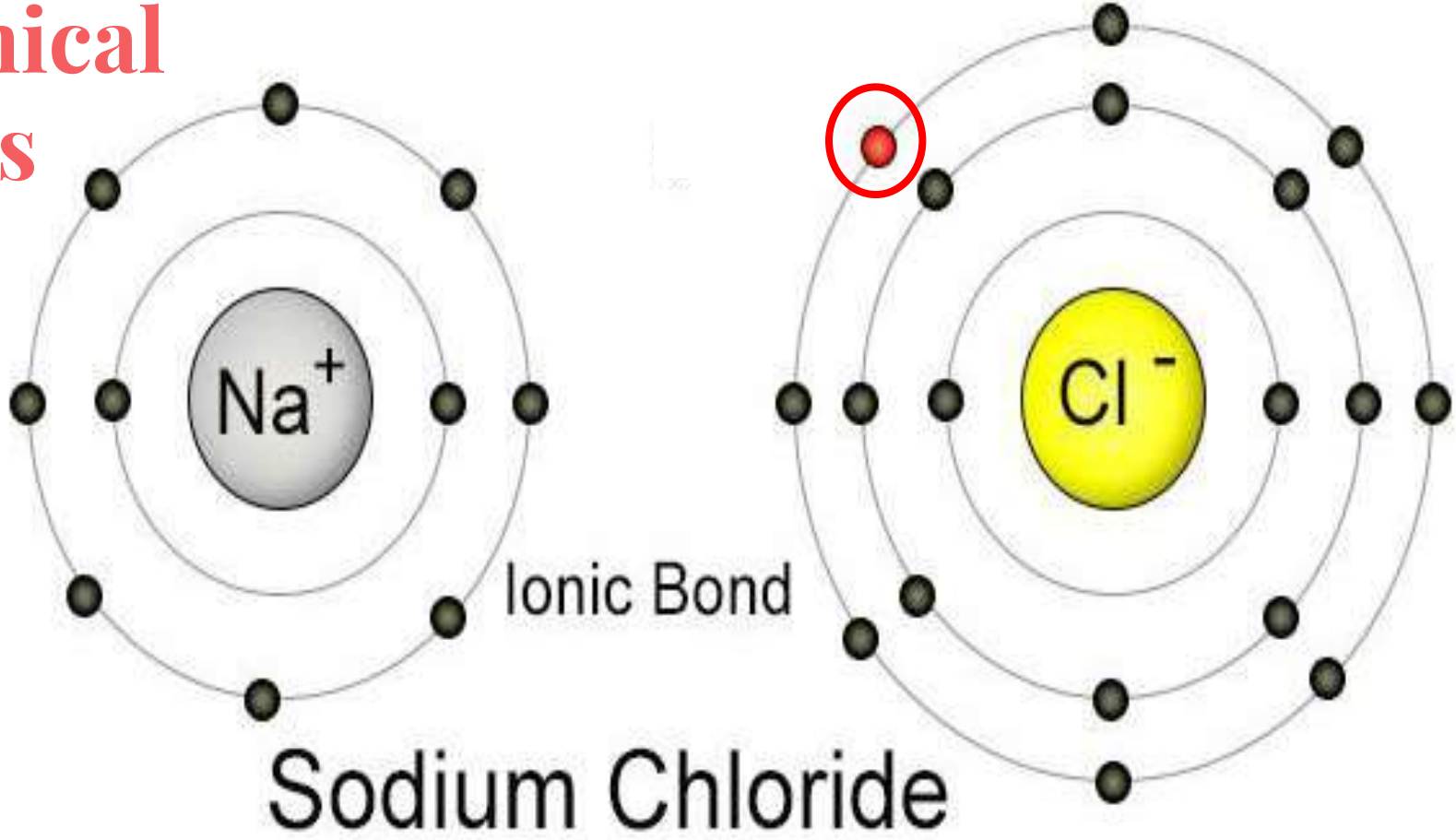


17 Electrons

Chemical Bonds

- The valence electron is transferred from sodium to chlorine.
- Sodium now becomes a Sodium Ion (Na^+)
- Chlorine is now negative and is a Chlorine Ion (Cl^-)
- Sodium Chloride is held together by “OPPOSITES ATTRACT”, the attraction between a Sodium Ion (Na^+) and Chlorine Ion (Cl^-)

Chemical Bonds



Chemical Bonds

- Covalent Bond:

  - forms when electrons are shared between atoms

- It means that the moving electrons actually travel in the orbitals of both atoms

- These bonds very strong and usually do not break easily

Think of CO-MVP Award: Both are trying to take it

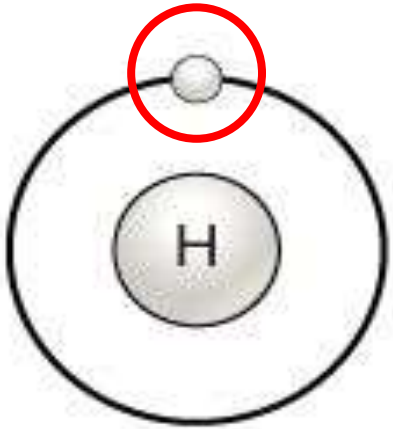
Chemical Bonds

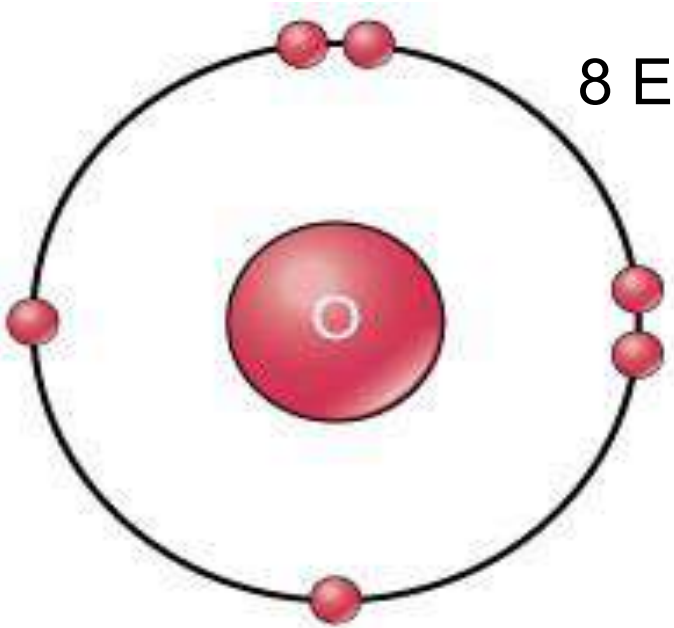
- Hydrogen (Symbol H) is a chemical element

Oxygen (Symbol O) is a chemical element

- When 2 hydrogen atoms and 1 oxygen atom bond together (Symbol H2O) they form the compound commonly known as water

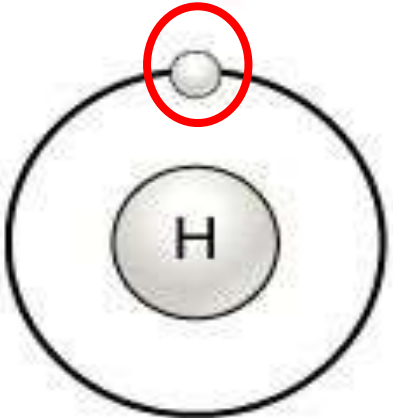
Chemical Bonds





8 Electrons

1 Electron Each



Chemical Bonds

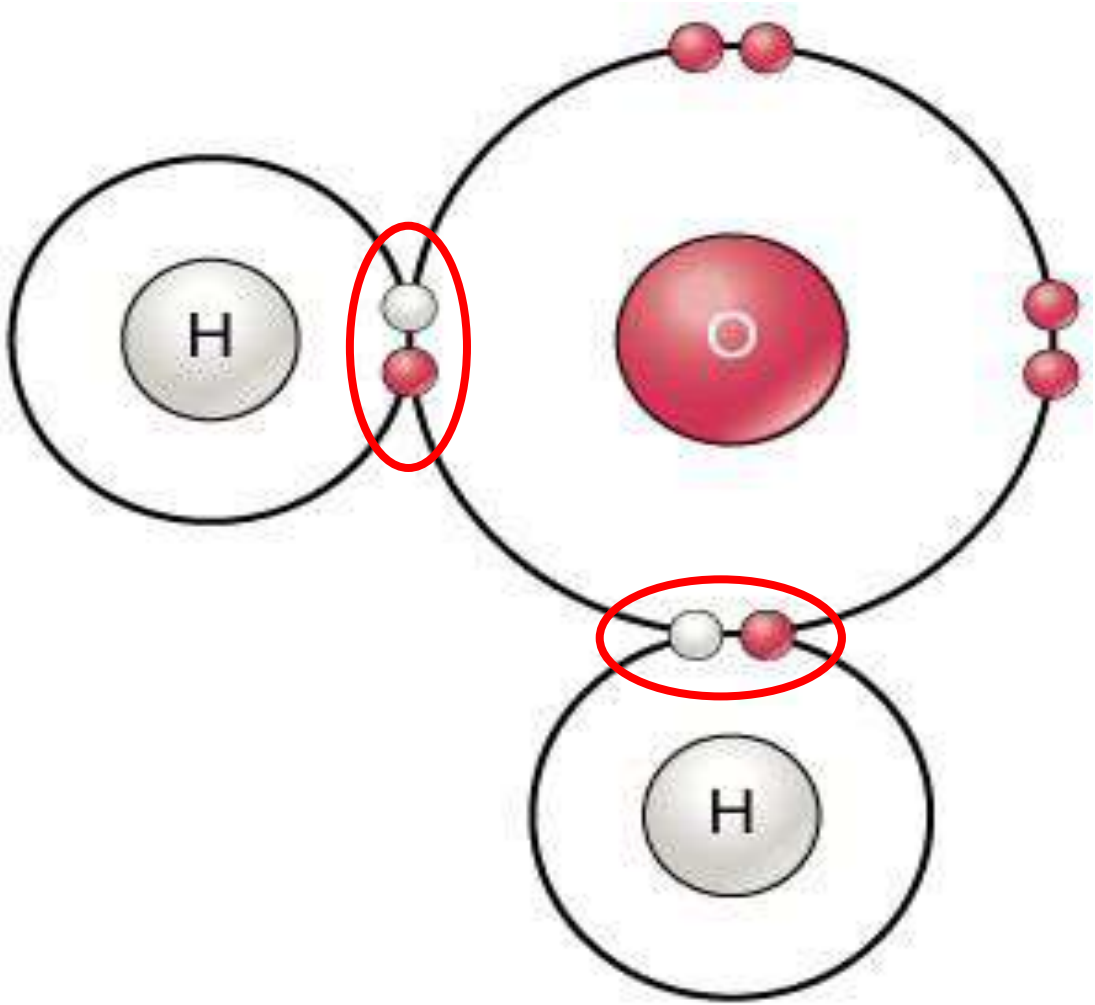
- The valence electrons are shared between the 2 hydrogen and oxygen atoms

- The electron orbitals actually overlap so that the shared valence electrons fly around the nuclei of all 3 atoms.
- This is an example of a covalent bond.

Chemical Bonds

Covalent Bond

Water



Let’s stop & Think:
Out of the two bonds, which type of bond is stronger, ionic or covalent?

Any idea why?

Journal Entry

Water

- Water is the single most abundant compound in most living things
- Water covers three fourths of Earth's surface
- Water is one of the few compounds that is a liquid at the temperatures found over much of Earth's surface

Water

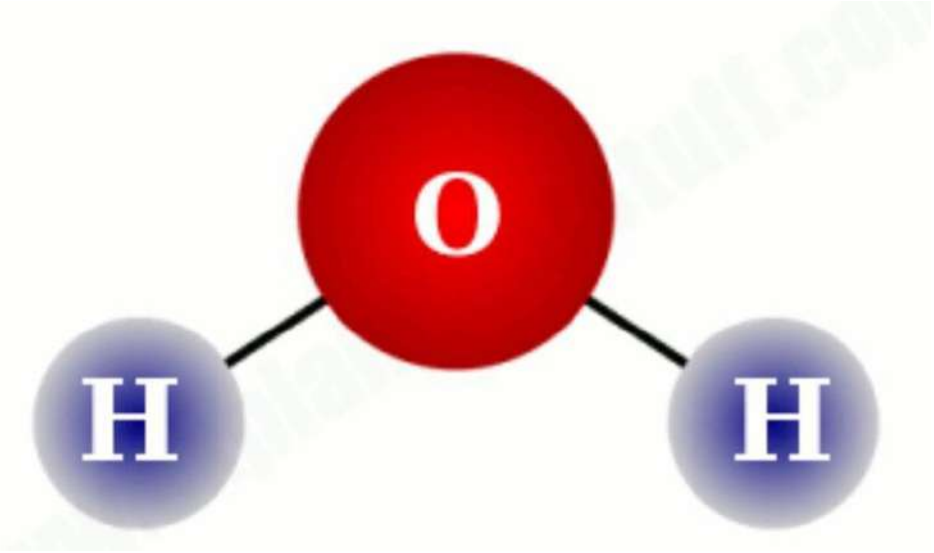
- Unlike most substances, water expands as it freezes
- Ice is less dense than liquid water, which explains why ice floats on the surface of lakes and rivers
- Water is found on earth in all 3 phases
    - Solid
    - Liquid
    - Gas

Water

- Water is a neutral molecule
- The positive charges on its 10 protons balance out the negative charges on its 10 electrons
- Water (H_2O)

  Oxygen has 8 protons

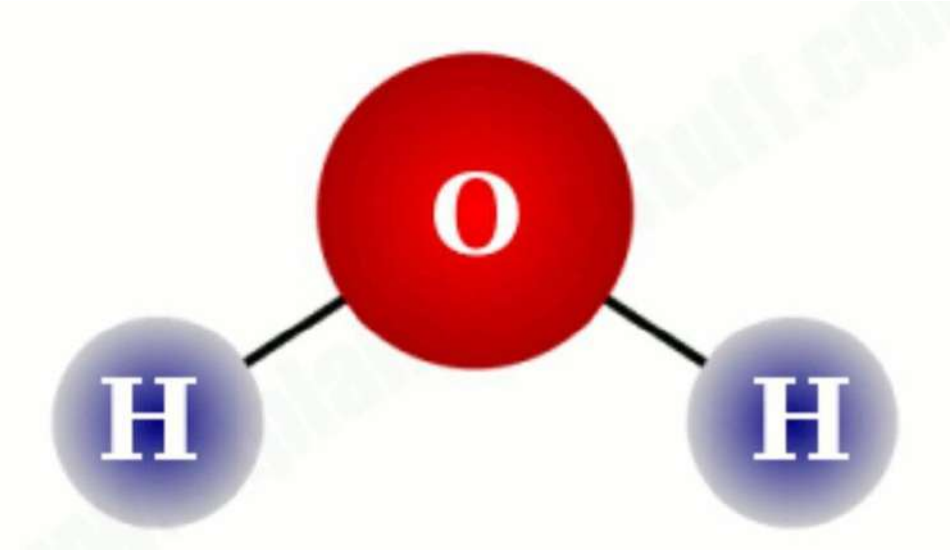
  Hydrogen has 1 proton



Water

- With 8 protons in its nucleus, an oxygen atom has a much stronger attraction for electrons than does the hydrogen atom with a single proton in its nucleus

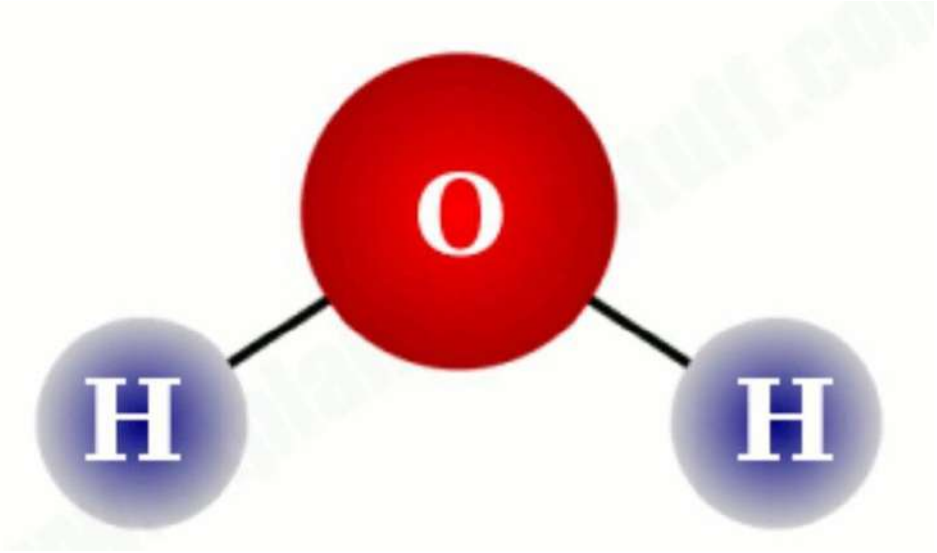
- At any moment, there is a greater probability of finding the shared electrons near the oxygen atom than near the hydrogen atom



Water

- Water has a bent shape

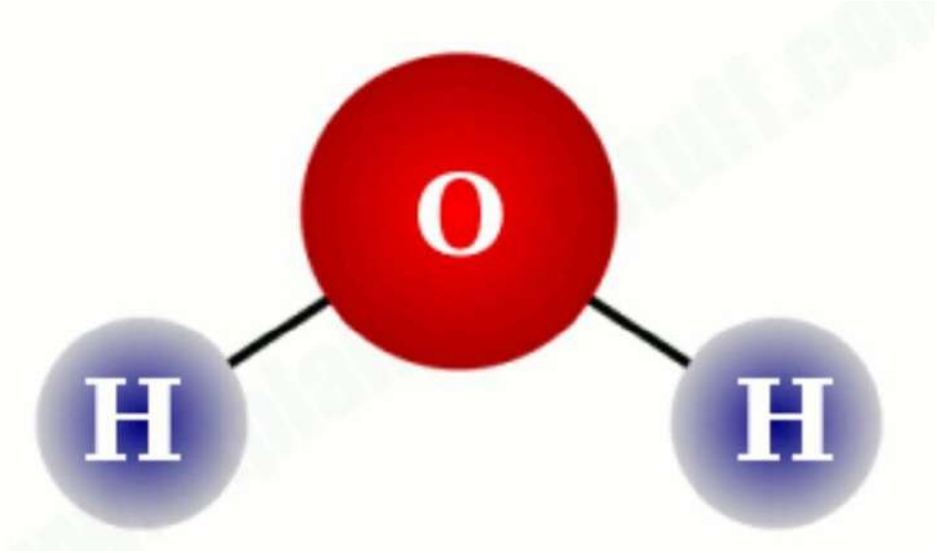
- Therefore the oxygen atom is on one end of the molecule and the hydrogen atoms are on the other



Water

- Oxygen's larger size & greater attraction for electrons causes the Oxygen side of the water molecule to have a slightly negative charge

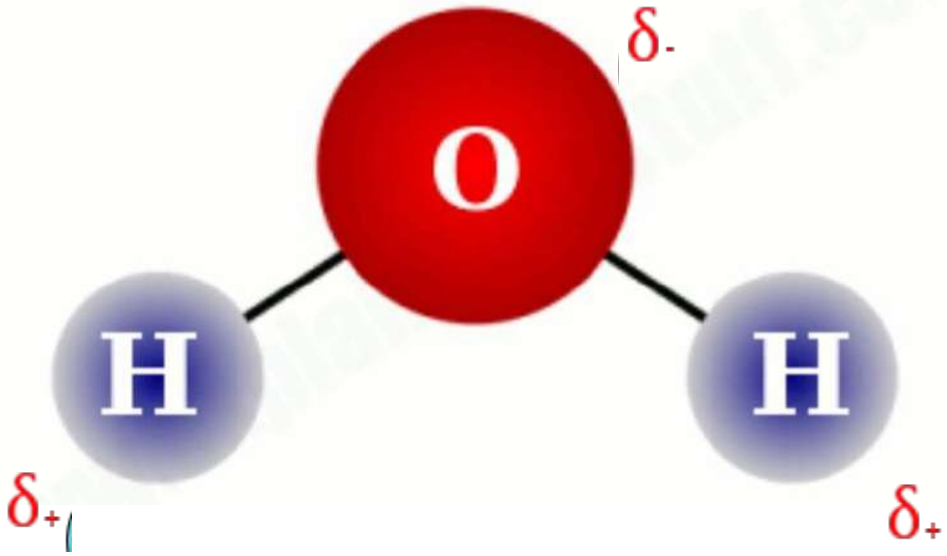
- Hydrogen atoms will have a slightly positive charge



Water

- Polar molecule:

  - A molecule in which the charges are unevenly distributed



- A water molecule is polar because there is an uneven distribution of charge between the slightly positive Hydrogen atoms & the slightly negative oxygen atoms

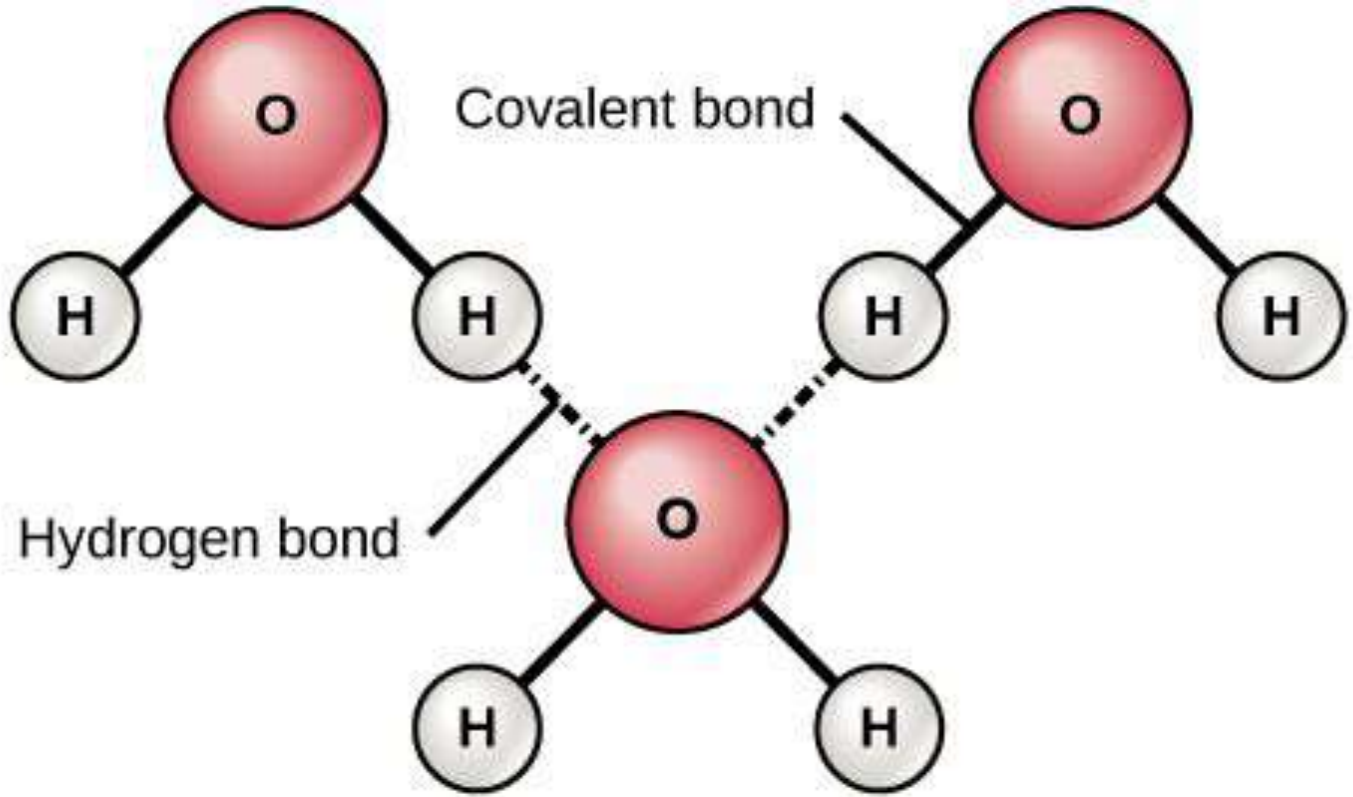
Hydrogen Bonds

- Because of its polarity, water molecules form hydrogen bonds with other water molecules
- Polar molecules have a very strong attraction toward one another
- The attraction between the hydrogen atom on one water molecule and the oxygen atom on another water molecule is an example of a hydrogen bond

Hydrogen Bonds

- Hydrogen bonds are the bonds which hold individual water molecules together
- Hydrogen bonds are not as strong as covalent or ionic bonds
- Water's ability to form multiple hydrogen bonds is responsible for many of its special properties

Draw MULTIPLE hydrogen bonds between several water molecules



Hydrogen Bonds

- Cohesion:

    - an attraction between same molecules (substance)

- Due to surface tension, insects and spiders can walk on a pond's surface. They do not weigh enough to break the hydrogen bonds at the surface
- Cohesion causes molecules to draw inward at surface

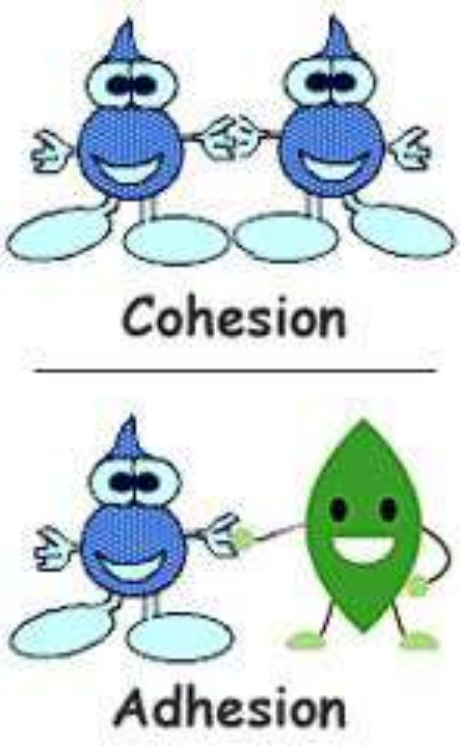
Hydrogen Bonds

- Adhesion

  - an attraction between molecules of different substances

- Adhesion causes water to bend at surface

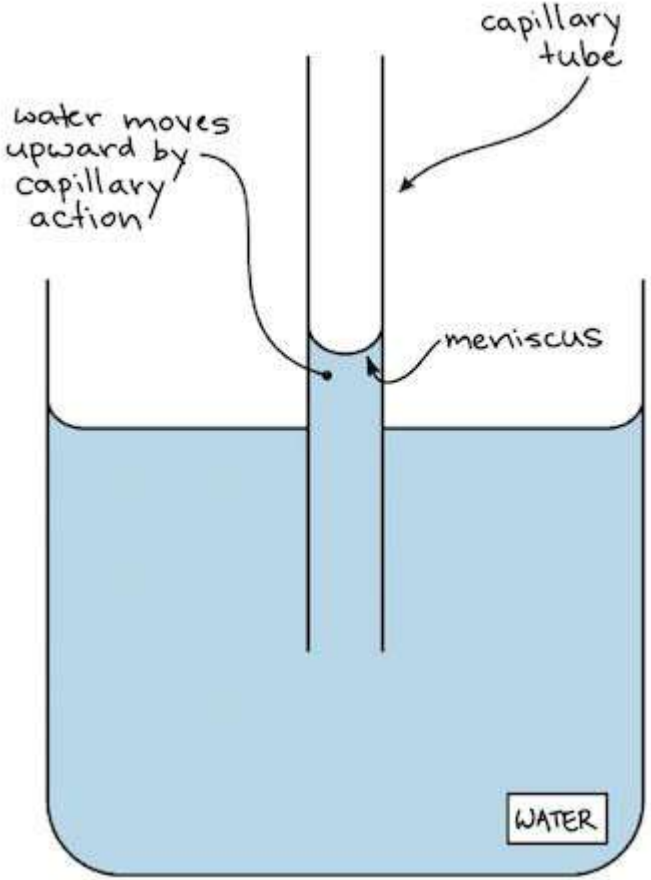
- It’s the ability of water molecules to stick to other materials



Hydrogen Bonds

- Adhesion between water and glass also causes water to rise in a narrow tube against the force of gravity

- Capillary action is one of the forces that draw water out of the roots of a plant and up into its stems and leaves.



Solutions & Suspensions

- Water is not always pure—it is often found as part of a mixture
- Mixture:
    - a material composed of two or more elements or compounds that are physically mixed together but not chemically combined.
- Example: Salt and pepper Sugar and Sand

Solutions & Suspensions

- Two types of mixtures that can be made with water are solutions and suspensions
- Solution:
    - mixture of two or more substances in which the molecules of the substances are evenly distributed
- Example: Salt & Water

Solutions & Suspensions

- The salt & chloride (NaCl: Table Salt) ions gradually become dispersed in the water
- Solute:
    - Substance that gets dissolved in a solution

        Example: Salt
- Solvent: The substance in which the solute dissolves in

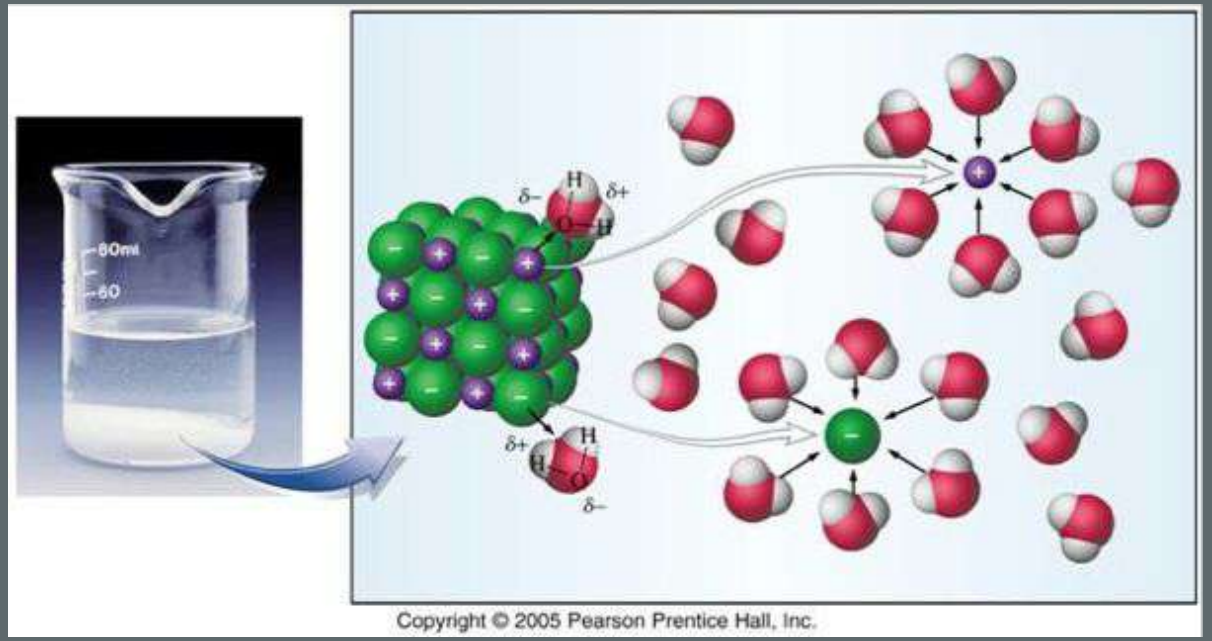
    Example: Water

Solutions & Suspensions

- Water's polarity gives it the ability to dissolve both ionic compounds and other polar molecules

- Without exaggeration, water is the greatest solvent on Earth

How does NaCl dissolve in water?



The positive hydrogen of H2O attracts the Cl- ion and the negative oxygen of H2O attracts the Na+ ion. Water literally pulls NaCl apart

Solutions & Suspensions

- Some materials do not dissolve when placed in water but separate into pieces so small that they do not settle out
- Suspensions:
    - A mixture of water and nondissolved materials

        Example: blood, milk, oil in water, mud in water

Solutions & Suspensions

- Are the following Solutions or Suspensions:

Salt and Water Solution

Sand and Water Suspension

Milk Suspension

Kool-Aid Solution

Chicken Noodle Soup Suspension

Salad dressing Solution

Orange Juice with Pulp Suspension

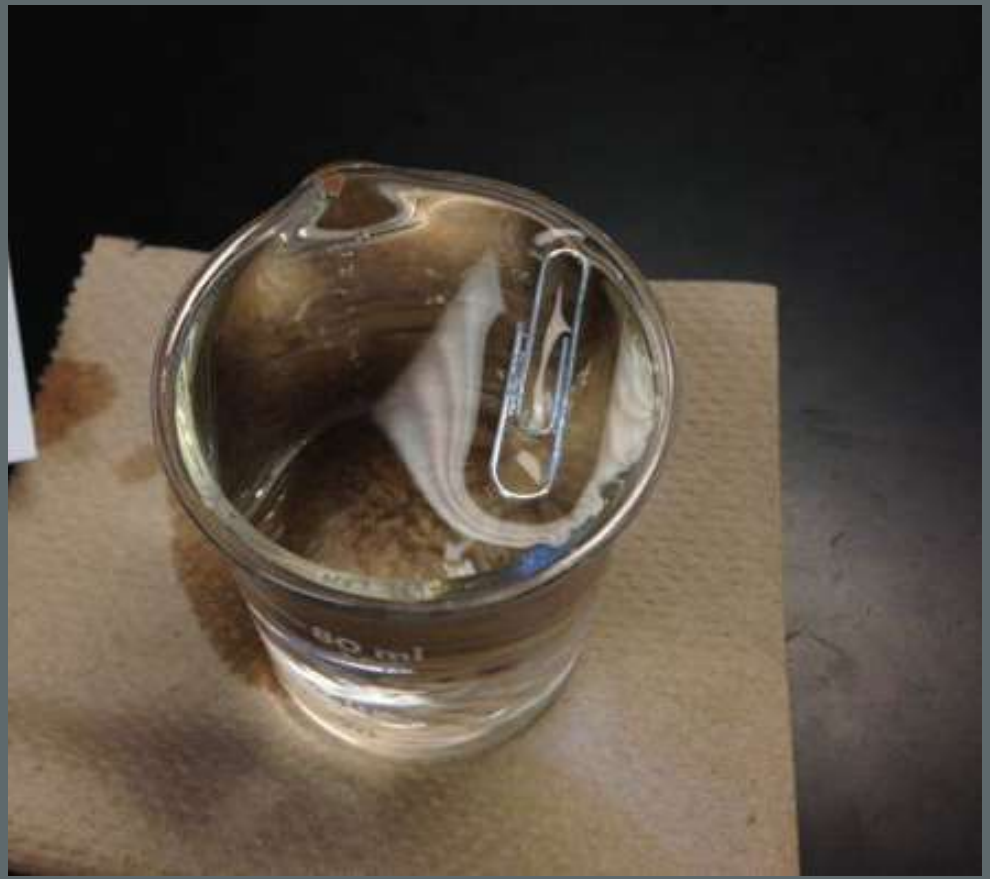
Blood Suspension

Coffee Solution

Properties of Water Lab

Why does water sit on the rim of the beaker without dripping off?

Why does the paperclip float?

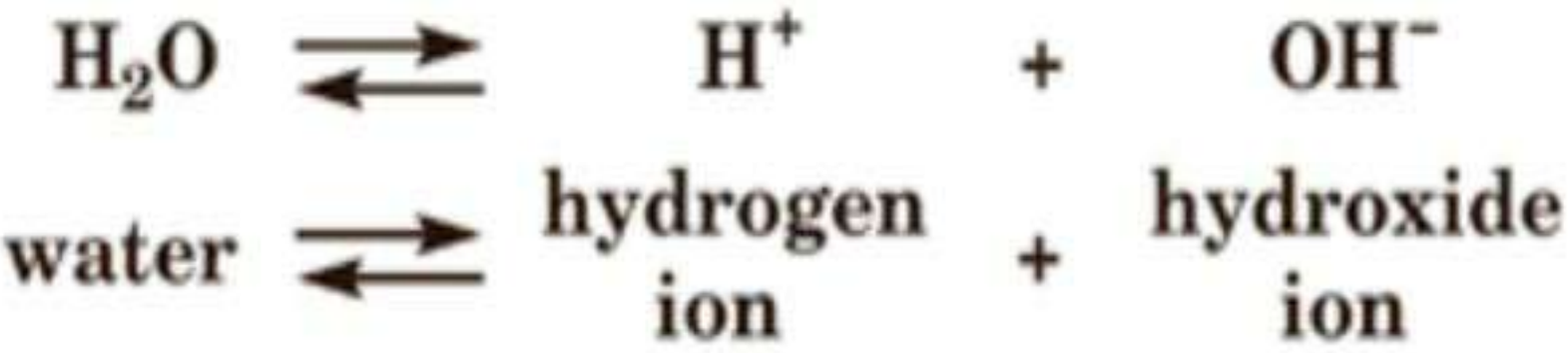


Why did the cotton absorb the water?

Why did the cotton eventually sink?

Acids, Bases, and pH

- A water molecule can react to form ions



- Because the number of positive hydrogen ions produced is equal to the number of negative hydroxide ions produced, water is neutral

Acids, Bases, and pH

- pH:

    - measurement system used to indicate the concentration of hydrogen ions (H+) in solution; ranges from 0 to 14

- At a pH of 7, the concentration of H+ ions and OH− ions is equal

Acids, Bases, and pH

- Acidic:
    - Solutions with a pH below 7
    - They have more H^+ ions than OH^- ions
- Strong acids tend to have pH values that range from 1 to 3

Acids, Bases, and pH

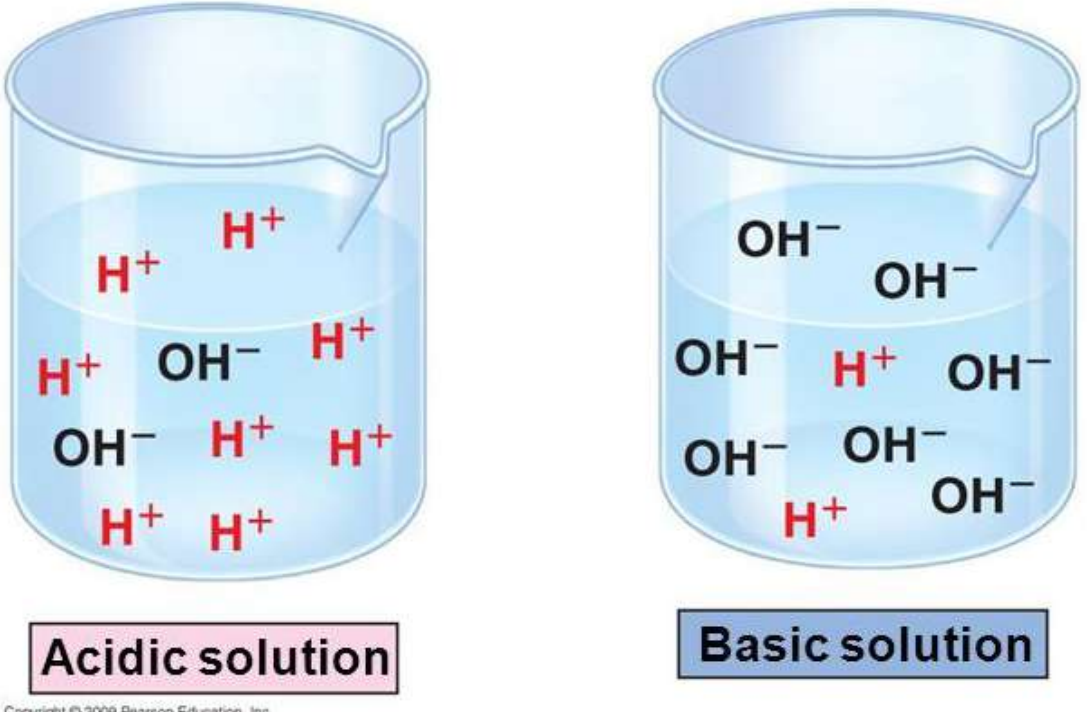
- Basic:
    - Solutions with a pH above 7
    - They have more OH^- ions than H^+ ions
- Strong bases, such as lye, tend to have pH values ranging from 11 to 14

Acids, Bases, and pH

	Type of Ions	pH	Examples	Characteristics
Acids	H^+	1-7	Lemon, vinegar, soda, aspirin	Sour, burns, dissolves things
Neutrals	H_2O	7	Pure Water	Not acidic, not basic!
Bases	OH^-	7-14	Soap, baking soda, ammonia	Bitter, slippery

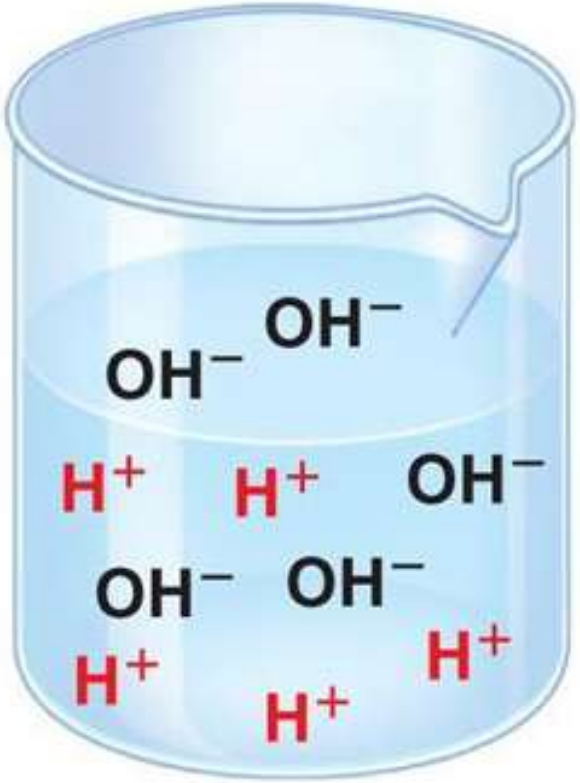
Acids, Bases, and pH

- Drawing: How would a basic solution differ from an acidic solution?



Acids, Bases, and pH

- Drawing: What happens when you mix an Acid & Base solution?



Acids, Bases, and pH

- Buffers
    - weak acids or bases that react with strong acids and bases to prevent sharp changes in pH
- Buffers are so important:

    When acids and bases are added to the body, the blood “buffers” prevent a drastic pH change

Acids, Bases, and pH

- Buffers help to neutralize pH

- Buffers help control pH in blood, etc

- The pH of the fluids within most cells in the human body must generally be kept between 6.5 and 7.5.

- If the pH is lower or higher, it will affect the chemical reactions that take place within the cells

Helps with maintaining homeostasis

Examples of pH Conditions:

pH 2	pH 4	pH 5	pH 7	pH 7.4	pH 10	pH 12
						
gastric juices	*tomato juice*	*human urine*	*pure water*	*human blood*	*hand soap*	*household bleach*

Journal Entry

Macromolecule Jigsaw & Concept Map

Chemical Reactions

- Chemical Reactions:
    - Process that transforms one set of compounds into another
- Some reactions occur very quickly, while others occur extremely slowly
- Anything your body does involves a chemical reaction

Chemical Reactions

- How do you know when a chemical reaction has occurred:
    - Change in temperature (products feel cold or hot)
    - Change in color
    - Formation of a solid
    - Formation of a gas – bubbles!
    - Giving off light

Chemical Reactions

- Chemical reactions are a change from an initial set of molecules to another set of molecules through the breaking of bonds and formation of new bonds
- Reactants:
    - The elements or compounds that enter into a chemical reaction
- Starting substances (left side) of a chemical equation

Chemical Reactions

- Products:

    - The elements or compounds produced by a chemical reaction
- Substances formed (right side) of a chemical equation

Chemical Equations

- How to write a chemical reaction
  - Reactants + Reactant → Product + Product
- Real Life Example:

  carbon dioxide + water → glucose + oxygen
- Chemical Reaction:

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

Chemical Equations

- Chemical Reaction:

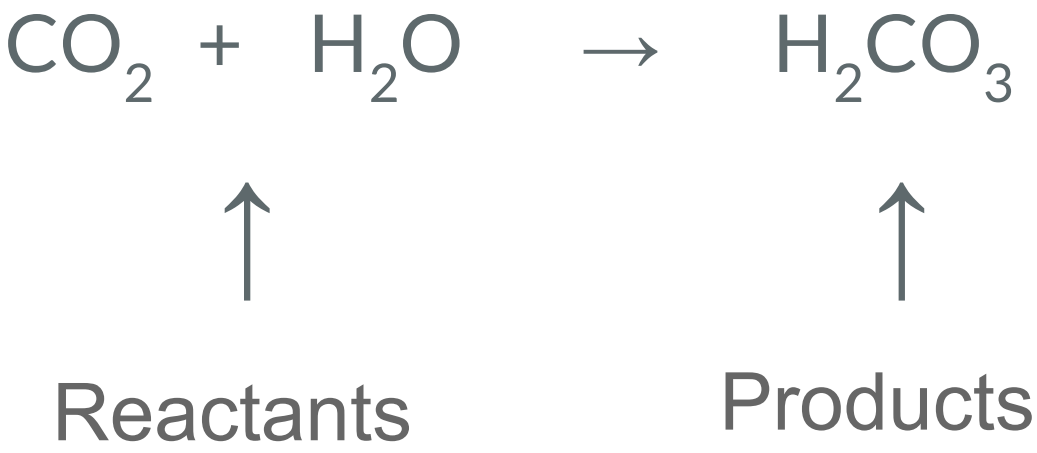
$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$

Reactants

Products

Chemical Equations

- Chemical Reaction:



Energy in Reactions

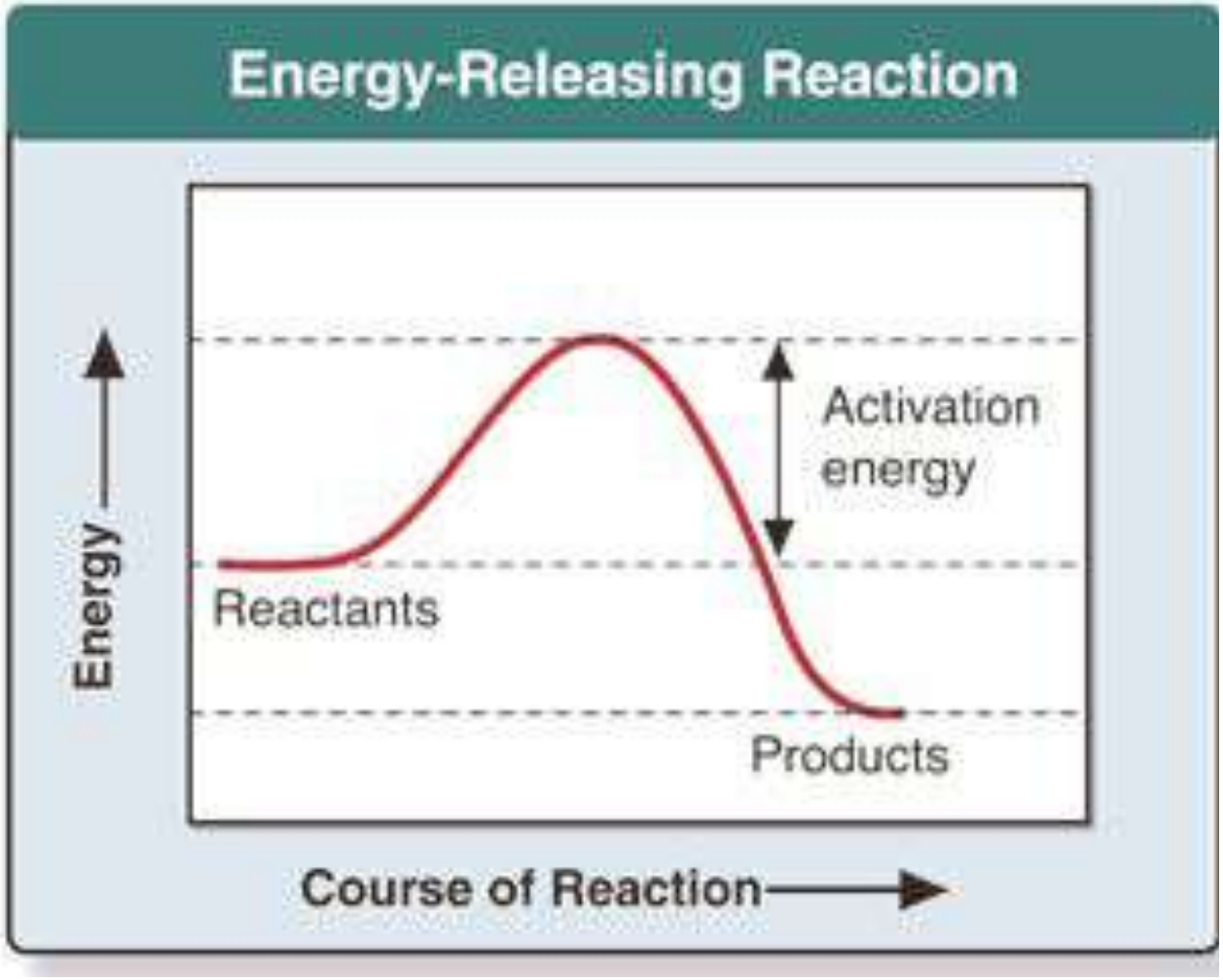
- Energy is released or absorbed whenever chemical bonds form or are broken

- Some chemical reactions release energy, and other reactions absorb energy

- Energy changes are one of the most important factors in determining whether a chemical reaction will occur

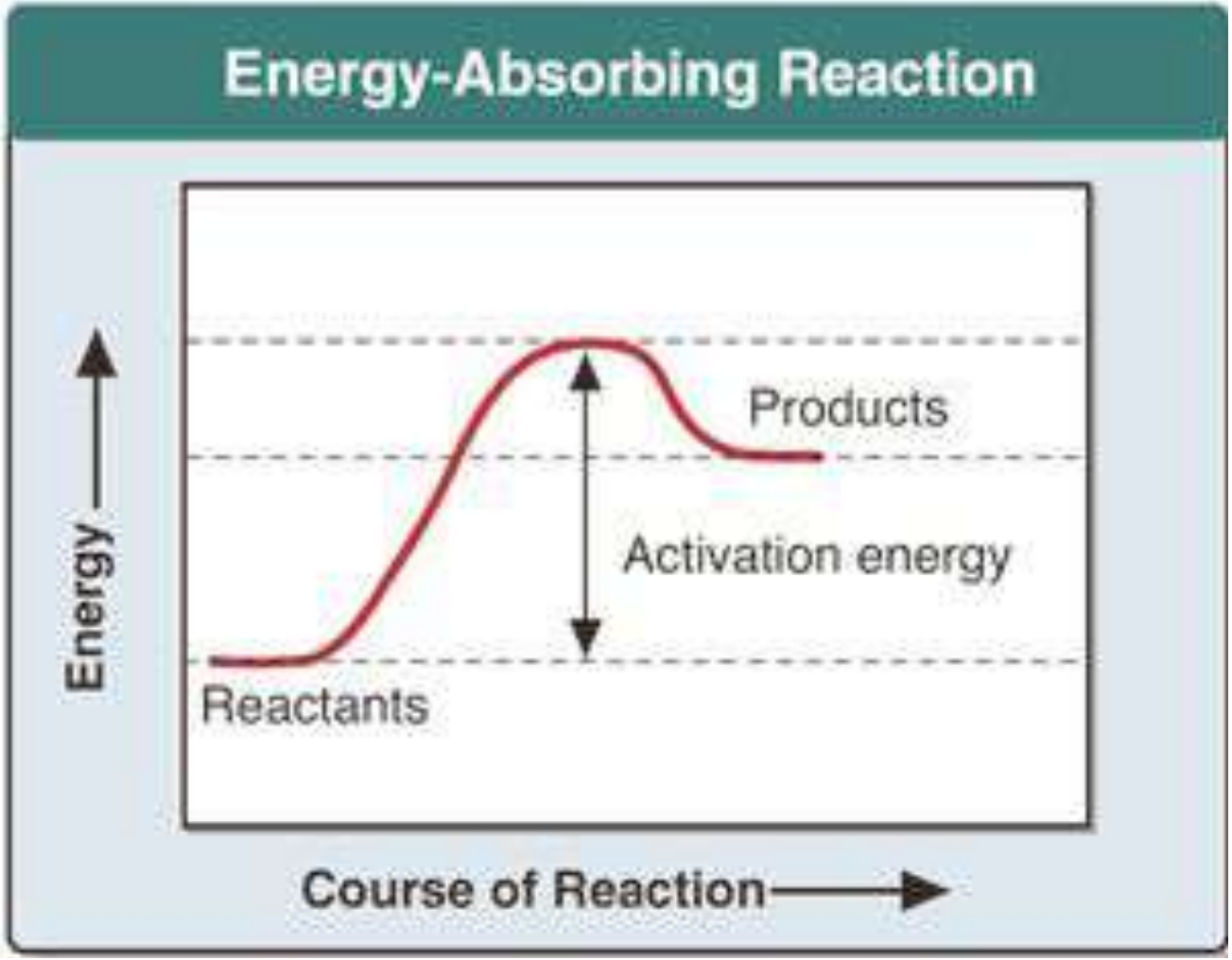
Energy in Reactions

- Chemical reactions that release energy often occur spontaneously
    - Energy is released in the form of heat
- This is called an Exothermic (releases heat) reaction
    - Energy of the products is lower than the energy of the reactants
    - Example: Combustion

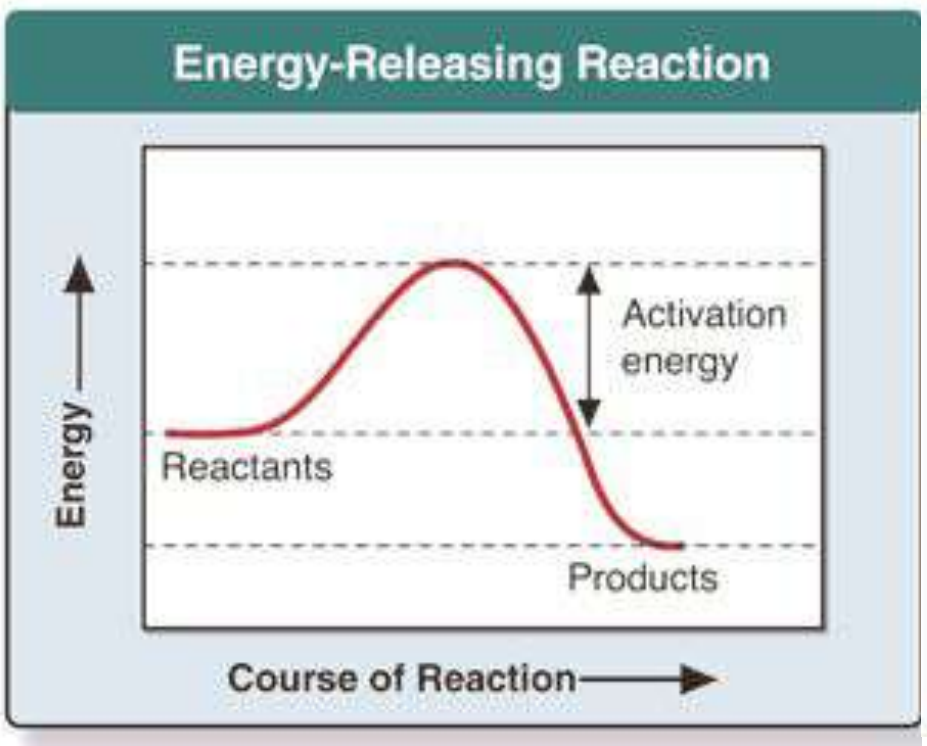

Energy-Releasing Reaction
Activation energy
Reactants
Products
Energy
Course of Reaction

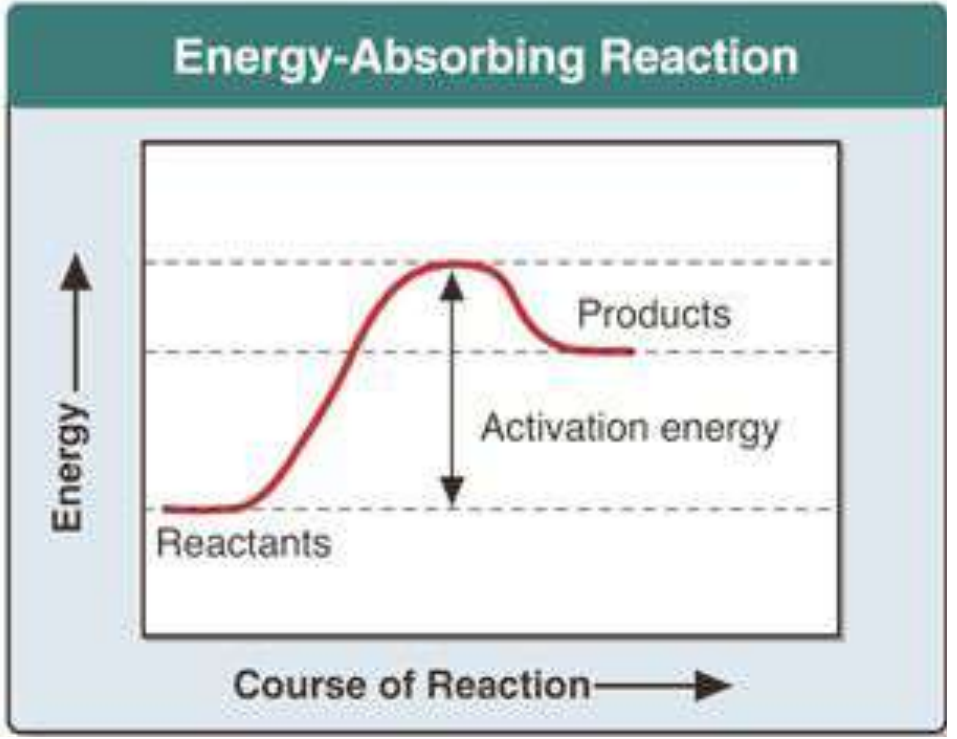
Energy in Reactions

- Chemical reactions that absorb energy will not occur without a source of energy
    - Energy is taken in from the surroundings
- This is called an Endothermic (absorbs heat)
    - Energy of the products is higher than energy of the reactants
    - Example: Ice Packs


Energy-Absorbing Reaction
Energy
Products
Activation energy
Reactants
Course of Reaction

What is similar between both reactions?





Energy in Reactions

- Even chemical reactions that release energy do not always occur spontaneously
- Let's think about it

Why aren't our note pages spontaneously bursting into flames?

- We need to put IN the energy to get the fire started, which is called the Activation Energy

Energy in Reactions

- Activation Energy:

    - The energy that is needed to get a reaction started

- Activation energy is a factor in whether the overall chemical reaction releases energy or absorbs energy.

- REMEMBER:

    All chemical reactions require ACTIVATION ENERGY to get started.

Enzymes

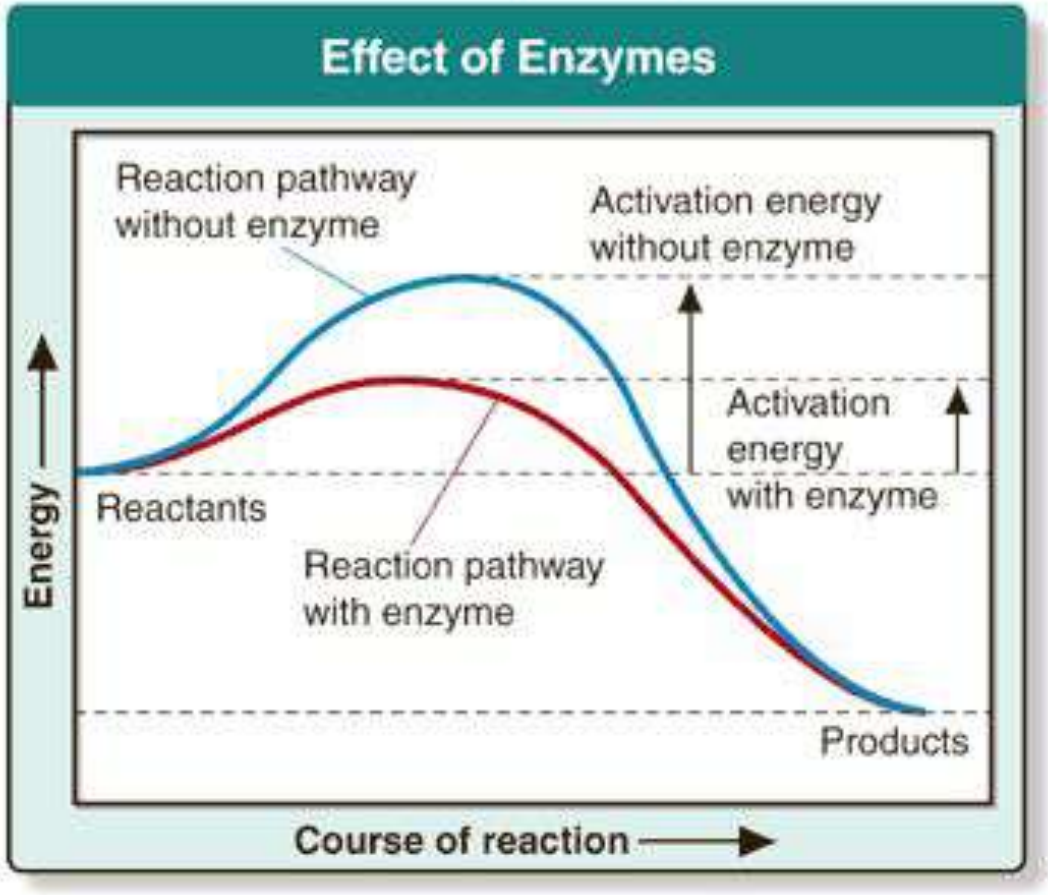
- Some chemical reactions that make life possible are too slow or have activation energies that are too high to make them practical for living tissue.
- These chemical reactions are made possible by catalyst
- Catalyst:

    - substance that speeds up the rate of a chemical reaction by lowering the activation energy

Enzymes

- Enzymes:

  - Proteins that act as biological catalysts by speeding up chemical reactions that take place in cells



Enzymes

- Enzymes are very specific, generally catalyzing only one chemical reaction
- Part of an enzyme's name is usually derived from the reaction it catalyzes
- Enzymes provide a site where reactants can be brought together to react
    - This site reduces the energy needed for reaction

Enzymes

- Substrates:
    - reactant of an enzyme-catalyzed reaction
- Active Site:
    - site on the enzyme where the substrate binds
- Active Site & Substrate have complementary shapes and fit together like a lock & key
    - Referred to as the Enzyme/Substrate Complex

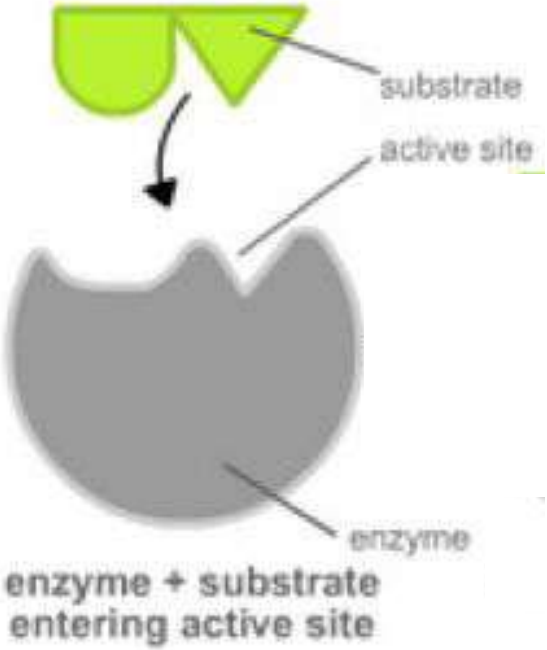
Enzymes

- Enzymes are specific and only work with their specific substrate
- Once they bind, they “unlock” the energy in that substrate to change it into a different product
    - Example: amylase is an enzyme that breaks down amylose (compound found in starch)
- Once the reaction is over, the products of the reaction are released and the enzyme is free to start the process again

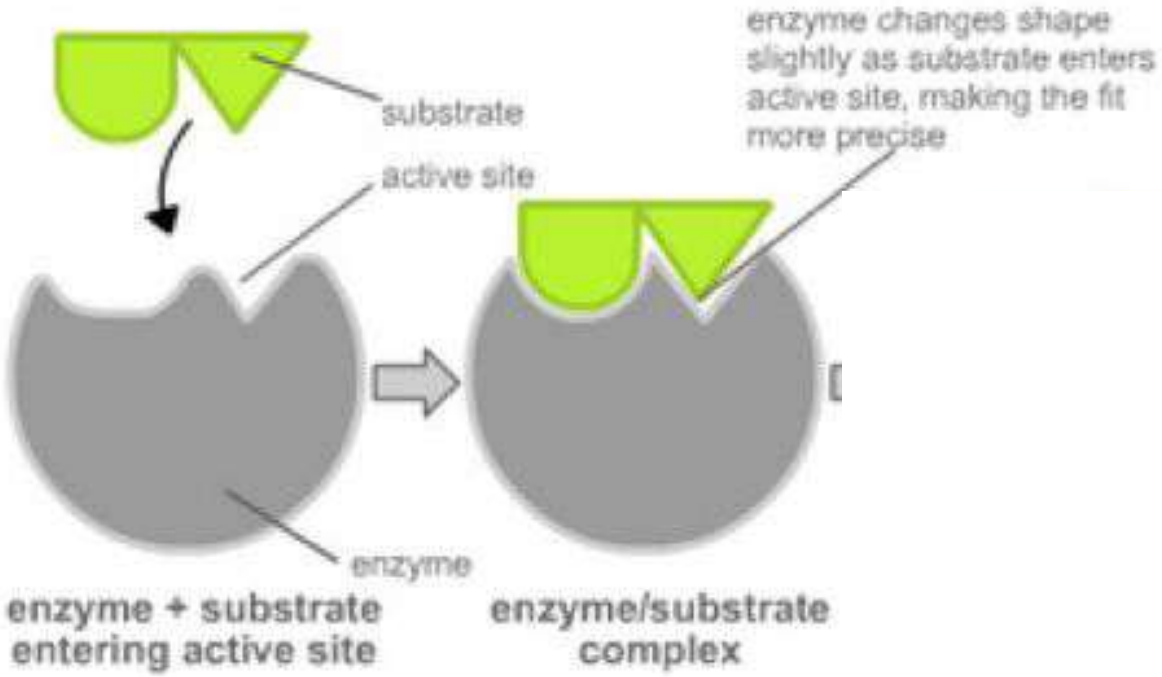
Enzymes

- Enzymes are not changed during the chemical reaction.
    - They can be reused after
- Enzymes are involved in many reactions in human bodies, such as muscle contractions, metabolism, and digestion
- Enzymes are also used commercially in products like detergents to break down stains on clothing

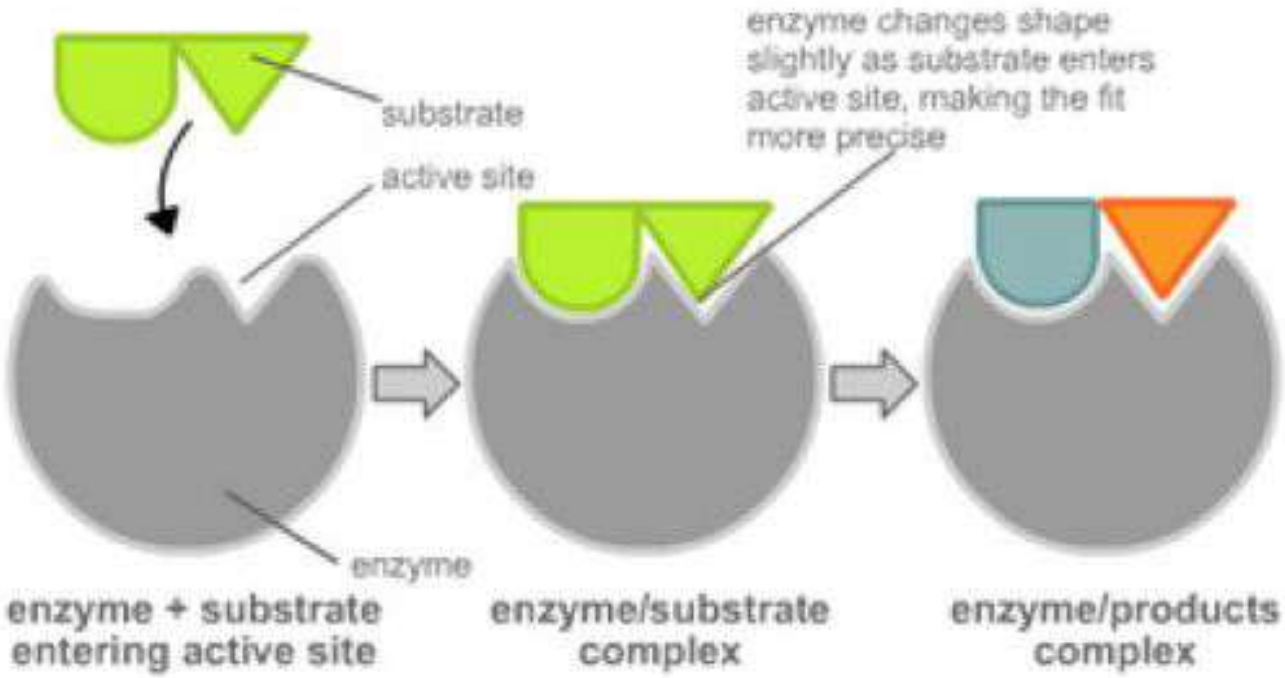
Label Enzyme Diagram



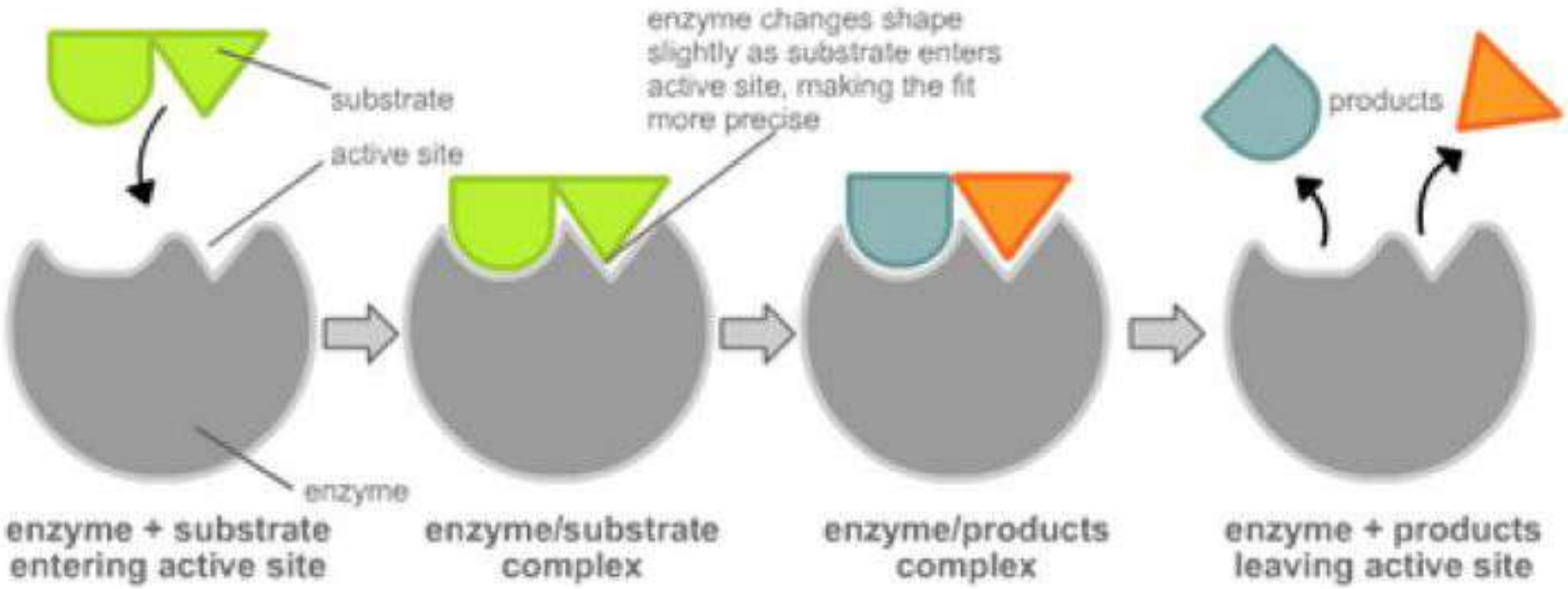
Label Enzyme Diagram



Label Enzyme Diagram



Label Enzyme Diagram



Regulation of Enzyme Activity

- Enzymes can be affected by any variable that influences a chemical reaction
    - Temperature
    - pH Levels
    - Inhibitors
    - Coenzymes

Regulation of Enzyme Activity

- Temperature:
  - Each enzyme has a temperature range in which it is most effective
  - High temperature (too hot) can denature enzyme (break it apart)
  - Low temperature (too cold) can slow down or stop enzyme activity

Regulation of Enzyme Activity

- pH:
    - Each enzyme has an ideal pH range
    - Too acidic or too basic can slow down the productivity of an enzyme
- Changes in temp & pH cause a DECREASE in product production

Regulation of Enzyme Activity

- Competitive Inhibitor:
  - A compound that is similar to the substrate
  - It binds to the active site & blocks the substrate
  - Competitive Inhibitors cause a DECREASE in product production.

Regulation of Enzyme Activity

- Coenzyme:
  - Enzyme helper
  - Compound that helps enzyme & substrate bind
  - Coenzymes cause an INCREASE in product production