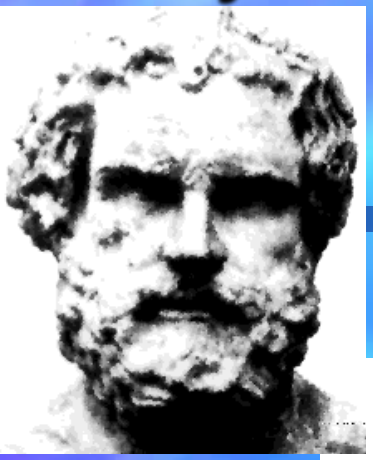
Chapter 2: The Chemistry of Life

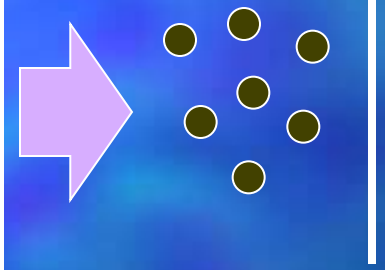
Section 1, The Nature of Matter

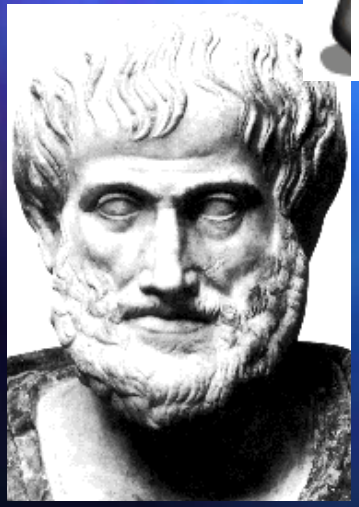
Early Greek Theories



Democritu

- 400 B.C. - Democritus thought matter could not be divided indefinitely.



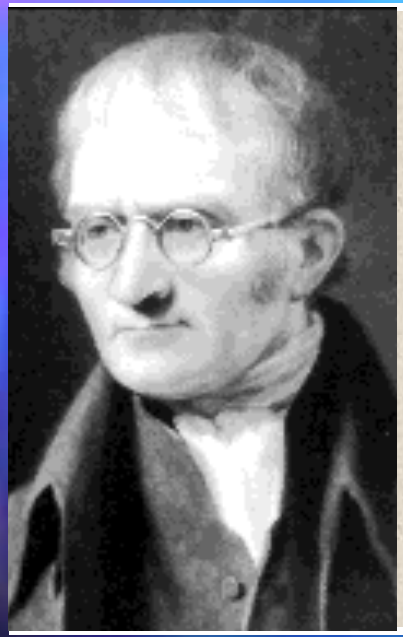


Aristotle

- 350 B.C - Aristotle modified an earlier theory that matter was made of four “elements”: earth, fire, water, air.
- Aristotle was wrong. However, his theory persisted for 2000 years.

John Dalton

- 1800 -Dalton proposed a modern atomic model based on experimentation not on pure reason.



- All matter is made of atoms.
- Atoms of an element are identical.
- Each element has different atoms.
- Atoms of different elements combine in constant ratios to form compounds.
- Atoms are rearranged in reactions.

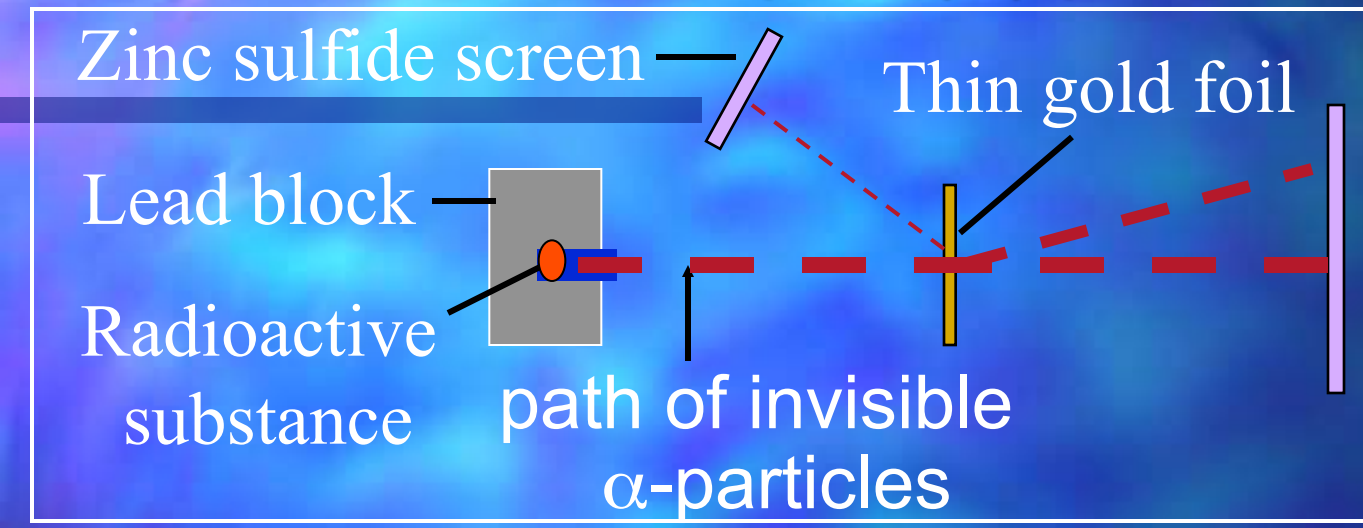
- His ideas account for the law of conservation of mass (atoms are neither created nor destroyed) and the law of constant composition (elements combine in fixed ratios).

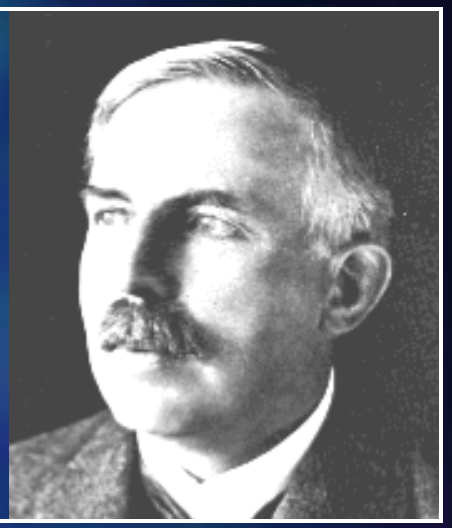
Atoms

- Define atom.
- The basic unit of matter.
- What are subatomic particles.
- Particles making up an atom called protons, neutrons, and electrons.*

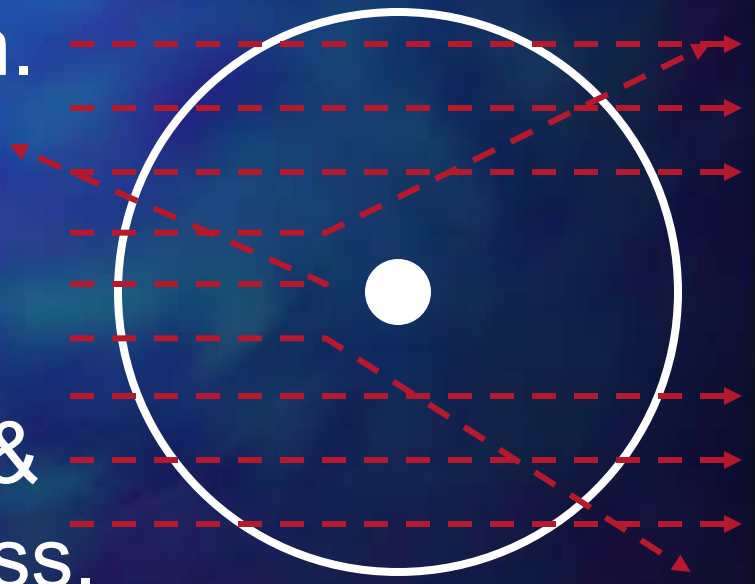
Ernest Rutherford

- Rutherford shot alpha (α) particles at gold foil.





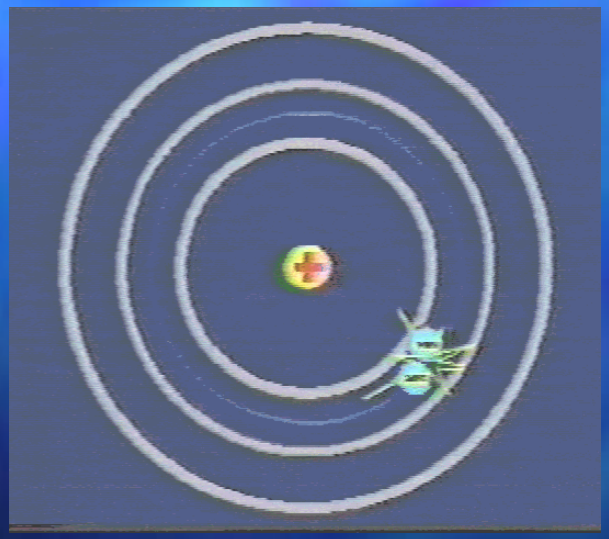
Most particles passed through.
So, atoms are mostly empty.
Some positive α-particles deflected or bounced back!
Thus, a "nucleus" is positive & holds most of an atom's mass.

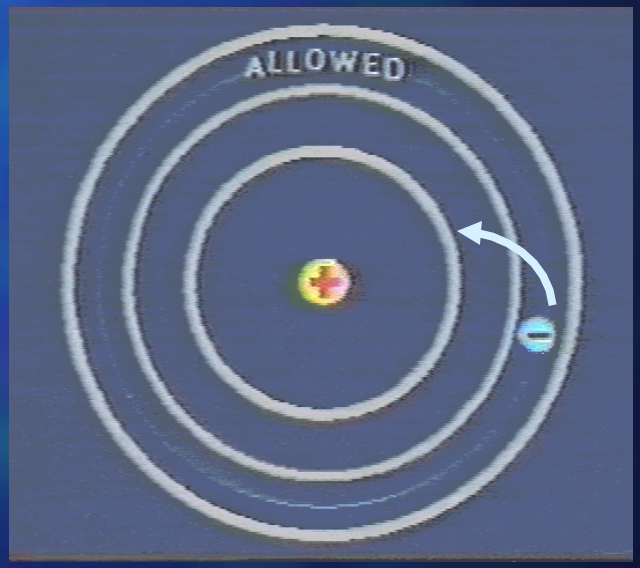


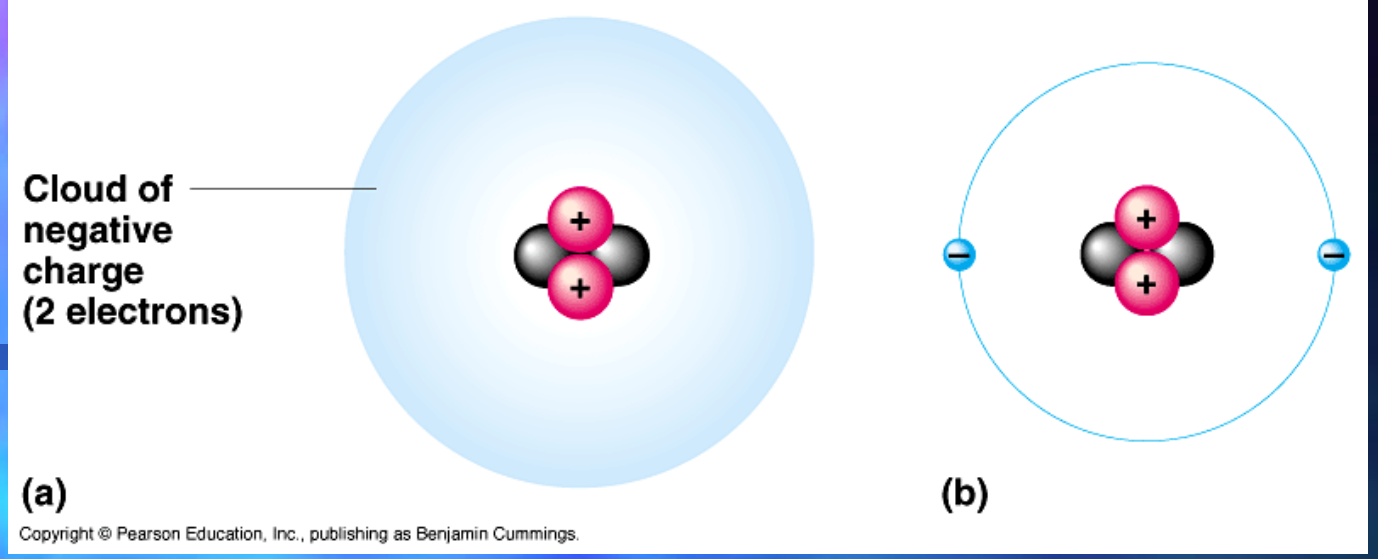
- What is a nucleus of an atom?
- The center of the atom where the protons and neutrons are.
- What charge does the proton have?
- Positive.
- What charge is the neutron?
- Neutral.
- What is an electron?
- A negatively charged particle moving around the nucleus.
- What is the overall charge of an atom?
- Neutral or no charge.
- Why?
- Because normal atoms have the same number of protons and electrons.*

Bohr's model

- Electrons orbit the nucleus in "shells"
- Electrons can be bumped up to a higher shell if hit by an electron or a photon of light.

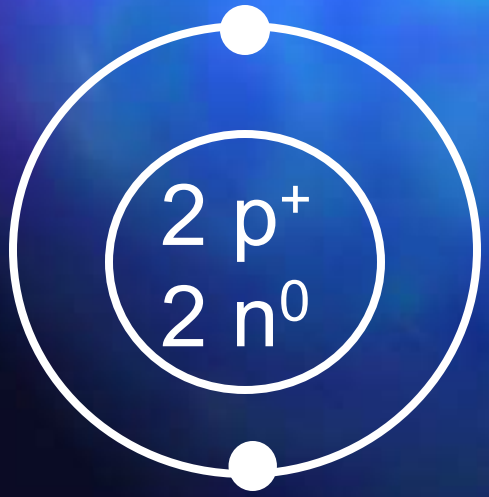






Bohr - Rutherford diagrams

He



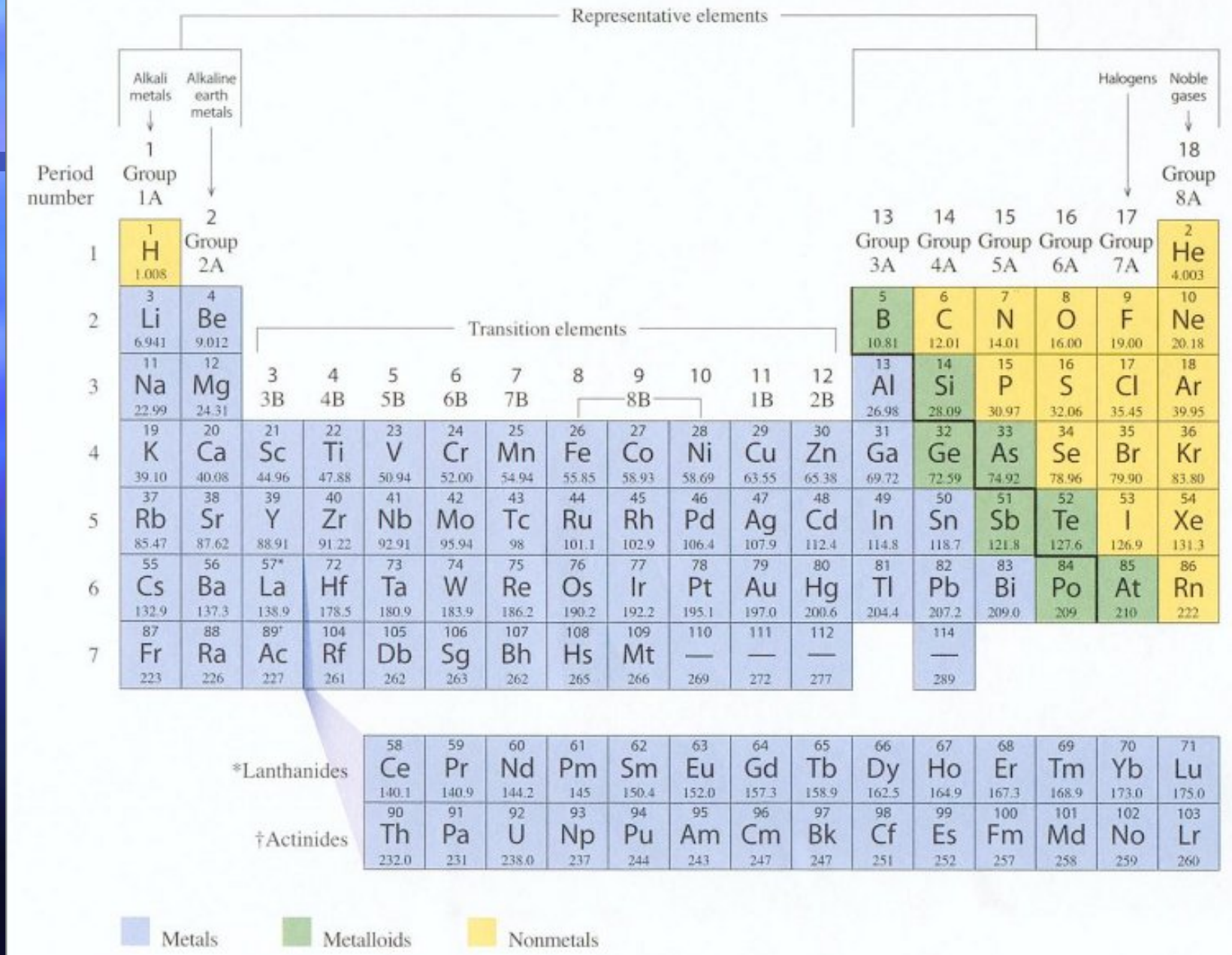
Li

Li shorthand

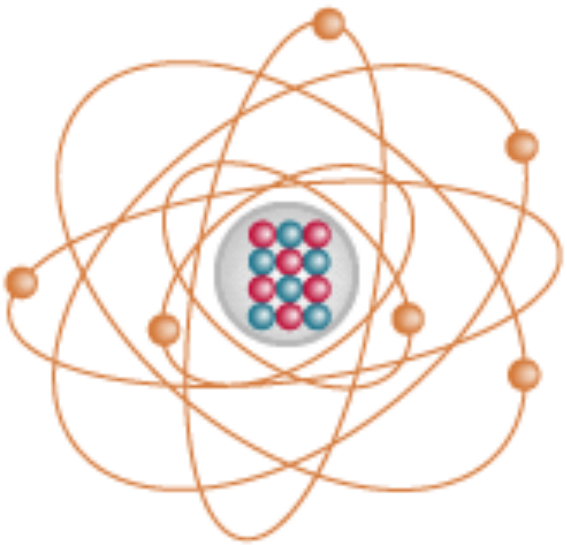
Elements and Isotopes

- Define element.
- A pure substance that consists entirely of one type of atom.
- How do we represent an element?
- Letters such as H for hydrogen, He for helium, Li for lithium and so on.
- What is an atomic number?
- The number of protons and also the number of electrons in any given element.
- What is an atomic mass?
- The sum total of protons and neutrons in the nucleus.*

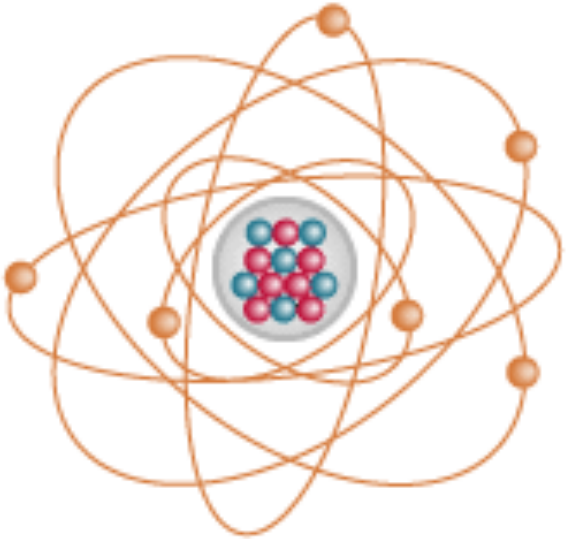
Periodic Table of Elements



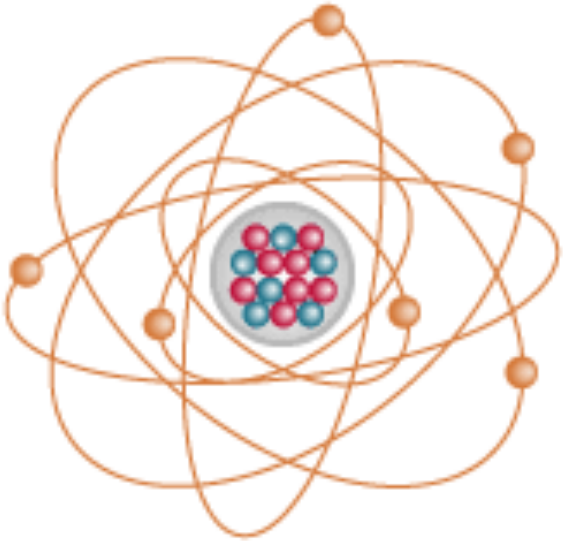
- What is an isotope?
- An element with the same number of protons but a different number of neutrons.
- “Because they have the same number of electrons, all isotopes of an element have the same chemical properties.”
- What are radioactive isotopes?
- Isotopes of an element in which their nucleus is unstable and break down at a constant rate over time.
- What do we use radioactive isotopes for?
- Treating cancer, killing bacteria, labeling or tracing the movement of substances within organisms.*



Carbon-12
stable



Carbon-13
stable



Carbon-14
unstable (radioactive)

Proton Neutron Electron

Chemical Compounds

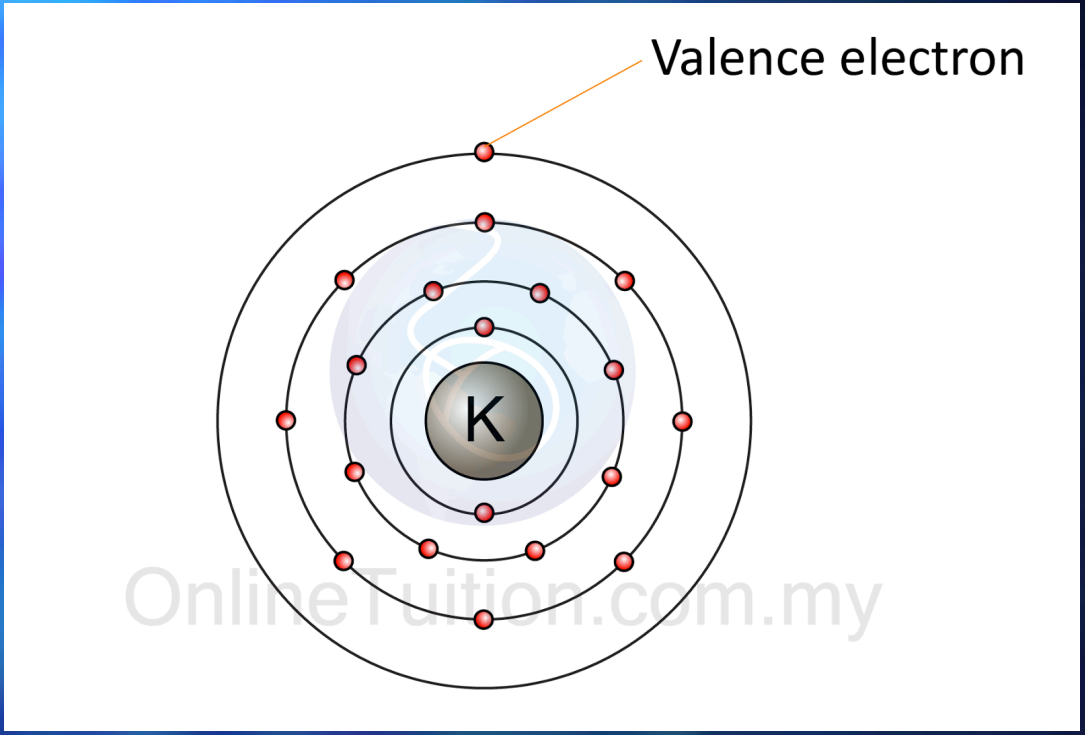
- What is a chemical compound?
  A substance formed by the chemical combination of two or more elements in definite proportions.
- Shorthand for compounds: H_2O, H_2SO_4, $C_6H_{12}O_6$.
- Remember the properties of compounds can be very different than the properties of the element themselves.*

Energy Levels

- Electrons reside in shells called energy levels.
- Each level can hold a certain number of electrons.
- Electrons fill from the lowest level to the higher level.
- The higher the level the higher the energy.

Valence Electrons

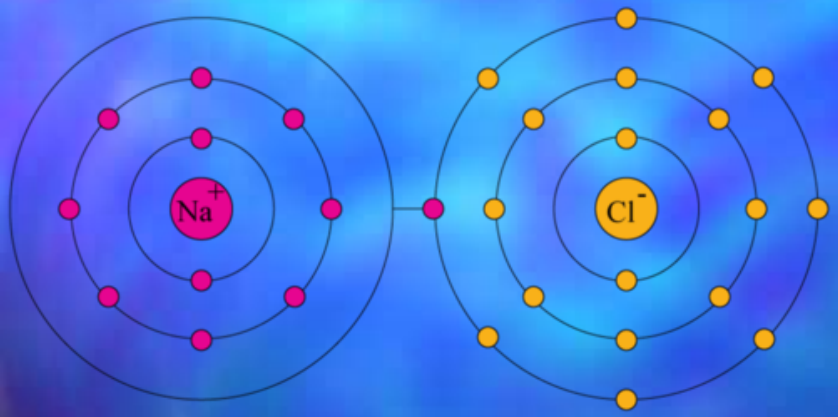
- The electrons in the outermost energy level.
- Many properties of elements are determined by these electrons.*

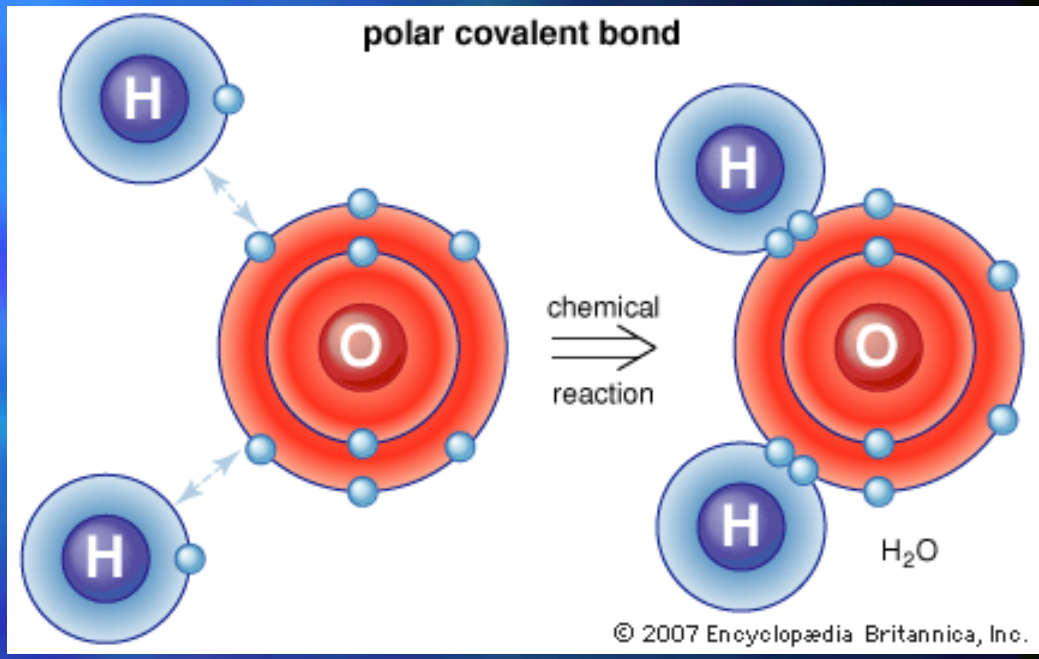


Chemical Bonds

- What holds the elements of compounds together?
- Bonds.
-  "The main types of chemical bonds are ionic bonds and covalent bonds."
- What is an ion?
- An atom that has lost or gained an electron.
- How will this affect the charge of an atom?
- Losing an electron makes the atom slightly positive and gaining an electron make the atoms slightly negative.*

- What is an ionic bond?
- A bond where electrons are transferred from one element to another.





- What is an covalent bond?
- A bond where electrons are shared between elements.

Van der Waals Forces

- What are van der Waals forces?
- Intermolecular force of attraction between nearby molecules.
- Why do they attract each other?
- Unequal sharing of covalent electrons cause oppositely charges areas to attract.



Section 2-1 Assessment

- Describe the structure of an atom.
- Why do all isotopes of an element have the same chemical properties? In what way do isotopes of an element differ?
- What is a covalent bond? An ionic bond?
- What is a compound? How are compounds related to molecules?
- How do van der Waals forces hold molecules together?*

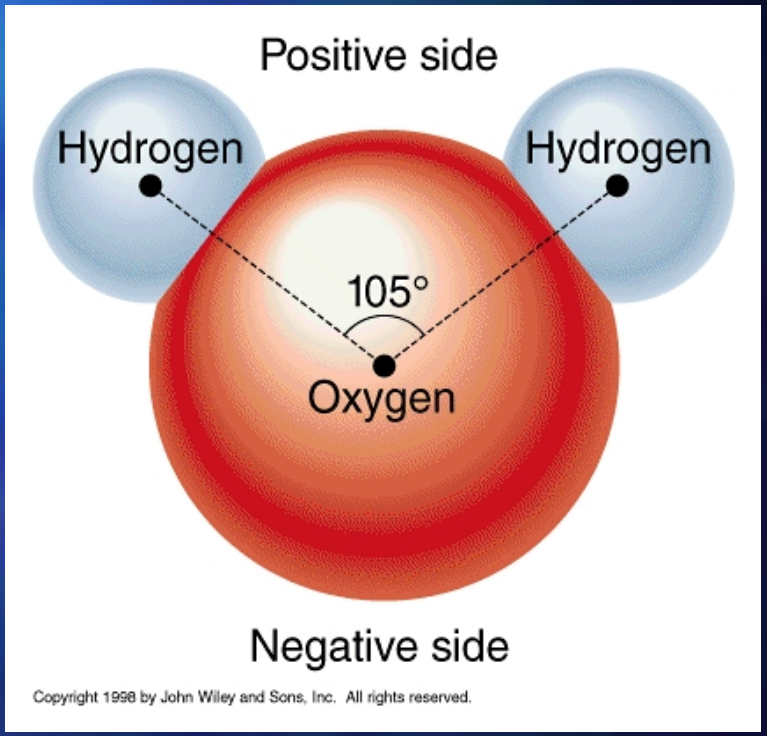
Chapter 2

Section 2: Properties of Water

The Water Planet

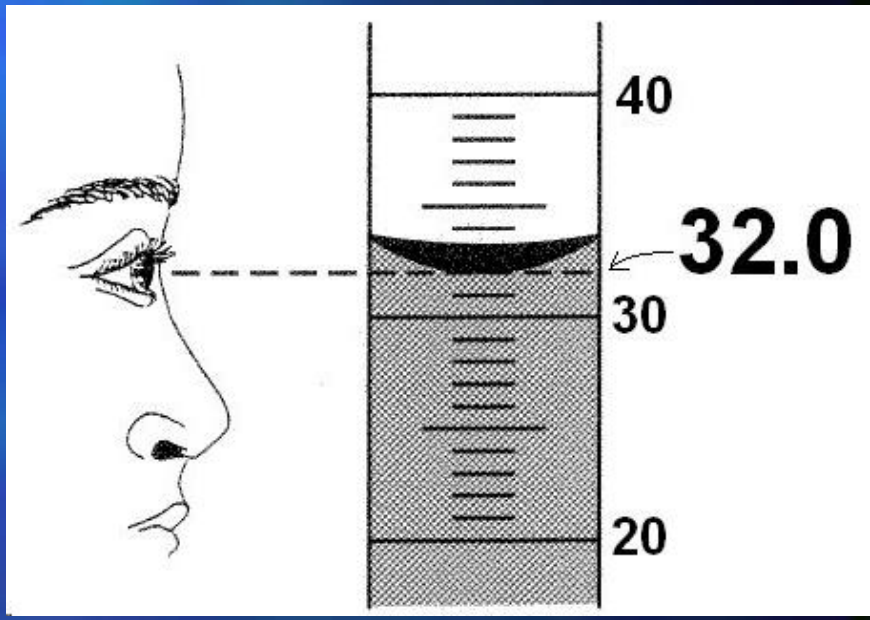
The Water Molecule

- Why does the neutral water molecule have a positive and negative side?
- The 8 protons in the O atom have a much stronger attraction for electrons than the H side.
- What do you call this type of molecule?
- A polar molecule.*



- A water molecule is polar because there is an uneven distribution of electrons between the oxygen and hydrogen atoms.
- Because of the polarity what kind of bonds form between water molecules?
- Hydrogen bonds.
- The ability of water to form multiple hydrogen bonds is responsible for many of water's properties.
- What is cohesion?
- An attraction between molecules of the same substance.
- Cohesion allows water to form drops or insects to walk on water.*

- Define adhesion.
- An attraction between molecules of different substances.
- What causes water to rise against gravity in a narrow tube or move water from the roots to the top of a plant?
- Capillary action. Cohesion holds the water column together as it rises.*

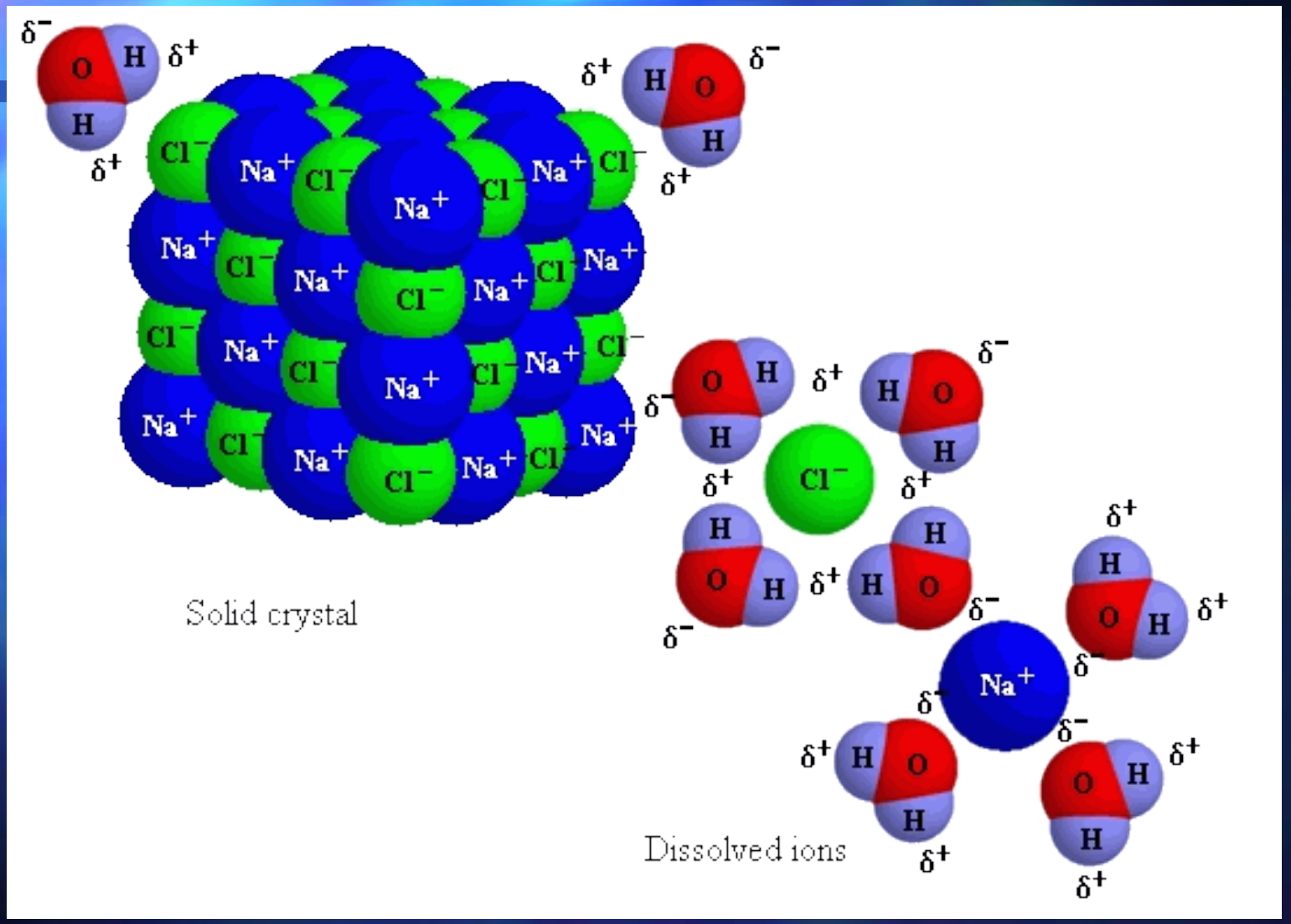


Solutions and Suspensions

- Define mixture.
- A material composed of two or more elements or compounds that are physically mixed together but not chemically combined.
- Salt and pepper stirred together, sugar and sand mixed, or the gasses in our atmosphere are mixtures.
- What are the two types of mixtures made with water?
- Solutions and suspensions.*

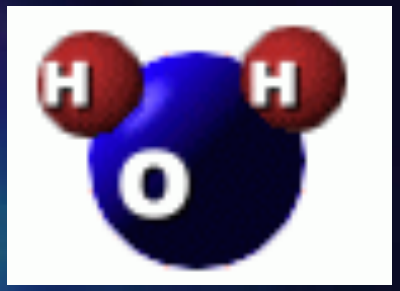
- Define a solution.
- A mixture where all of the components are evenly mixed throughout.
- What do you call the substance which is dissolved?
- The solute.
- What do you call the substance in which the solute dissolves?
- The solvent.
- What is the greatest solvent on earth?
- Water.*

Solutions of Salt



- What do you call mixture of water and non-dissolved material?
- Suspensions.
- What keeps the small particles suspended?
- The movement of water molecules.
- Blood is a form of both suspension and solution.*

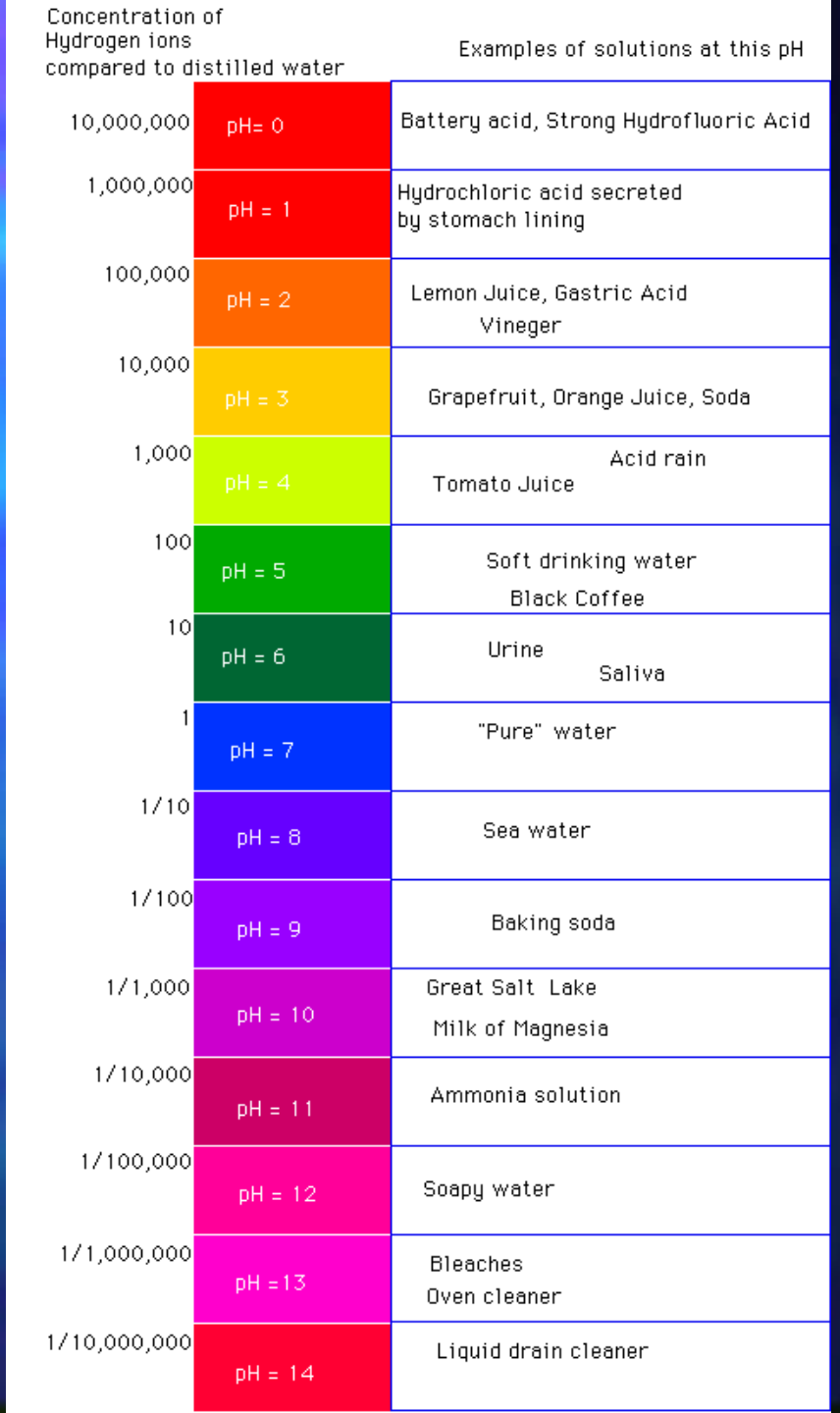
Acids, Bases, and pH



- Water can react to form ions.
- Define the pH scale.
- A measurement system devised to indicate the concentration of H^+ ions in a solution.*

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

pH Scale


Concentration of Hydrogen ions compared to distilled water
Examples of solutions at this pH
10,000,000
pH= 0
Battery acid, Strong Hydrofluoric Acid
1,000,000
pH = 1
Hydrochloric acid secreted by stomach lining
100,000
pH = 2
Lemon Juice, Gastric Acid
Vineger
10,000
pH = 3
Grapefruit, Orange Juice, Soda
1,000
pH = 4
Acid rain
Tomato Juice
100
pH = 5
Soft drinking water
Black Coffee
10
pH = 6
Urine
Saliva
1
pH = 7
"Pure" water
1/10
pH = 8
Sea water
1/100
pH = 9
Baking soda
1/1,000
pH = 10
Great Salt Lake
Milk of Magnesia
1/10,000
pH = 11
Ammonia solution
1/100,000
pH = 12
Soapy water
1/1,000,000
pH =13
Bleaches
Oven cleaner
1/10,000,000
pH = 14
Liquid drain cleaner

- What pH is a neutral solution?
- pH of 7.
- Define an acid.
- Any compound that forms H^+ ions in solution.
- Acidic solutions contain higher concentrations of H^+ ions than pure water and have pH values below 7.
- Define a base.
- A compound that produces hydroxide ions (OH^- ions) in solution.
- Basic, or alkaline, solutions contain lower concentrations of H^+ ions than pure water and have pH values above 7.
- What is a buffer?
- A compound that can react with strong acids or bases to prevent sharp, sudden changes in pH.
- Buffers help maintain homeostasis in the body.*

Section 2-2 Review

- Use the structure of a water molecule to explain why it is polar.
- Compare acidic and basic solution in terms of their H^+ ion and OH^- ion concentrations.
- What is the difference between a solution and a suspension?
- What does pH measure?
- The strong acid hydrogen fluoride can be dissolved in pure water. Will the pH of the solution be greater or less than 7.0.*

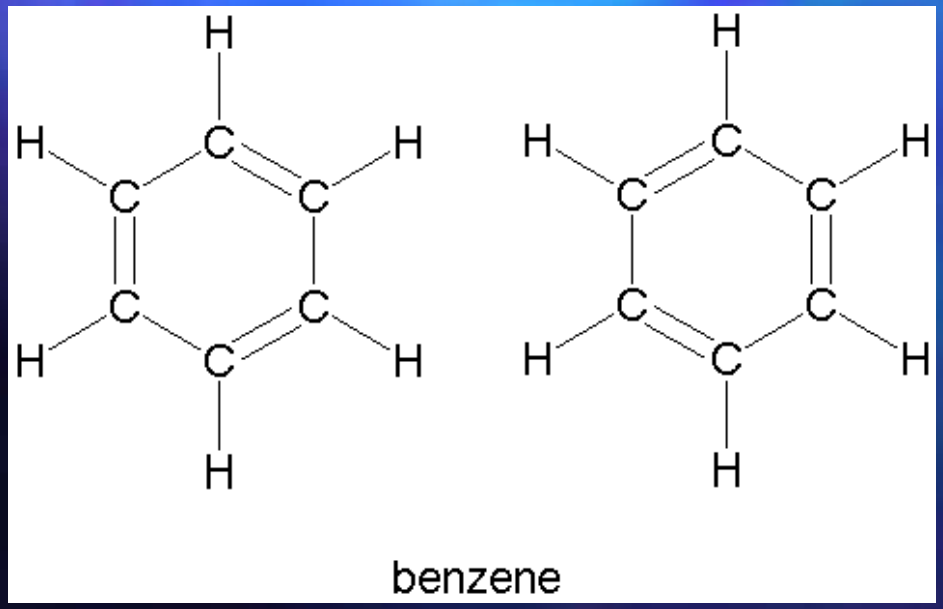
Chapter 2

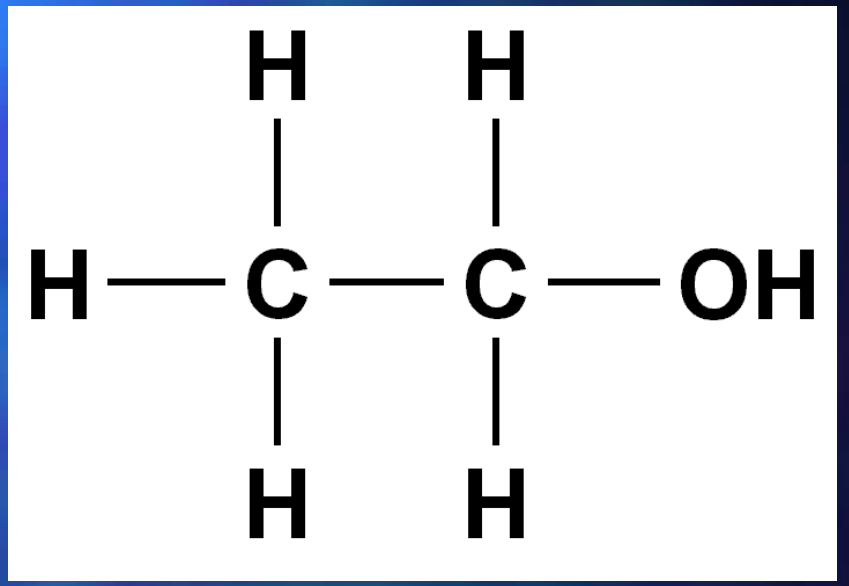
Section 3: Carbon Compounds

The Chemistry of Carbon

- How many electrons are in carbon's valence level?
- 4 electrons.
- How many electrons would the valence level need to be full?
- 8.
- What kinds of bonds do you think carbon make?
- Four covalent bonds.
- What is organic chemistry?
- The study of all compounds containing carbon.*

- Why a whole branch of chemistry for carbon?
- Carbon forms 4 strong covalent bonds and can bond to other carbon atoms to form chains.

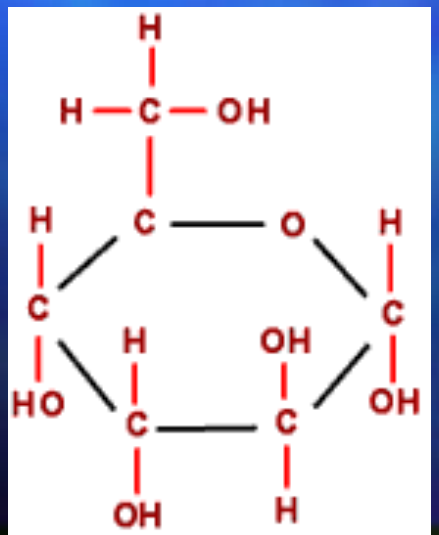




Macromolecules

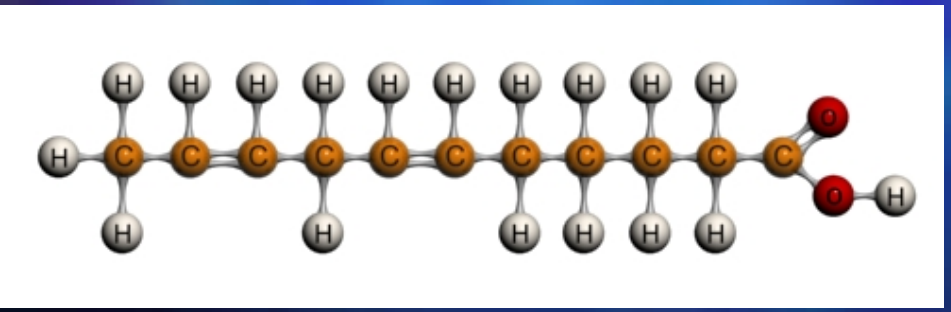
- What does the word macromolecule mean?
- Giant molecules.
- What is polymerization?
- Large compounds are built by joining smaller ones together.
- What are the small units called?
- Monomers.
- What are the larger molecules called?
- Polymers.*

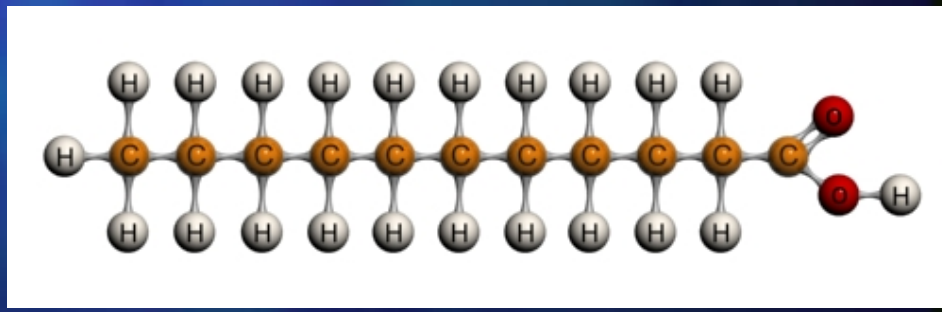
- What are the four groups of organic compounds found in living things?
- Carbohydrates, lipids, nucleic acids, and proteins.
- What are carbohydrates?
- Compounds made up of carbon, hydrogen, and oxygen, usually in the ratio of 1:2:1.
- Living things use carbohydrates as their main source of energy. Plants and some animals also use carbohydrates for structural purposes.



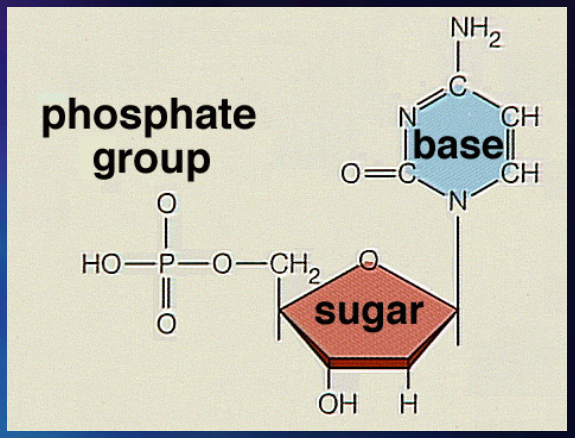
- What do you call single sugar molecules such as sucrose, glucose, and fructose?
- Monosaccharides.
- What do you call macromolecules formed from monosaccharides such as starch and cellulose?
- Polysaccharides.
- What are lipids?
- Large biological molecules generally not soluble in water.
- Examples are fats, oils, and waxes.
- Lipids can be used to store energy. Some lipids are important parts of biological membranes and waterproof coverings.*

- What does saturated fatty acid mean?
- The maximum number of hydrogen atoms are attached to the fatty acids.
- What are unsaturated fatty acids?
- The molecule has at least one carbon-carbon double bond, polyunsaturated if more than one double bond is present.
- Unsaturated fatty acids tend to be liquid at room temperature such as olive oil and the polyunsaturated fatty acids like corn, and peanut oil.*



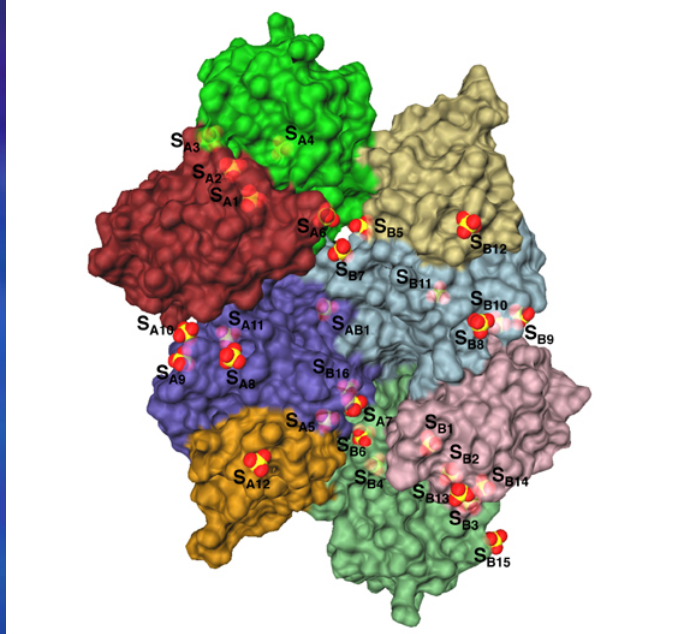


Nucleic acids



- What are nucleic acids?
- Macromolecules containing H, O, N, C, P.
- What monomers form the polymer nucleic acid?
- Nucleotides.
- What are the three parts of nucleotides?
  Sugar, phosphate group, and a nitrogenous base.
- What do nucleic acids do?
- Nucleic acids store and transmit hereditary, or genetic information.
- What are the two types of nucleic acids?
- DNA and RNA.*

Proteins



- What are proteins?
- Polymers of molecules called amino acids.
- Proteins help to carry out chemical reactions, transport small molecules in and out of cells, and fight diseases.
- Some proteins control the rate or reactions and regulate cell processes. Some are used to form bones and muscles. Others transport substances into or out of cells or help to fight disease.*

Section 2.3 Review

- Name four groups of organic compounds found in living things.
- Describe at lease one function of each group of organic compounds.
- What properties of carbon explain carbon's ability to form many different macromolecules?*

Chapter 2

Section 4: Chemical Reactions and Enzymes

Chemical Reactions

- What is a chemical reaction?
- A process that changes one set of chemicals into another set of chemicals.
- What do you call the elements or compounds which enter into a chemical reaction?
- Reactants.
- What do you call the elements or compounds produced by an chemical reaction?
- Products.

Chemical reactions always involve the breaking of bonds in reactants and the formation of new bonds in products.*

- Chemical reactions look like this.
- $CO_2 + H_2O \longrightarrow H_2CO_3$
- And the reverse reaction.
- $H_2CO_3 \longrightarrow CO_2 + H_2O$
- What happens to energy when bonds are broken or formed?
- Energy is either released or absorbed.
- Chemical reactions that release energy often occur spontaneously. Chemical reactions that absorb energy will not occur without a source of energy.
- $2H_2 + O_2 \longrightarrow 2H_2O$
- Define activation energy.
- The energy required to get a reaction started.*

Figure 2-19 Chemical Reactions

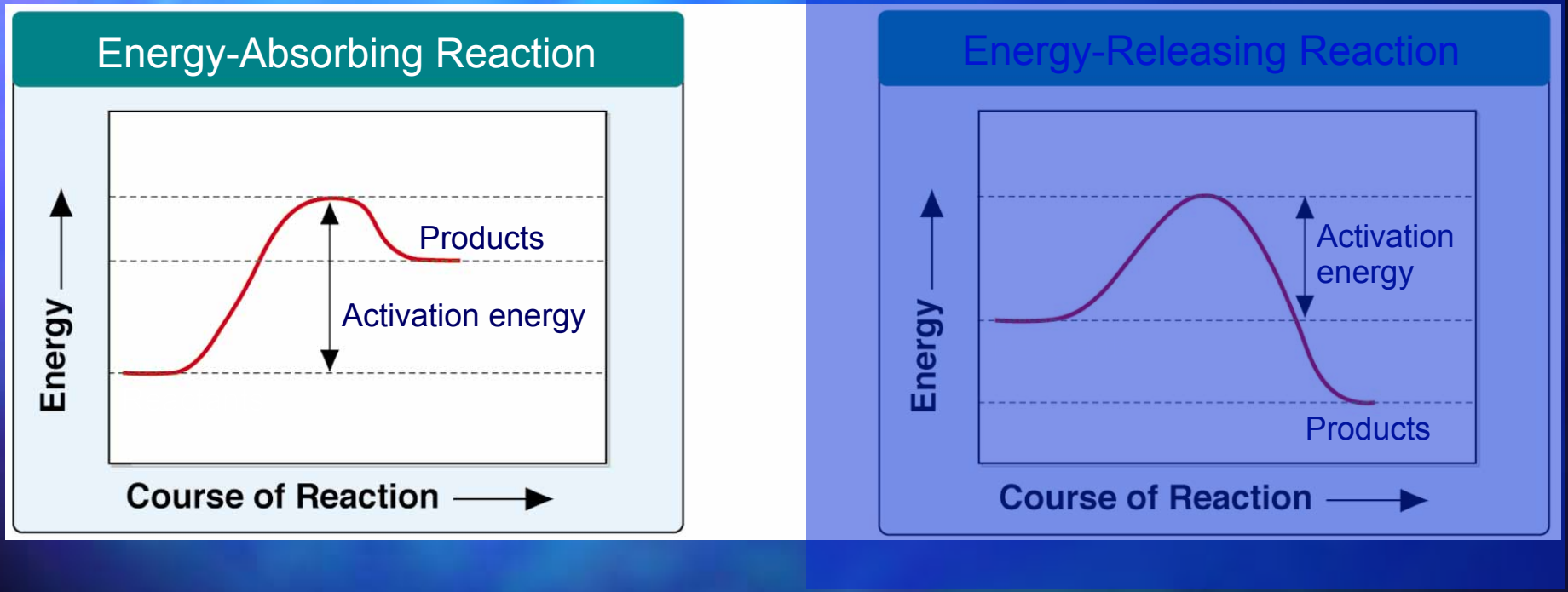
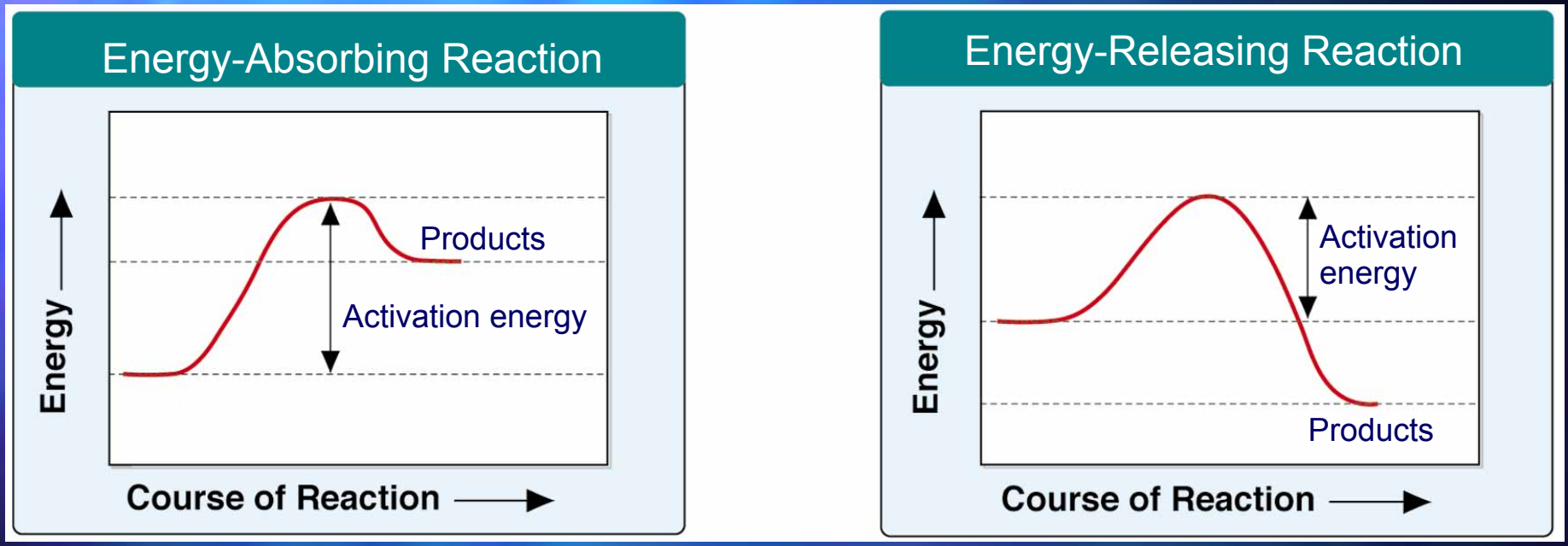


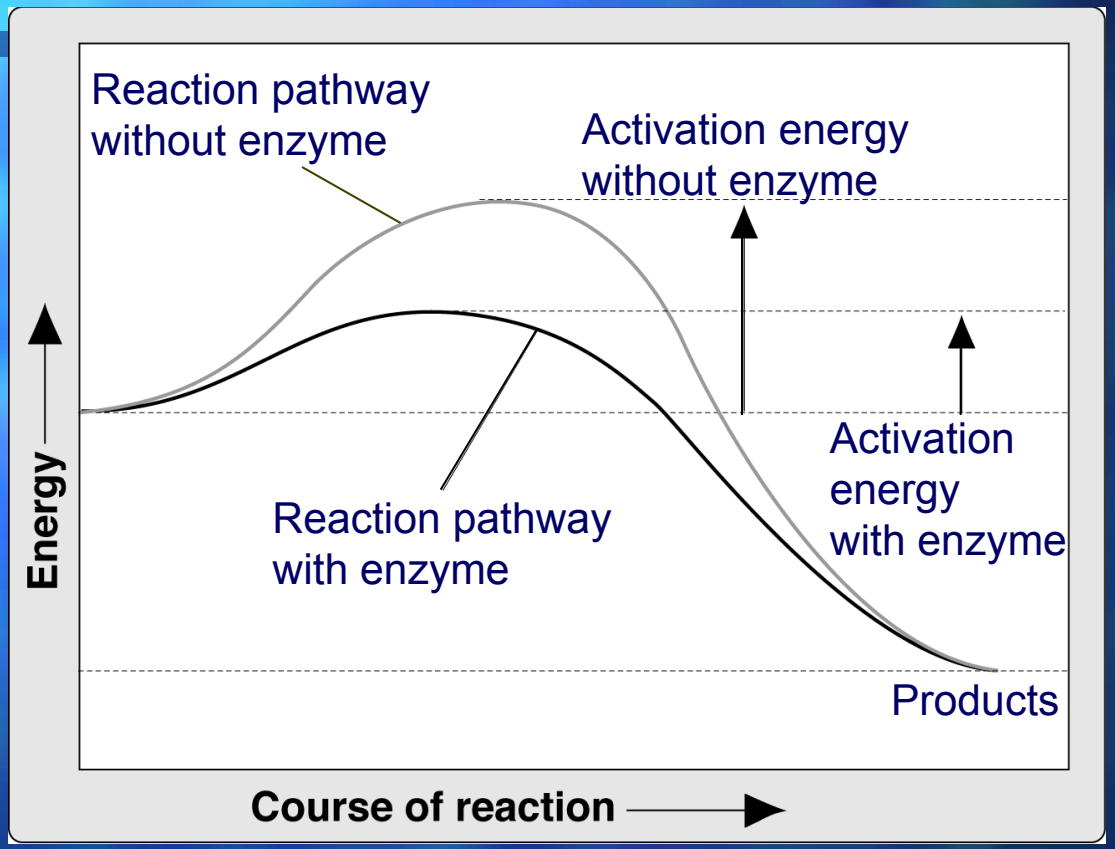
Figure 2-19 Chemical Reactions



Enzymes

- What either speeds up a reaction or lowers the activation energy of a reaction?
- Enzymes.
- Cells use enzymes to speed up chemical reactions that take place in cells.
- The reaction $CO_2 + H_2O \longrightarrow H_2CO_3$ sped up by a factor of 10 million times with the use of an enzyme called carbonic anhydrase.
- Specific enzymes usually catalyze only one specific reaction.

Effect of Enzymes



Enzyme Action

- What is a substrate?
- The reactants of an enzyme-catalyzed reaction.

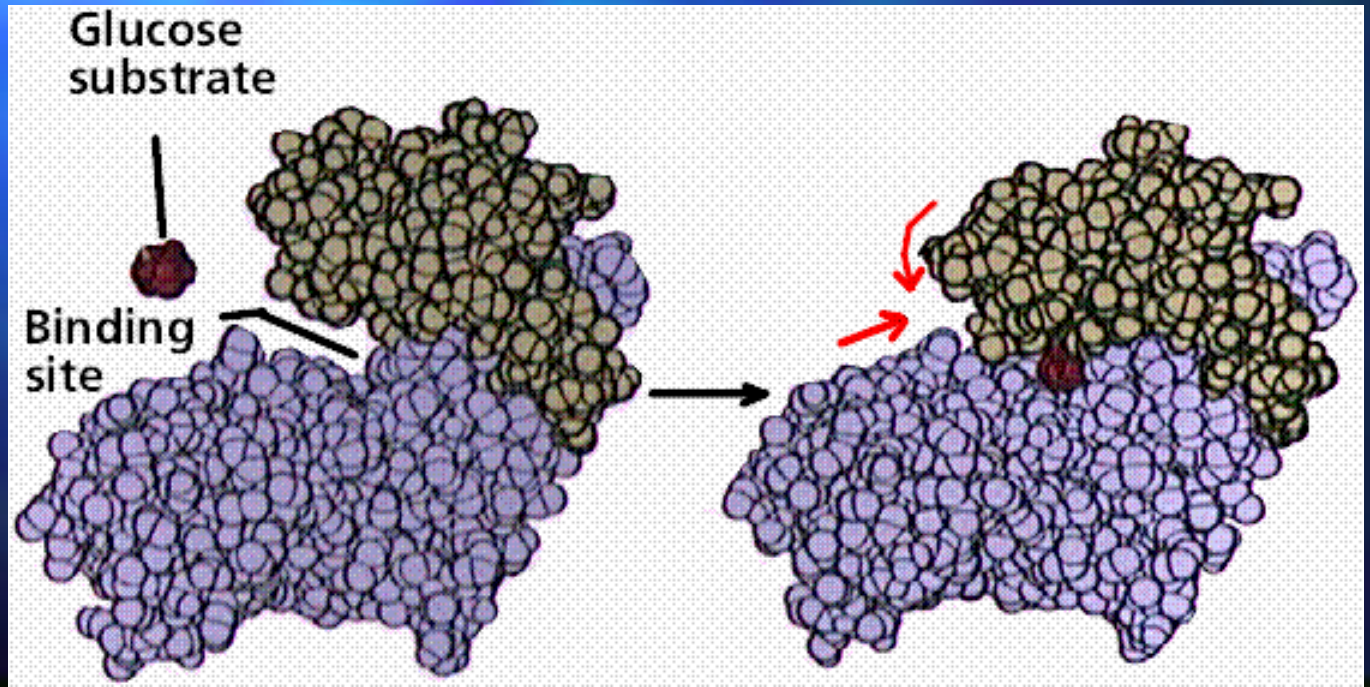


Figure 2-21 Enzyme Action

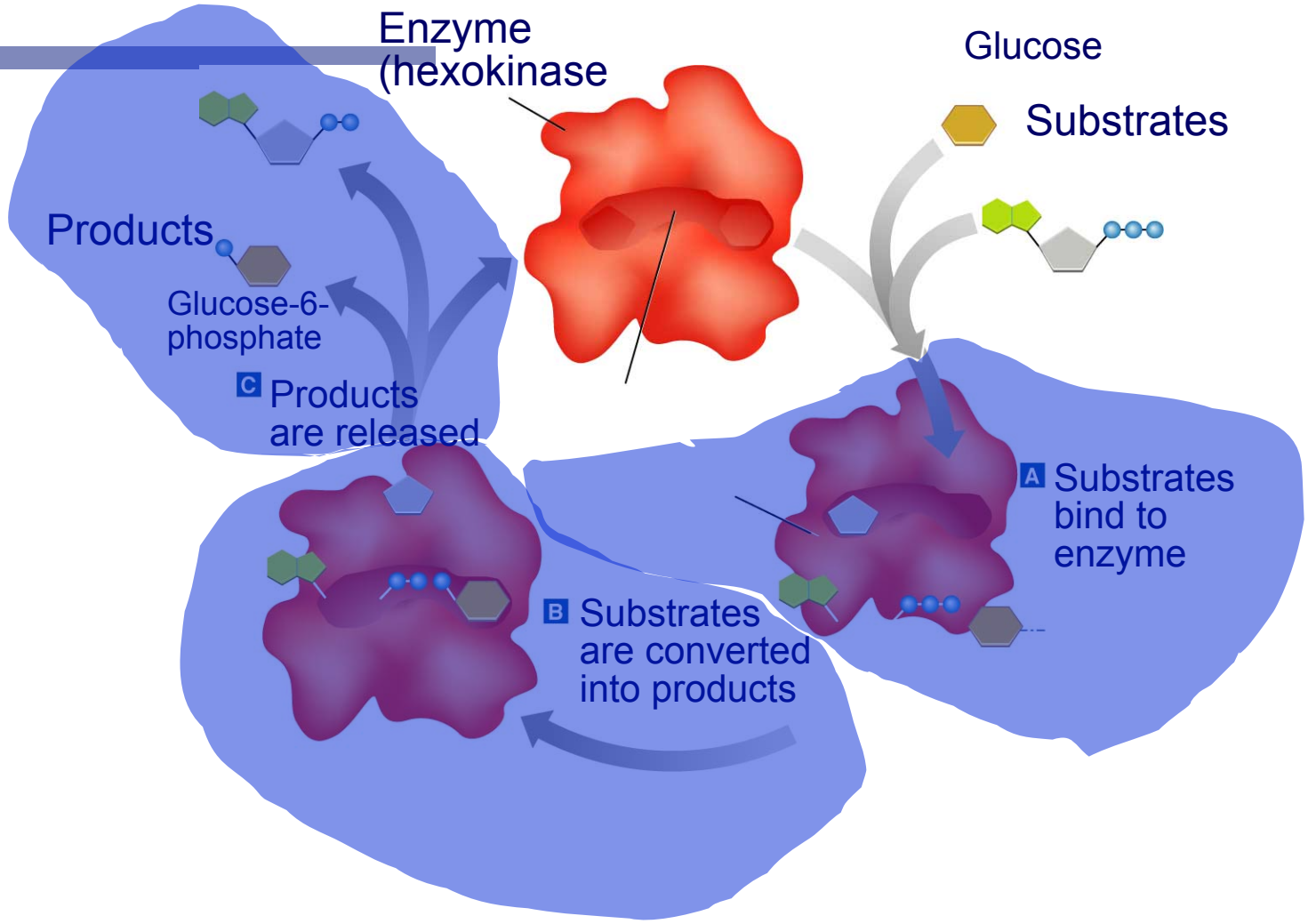


Figure 2-21 Enzyme Action

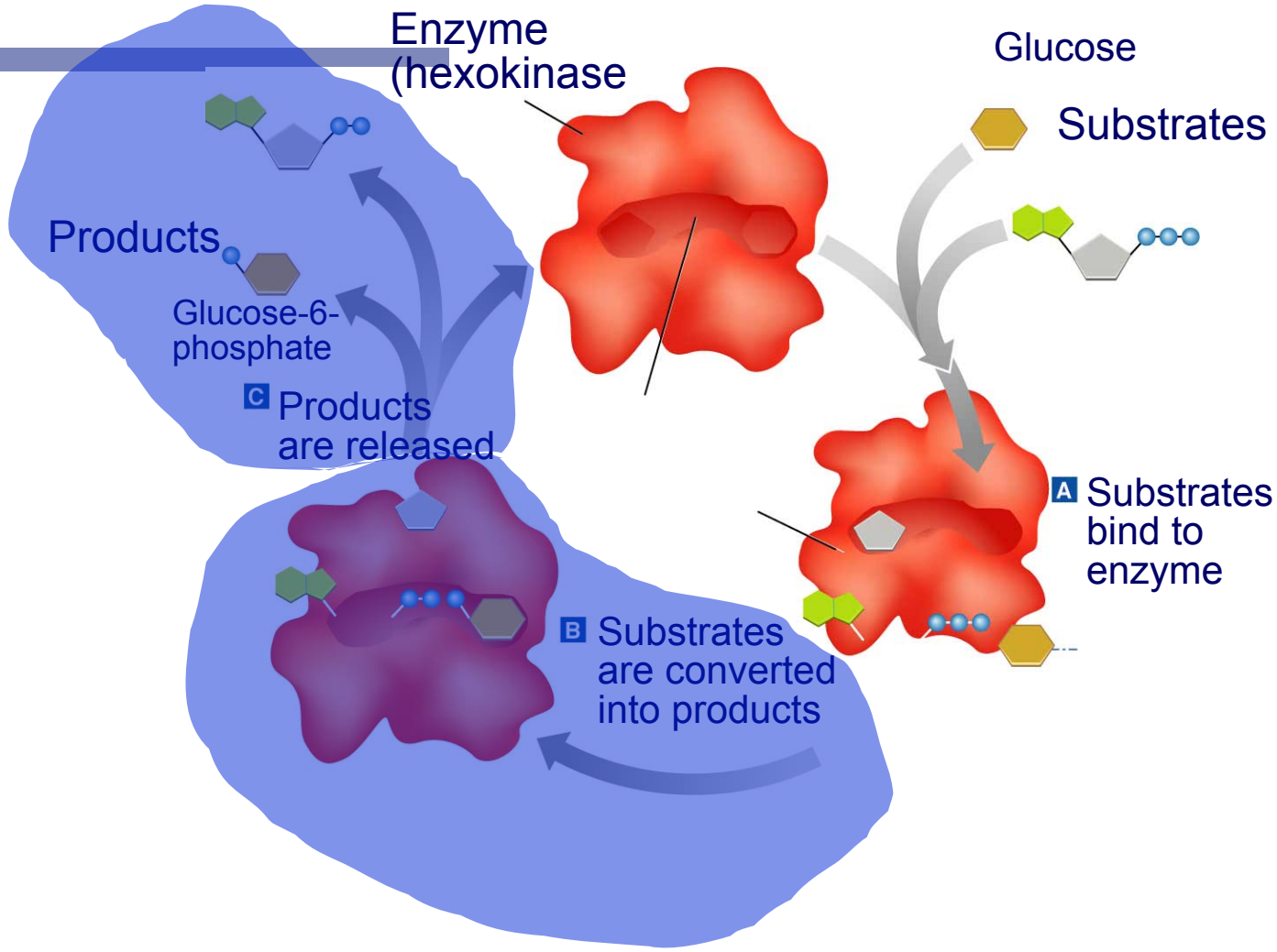


Figure 2-21 Enzyme Action

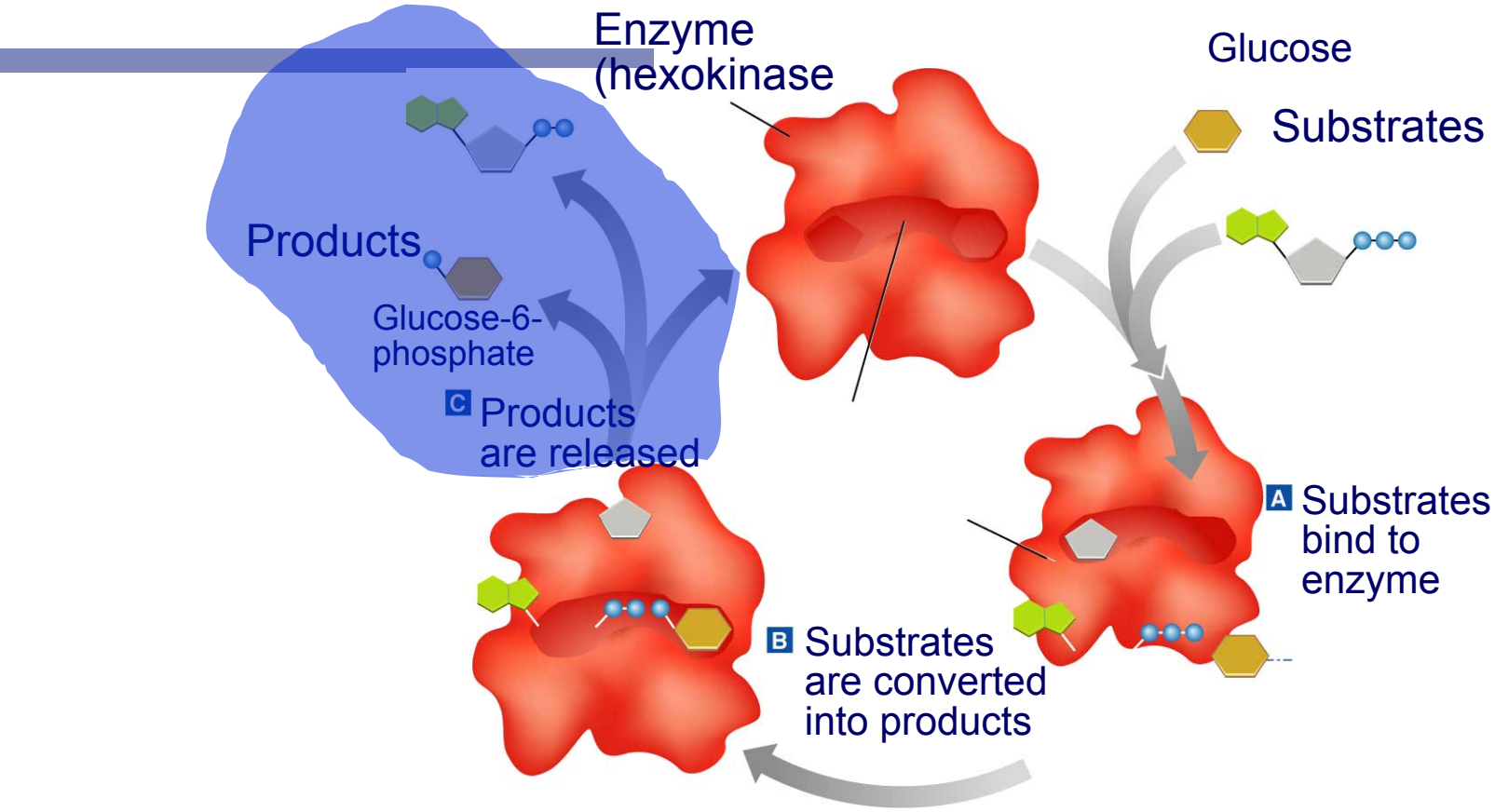
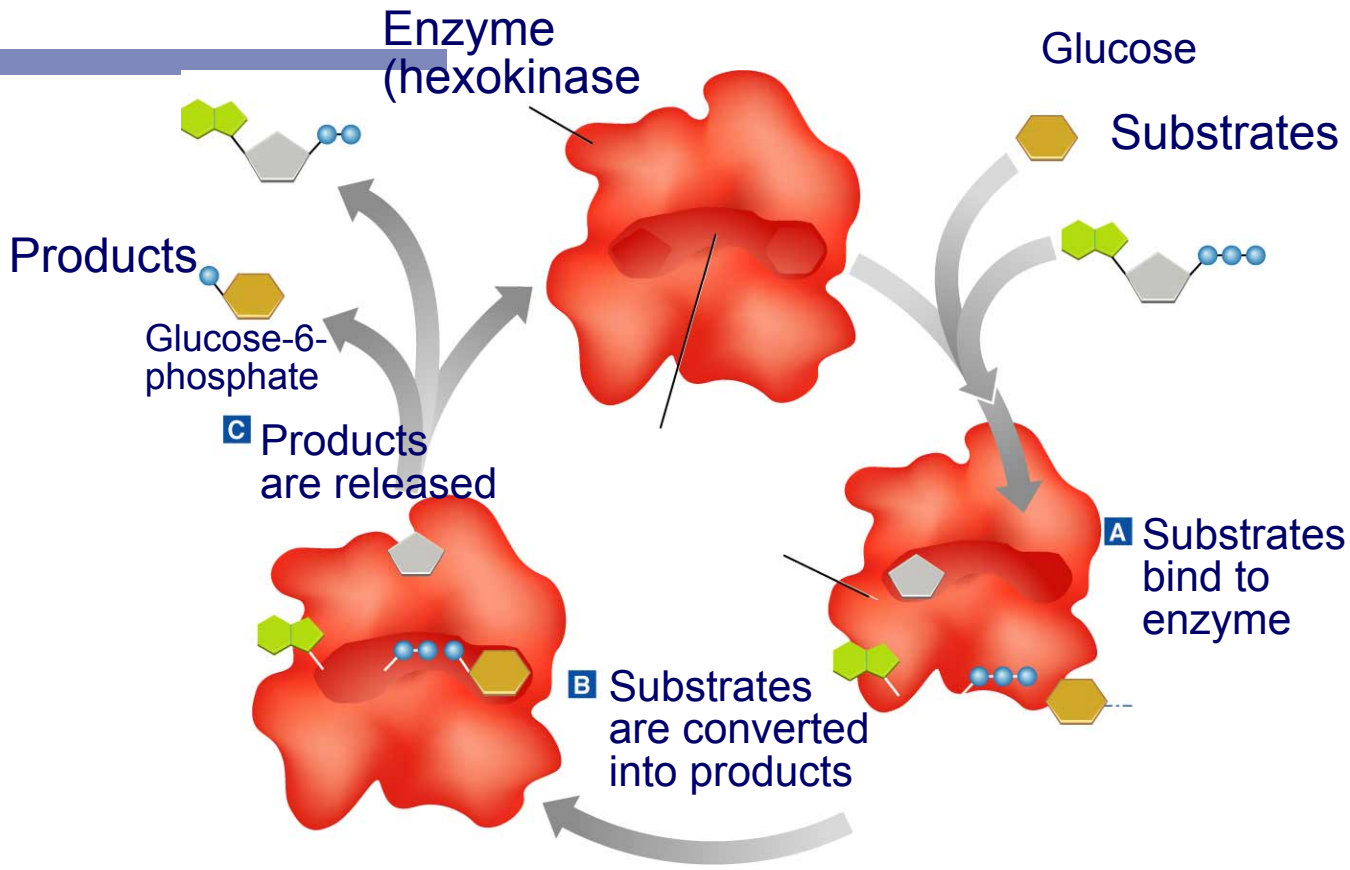


Figure 2-21 Enzyme Action



- What factors can effect the speed of an enzyme-catalyzed reactions?
- Temperature, pH, regulating proteins.
- Enzymes play a roll in regulating chemical pathways, making materials that cells need, releasing energy, and transferring information.*

Section 2-4 Review

- What happens to chemical bonds during chemical reactions?
- Describe the role of energy in chemical reactions.
- What are enzymes, and how are they important to living things?
- Describe how enzymes work, including the role of the enzyme-substrate complex.*