

1  **Chapter 2**

Chemical Principles

2  **The Structure of Atoms**

- Chemistry is the study of interactions between atoms and molecules
- The atom is the smallest unit of matter that enters into chemical reactions
- Atoms interact to form molecules

3  **The Structure of Atoms**

- Atoms are composed of
  - Electrons: Negatively charged particles
  - Protons: Positively charged particles
  - Neutrons: Uncharged particles

4  **The Structure of Atoms**

- Protons and neutrons are in the nucleus
- Electrons move around the nucleus

5  **Chemical Elements**

- Each chemical element has a different number of protons
- Electrons equal protons at ground state.
- Isotopes of an element are atoms with different numbers of neutrons. Isotopes of oxygen:

6 7  **Electronic Configurations**

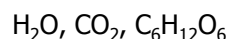
- Electrons are arranged in electron shells corresponding to different energy levels; think about how opposites attract.
- Atoms follow some basic tendencies in terms of electrons: (Octet Rule)
  - $e^-$  want to be paired
  - $e^-$  charge needs to balance  $p^+$  charge
  - need 8  $e^-$  in outer most shell

8  **Electronic Configurations**9  **Electronic Configurations**10  **How Atoms Form Molecules**

- Atoms combine to complete the outermost shell
- The number of missing or extra electrons in this shell is known as the valence
- Molecules hold together because the valence electrons of the combining atoms form attractive forces, called chemical bonds, between the atomic nuclei

11  **Chemical Bonds**

- A compound contains different kinds of atoms chemically bonded to one another.



- Do not confuse a compound with a mixture or a solution.
  - Mixture= two or more elements NOT chemically combined
  - Solution= elements dissolved in water or oil

12  **Ionic Bonds**

- The number of protons and electrons is equal in an atom
- Ions are charged atoms that have gained or lost electrons resulting in an overall positive or negative charge.

- 13  **Ionic Bonds**
- 14  **Ionic Bonds**
- Ionic bonds are attractions between ions of opposite charge. One atom loses electrons, and another gains electrons.
- 15  **Ionic Bonds**
- 16  **Covalent Bonds**
- Covalent bonds form when two atoms share one or more pairs of electrons
- 17  **Covalent Bonds**
- 18  **Hydrogen Bonds**
- Hydrogen bonds form when a hydrogen atom that is covalently bonded to an O or N atom is attracted to another N or O atom in another molecule
- 19  **Molecular Weight and Moles**
- The sum of the atomic weights in a molecule is the molecular weight
  - One mole of a substance is its molecular weight in grams
- 20  **Chemical Reactions**
- Chemical reactions involve the making or breaking of bonds between atoms
  - A change in chemical energy occurs during a chemical reaction
  - Endergonic reactions absorb energy
  - Exergonic reactions release energy
- 21  **Synthesis Reactions**
- Occur when atoms, ions, or molecules combine to form new, larger molecules
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  - 
  - 
  - 
  - Anabolism is the synthesis of molecules in a cell
- 22  **Decomposition Reactions**
- Occur when a molecule is split into smaller molecules, ions, or atoms
  - 
  - 
  - 
  - 
  - 
  - Catabolism is the decomposition reactions in a cell
- 23  **Exchange Reactions**
- Are part synthesis and part decomposition
- 24  **Reversible Reactions**
- Can readily go in either direction
  - Each direction may need special conditions
- 25  **Important Biological Molecules**
- Organic compounds always contain carbon and hydrogen
  - Inorganic compounds typically lack carbon
- 26  **Water**
- Inorganic

- Polar molecule
- Solvent
  - Polar substances dissociate, forming solutes

27  **Water**28  **Water**

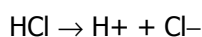
- H<sup>+</sup> and OH<sup>-</sup> participate in chemical reactions
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29  **Water**30  **Water**

- H bonds absorb heat
  - Makes water a temperature buffer

31  **Acids, Bases, and Salts**32  **Acids**

- Substances that dissociate into one or more H<sup>+</sup>

33  **Bases**

- Substances that dissociate into one or more OH<sup>-</sup>

34  **Salts**

- Substances that dissociate into cations and anions, neither of which is H<sup>+</sup> or OH<sup>-</sup>

35  **Acid-Base Balance**

- The amount of H<sup>+</sup> in a solution is expressed as pH
- $\text{pH} = -\log[\text{H}^+]$
- Increasing [H<sup>+</sup>], increases acidity
- Increasing [OH<sup>-</sup>] increases alkalinity
- Most organisms grow best between pH 6.5 and 8.5

36 37  **Structure and Chemistry**

- The chain of carbon atoms in an organic molecule is the carbon skeleton

38  **Structure and Chemistry**

- Functional groups are responsible for most of the chemical properties of a particular organic compound.

39  **Functional Groups**40  **Functional Groups**

- 41  **Functional Groups**
- Identify the functional groups in an amino acid:
  -
- 42  **Organic Compounds**
- Small organic molecules can combine into large macromolecules
  - Macromolecules are polymers consisting of many small repeating molecules
  - The smaller molecules are called monomers
- 43  **Polymers**
- Monomers join by dehydration synthesis or condensation reactions
- 44  **Carbohydrates**
- Cell structures and energy sources
  - Consist of C, H, and O with the formula  $(CH_2O)_n$
  - Monosaccharides are simple sugars with 3 to 7 carbon atoms
  - Ie. Glucose and fructose
- 45  **Carbohydrates**
- Disaccharides are formed when 2 monosaccharides are joined in a dehydration synthesis
  - Disaccharides can be broken down by hydrolysis
  - Ie. Sucrose, maltose, lactose
- 46  **Dehydration Synthesis and Hydrolysis**
- 47  **Carbohydrates**
- Oligosaccharides consist of 2 to 20 monosaccharides
  - Polysaccharides consist of tens or hundreds of monosaccharides joined through dehydration synthesis
    - Starch, glycogen, dextran, and cellulose are polymers of glucose that are covalently bonded differently
    - Chitin is a polymer of 2 sugars repeating many times
- 48  **Lipids**
- Primary components of cell membranes
  - Consist of C, H, and O
  - Are nonpolar and insoluble in water
- 49  **Simple Lipids**
- Fats or triglycerides
  - Contain glycerol and fatty acids; formed by dehydration synthesis
- 50  **Structural Formulas of Simple Lipids**
- 51  **Simple Lipids**
- Saturated fat: No double bonds
    - Animal fat
    - Solid @rm temp
  - Unsaturated fat: One or more double bonds in the fatty acids
  - Plant fat/ oil
  - Liquid @ rm temp.
    - *cis*: H atoms on the same side of the double bond
    - *trans*: H atoms on opposite sides of the double bond
- 52  **Simple Lipids**
- 53  **Complex Lipids**

- Contain C, H, and O + P, N, or S
- Membranes are made of phospholipids

54  **Steroids**

- 4 carbon rings with an –OH group attached to one ring
- Part of membranes

55  **Proteins**

- Are essential in cell structure and function
- Enzymes are proteins that speed chemical reactions
- Transporter proteins move chemicals across membranes
- Flagella are made of proteins
- Some bacterial toxins are proteins

56  **Amino Acids**

- Proteins consist of subunits called amino acids

57  **Amino Acids**

- Exist in either of two stereoisomers:  
D or L.
- L-forms are most often found in nature.

58  **Amino Acids**59  **Peptide Bonds**

- Peptide bonds between amino acids are formed by dehydration synthesis

60  **Levels of Protein Structure**

- The primary structure is a polypeptide chain

61  **Levels of Protein Structure**

- The secondary structure occurs when the amino acid chain folds and coils in a regular helix or pleats

62  **Levels of Protein Structure**

- The tertiary structure occurs when the helix folds irregularly, forming disulfide bonds, hydrogen bonds, and ionic bonds between amino acids in the chain

63  **Levels of Protein Structure**64  **Levels of Protein Structure**

- The quaternary structure consists of 2 or more polypeptides.

65  **Protein Structure**66  **Levels of Protein Structure**

- Conjugated proteins consist of amino acids and other organic molecules
  - Glycoproteins
  - Nucleoproteins
  - Lipoproteins

67  **Nucleic Acids**

- Consist of nucleotides
- Nucleotides consist of a
  - Pentose
  - Phosphate group
  - Nitrogen-containing (purine or pyrimidine) base
- Nucleosides consist of a
  - Pentose

- Nitrogen-containing base

68  **Nucleic Acids**

69  **DNA**

- Deoxyribonucleic acid
- Has deoxyribose
- Exists as a double helix
- A hydrogen bonds with T
- C hydrogen bonds with G

70  **DNA**

71  **RNA**

- Ribonucleic acid
- Has ribose
- Is single-stranded
- A hydrogen bonds with U
- C hydrogen bonds with G

72  **RNA**

73  **ATP**

- Adenosine triphosphate
- Has ribose, adenine, and 3 phosphate groups.

74  **The Structure of ATP**

75  **ATP**

- Is made by dehydration synthesis
- Is broken by hydrolysis to liberate useful energy for the cell