Name _____ Class _____ Date _____

2.1 The Nature of Matter

Lesson Objectives

- Identify the three subatomic particles found in atoms.
- Explain how all of the isotopes of an element are similar and how they are different.
- Explain how compounds are different from their component elements.
- Describe the two main types of chemical bonds.

Lesson Summary

Atoms The **atom** is the basic unit of matter, made up of three subatomic particles.

- Protons have a positive charge and neutrons carry no charge. Strong forces bind protons and neutrons together in the **nucleus.**
- An **electron** is a negatively charged particle that has only about 1/1840 the mass of a proton. Electrons constantly move around the space surrounding the atom's nucleus.
- Because an atom has the same number of protons and electrons, if it is electrically neutral.

Elements and Isotopes A chemical **element** is a pure substance that consists entirely of one type of atom.

- Atoms of the same element that differ in the number of neutrons are called **isotopes.** Isotopes are identified by their mass number, the total number of protons and neutrons in the nucleus. Because they have the same number of electrons in each atom, all isotopes of an element have the same chemical properties.
- Radioactive isotopes have unstable nuclei and break down at a constant rate.

Chemical Compounds A chemical **compound** is a substance formed by the chemical combination of two or more elements in definite proportions. The physical and chemical properties of a compound are usually very different from those of the elements from which it is formed. Scientists use formulas to show the ratio of elements that make up a compound.

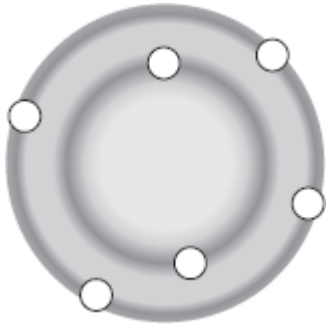
Chemical Bonds The atoms in compounds are held together by chemical bonds. Electrons that are available to form bonds are called valence electrons.

- An **ionic bond** forms when one or more electrons are transferred from one atom to another, forming **ions.** An atom that loses electrons becomes positively charged. An atom that gains electrons becomes negatively charged.
- A **covalent bond** forms when electrons are shared rather than transferred. The structure formed by atoms joined by covalent bonds is called a **molecule.** The molecule is the smallest unit of most compounds.
- When molecules are close together, a slight attraction can form between the oppositely charged portions of nearby molecules. These intermolecular forces of attraction are called **van der Waals forces.**

Name _____ Class _____ Date _____

Atoms

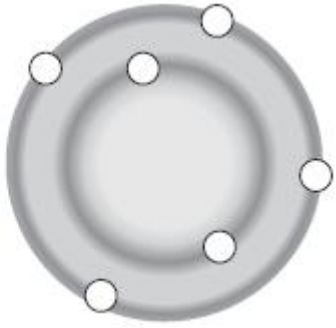
1. **THINK VISUALLY** The diagram shows a model of a carbon atom, with an atomic number of 6. Complete the diagram by drawing in the rest of the atomic particles, including their charges. Label all particles and the nucleus.



Elements and Isotopes

2. **THINK VISUALLY** The diagrams show models of carbon isotopes. Complete the diagrams by drawing in the rest of the atomic particles, including their charges.

Nonradioactive carbon-13



Radioactive carbon-14

Use your completed diagrams to answer Questions 3–4.

3. Identify two differences between carbon-12 and carbon-14.

_____

_____

4. Identify two ways in which carbon-12, carbon-13, and carbon-14 are alike.

_____

_____

For Questions 5–7, complete each statement by writing the correct word or words.

5. A chemical element is a pure substance that consists entirely of one type of _____.

6. Atoms of the same element that differ in the number of neutrons they contain are called _____.

7. An atom is made up of protons, neutrons, and _____.

Name _____ Class _____ Date _____

Chemical Compounds

8. What is a chemical compound?

_____

_____

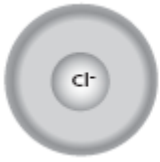
9. What do the formulas for table salt, NaCl, and water, H_2O, indicate about these compounds?

_____

_____

Chemical Bonds

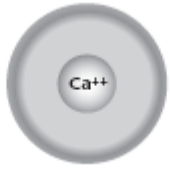
10. Sea salt contains calcium chloride ($CaCl_2$), an ionic compound similar to table salt. One atom of calcium (atomic number 20) bonds to two atoms of chlorine (atomic number 17). Fill in the number of protons and electrons in each ion.



Chloride ion

Protons _____

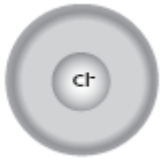
Electrons _____



Calcium ion

Protons _____

Electrons _____



Chloride ion

Protons _____

Electrons _____

11. What is the difference between an ionic bond and a covalent bond?

_____

_____

Apply the Big idea

12. How are chemical bonds important in metabolism?

_____

_____

_____

Name _____ Class _____ Date _____

2.2 Properties of Water

Lesson Objectives

- Discuss the unique properties of water.
- Differentiate between solutions and suspensions
- Explain what acidic solutions and basic solutions are.

Lesson Summary

The Water Molecule Water molecules (H_2O) are polar because of an uneven distribution of electrons, creating a slight negative (–) charge in the oxygen atom and a slight positive (+) charge in each hydrogen atom. The attraction between a hydrogen atom of one water molecule and the oxygen atom of another water molecule is called a **hydrogen bond**.

- **Cohesion** is an attraction between molecules of the same substance. It causes water molecules to be drawn together, producing surface tension
- **Adhesion** is an attraction between molecules of different substances. It causes capillary action, an effect that causes water to rise in a narrow tube against the force of gravity.

Solutions and Suspensions A **mixture** is a material composed of two or more elements or compounds that are physically mixed together but not chemically combined. A **solution** is a mixture in which all the components are evenly spread out: the substance dissolved is the **solute**; the substance that causes the dissolving is the **solvent**. Mixtures of water and undissolved materials are **suspensions**.

Acids, Bases, and pH A water molecule (H_2O) can split apart to form a hydrogen ion (H^+) and a hydroxide ion (OH^-).

- The **pH scale** measures the concentration of hydrogen ions in a solution. The scale ranges from 0 to 14. Pure water has a pH of 7.
- An **acid** is any compound that forms H^+ ions in solution. Acidic solutions have pH values below 7. A **base** is a compound that forms OH^- ions in solution. Basic, or alkaline, solutions have pH values above 7.
- **Buffers** are weak acids or bases that can react with strong acids or bases to prevent sudden changes in pH.

The Water Molecule

For Questions 1–4, write True or False on the line provided.

_____ **1.** Water is a polar molecule.

_____ **2.** Hydrogen bonds are an example of adhesion.

_____ **3.** Covalent bonds give water a low heat capacity.

_____ **4.** A hydrogen bond is stronger than a covalent bond.

Name _____ Class _____ Date _____

Solutions and Suspensions

5. Complete the table

Substance	Definition	Example(s)
	Physical combination of two or more substances	Cinnamon sugar
Solute		Salt in saltwater
	Mixture of water and nondissolved substance	Blood
Solution		

Acids, Bases, and pH

6. What makes pure water neutral?

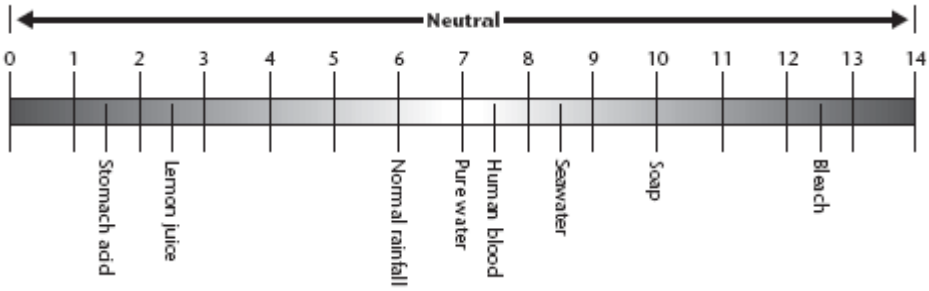
_____

_____

7. What does the pH scale measure?

_____

8. On the pH scale, indicate which direction is increasingly acidic and which is increasingly basic.



9. Identify two solutions that have more H^+ ions than OH^- ions.

_____

10. Identify two solutions that have more OH^- ions than H^+ ions.

_____

11. How would you buffer a solution that has a pH of 12?

_____

Apply the Big idea

12. Why are buffers important to living things?

_____

_____

Name _____ Class _____ Date _____

2.3 Carbon Compounds

Lesson Objectives

- Describe the unique qualities of carbon.
- Describe the structures and functions of each of the four groups of macromolecules.

Lesson Summary

The Chemistry of Carbon Organic chemistry is the study of compounds with bonds between carbon atoms. Carbon atoms have four valence electrons, allowing them to form strong covalent bonds with many other elements, including hydrogen, oxygen, phosphorus, sulfur, and nitrogen. Living organisms are made up of molecules made of carbon and these other elements.

- One carbon atom can bond to another to form chains and rings.
- Carbon can form millions of different large and complex structures.

Macromolecules Many of the carbon molecules in living things are so large they are called macromolecules. Macromolecules form by polymerization, in which smaller units called **monomers** join together to form **polymers.** Biochemists sort the macromolecules in living things into groups based on their chemical composition.

- **Carbohydrates** (starches and sugars) are composed of carbon, hydrogen, and oxygen. Carbohydrates are the main energy source for living things. Plants and some animals also use carbohydrates for structural purposes. Molecules with one sugar monomer are **monosaccharides.** A disaccharide is made of two monosaccharides.
- **Lipids** (fats, oils, and waxes) are made mostly of carbon and hydrogen atoms. Lipids can be used to store energy and form parts of biological membranes and waterproof coverings. Steroids manufactured by the body are lipids as well.
- **Nucleic acids** contain hydrogen, oxygen, nitrogen, carbon, and phosphorus. They are polymers of **nucleotides.** A nucleotide has three parts: a 5-carbon sugar, a phosphate ($-PO_4$) group, and a nitrogenous base. Nucleic acids store and transmit hereditary (genetic) information. There are two kinds of nucleic acids: DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).
- **Proteins** are made up of nitrogen, carbon, hydrogen, and oxygen. Proteins are polymers of **amino acids.** An amino acid molecule has an amino group ($-NH_2$) on one end and a carboxyl group (–COOH) on the other end. Proteins control the rate of reactions, regulate cell processes, form cellular structures, carry substances into or out of cells, and help fight disease.
  - More than 20 different amino acids are found in nature. Any amino acid can bond with any other.
  - Covalent bonds called peptide bonds link amino acids together to form a polypeptide.
  - Amino acids are assembled into polypeptide chains according to instructions coded in DNA.

Name _____ Class _____ Date _____

The Chemistry of Carbon

1. How many valence electrons does each carbon atom have?

_____

2. What gives carbon the ability to form chains that are almost unlimited in length?

_____

Macromolecules

For Questions 3–5, complete each statement by writing the correct word or words.

3. Many of the molecules in living cells are so large they are called _____.

4. _____ is the process that forms large organic molecules.

5. When two or more _____ join together, a polymer forms.

6. Create a table in which you compare the components and functions of the following macromolecules: carbohydrates, lipids, nucleic acids, and proteins.

Apply the Big idea

7. How did organic compounds get their name? How is the word related to its meaning?

_____

_____

_____

Name _____ Class _____ Date _____

2.4 Chemical Reactions and Enzymes

Lesson Objectives

- Explain how chemical reactions affect chemical bonds.
- Describe how energy changes affect how easily a chemical reaction will occur.
- Explain why enzymes are important to living things.

Lesson Summary

Chemical Reactions Everything that happens in an organism is based on chemical reactions. A **chemical reaction** is a process that changes one set of chemicals into another set of chemicals.

- The elements or compounds that enter into the reaction are the **reactants**.
- The elements or compounds produced by the reaction are the **products**.
- Chemical reactions involve changes in the chemical bonds that join atoms in compounds.

Energy in Reactions Some chemical reactions release energy; others absorb energy.

- Chemical reactions that release energy often occur on their own.
- Chemical reactions that absorb energy require a source of energy. The energy needed to get a reaction started is called the **activation energy**.

Enzymes An **enzyme** is a protein that acts as biological catalyst. A **catalyst** is a substance that speeds up the rate of a chemical reaction. Catalysts work by lowering a reaction's activation energy.

- In an enzyme-catalyzed reaction, the reactants are known as **substrates**. Substrates bind to a part of an enzyme called the active site and remain bound to the enzyme until the reaction is complete, when the products are released.
- Temperature, pH, and regulatory molecules can affect the activity of enzymes.

Chemical Reactions

1. What is a chemical reaction?

_____

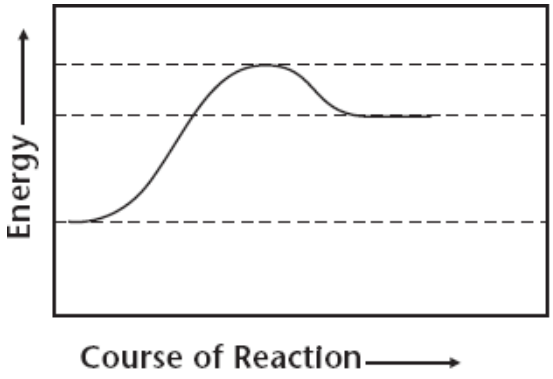
2. Complete the table about chemicals in a chemical reaction.

Chemicals in a Chemical Reaction	
Chemicals	**Definition**
Reactants	
Products	

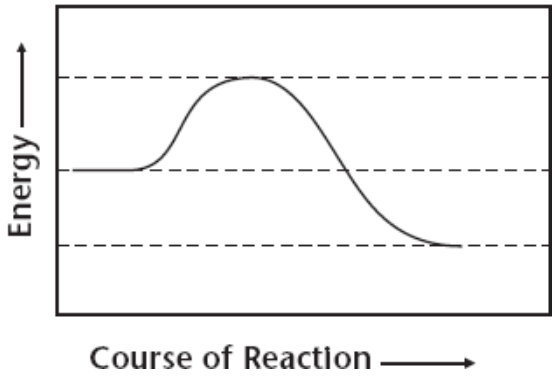
Name _____ Class _____ Date _____

Energy in Reactions

3. **THINK VISUALLY** The graphs below show the amount of energy present during two chemical reactions. One of the reactions is an energy-absorbing reaction, the other is an energy-releasing reaction. Label the type of reaction for each, label the energy level for the reactants and products, then draw an arrow on each to show the energy of activation.



Type of reaction: _____



Type of reaction: _____

4. What is released or absorbed whenever chemical bonds form or are broken?

_____

5. What is the energy of activation?

_____

6. Of the two reactions shown, which one is more likely to start spontaneously and why?

_____

_____

Enzymes

7. How does the addition of a catalyst affect the energy of activation of a chemical reaction?

_____

_____

8. What type of catalysts affect biochemical reactions?

_____

9. What makes proteins the ideal types of compounds to act as enzymes?

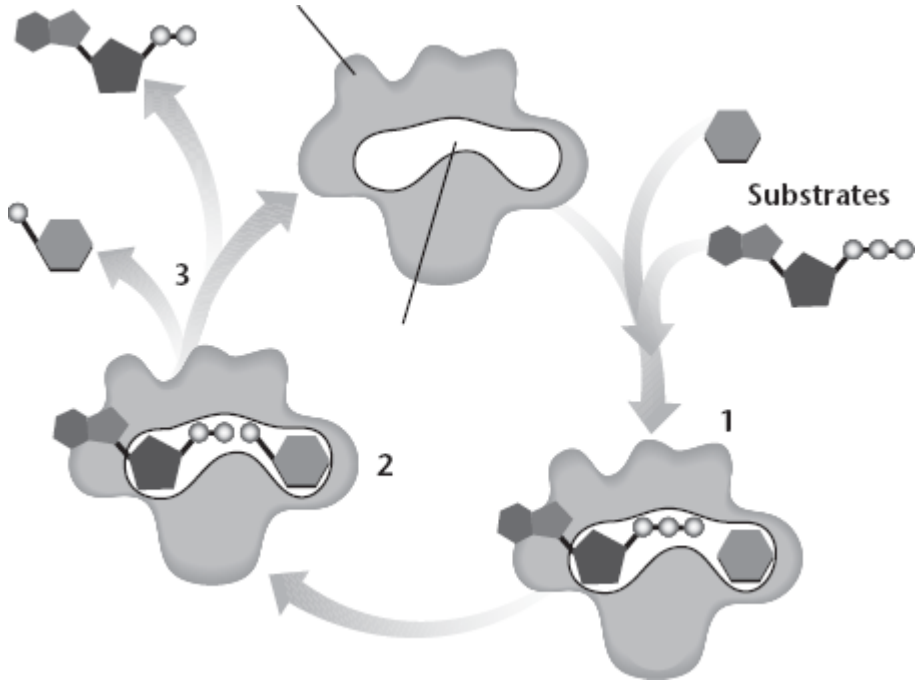
_____

_____

_____

Name _____ Class _____ Date _____

Use the diagram to answer Questions 10–11.



10. **THINK VISUALLY** Label the enzyme, the active site, and the products in the diagram.

11. Write what is happening at each numbered part of the diagram.

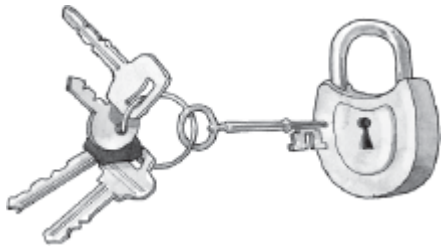
(1) _____

(2) _____

(3) _____

For Questions 12–13, refer to the Visual Analogy comparing the action of enzymes to a lock and key.

12. **VISUAL ANALOGY** How is a substrate and its enzyme like a lock and its key?



_____

_____

_____

_____

13. What is being unlocked in this analogy?

_____

Apply the Big idea

14. In terms of an organism and how it interacts with its environment, what is the benefit of having controls on the chemical reactions that take place in its body?

_____

_____

_____

Name _____ Class _____ Date _____

Chapter Vocabulary Review

Crossword Puzzle *Use the clues below to fill in the spaces in the puzzle with the correct words.*

Across

1. element or compound that enters into a chemical reaction

4. process that changes one set of chemicals into another

7. positively charged subatomic particle

8. substance formed by the chemical combination of elements

11. positively or negatively charged atom

12. carbon compound that stores and transmits genetic information

14. the center of an atom

16. bond formed when electrons are shared between atoms

17. macromolecule formed when monomers join together

Down

2. negatively charged subatomic particle

3. compound that forms hydroxide ions in solution

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

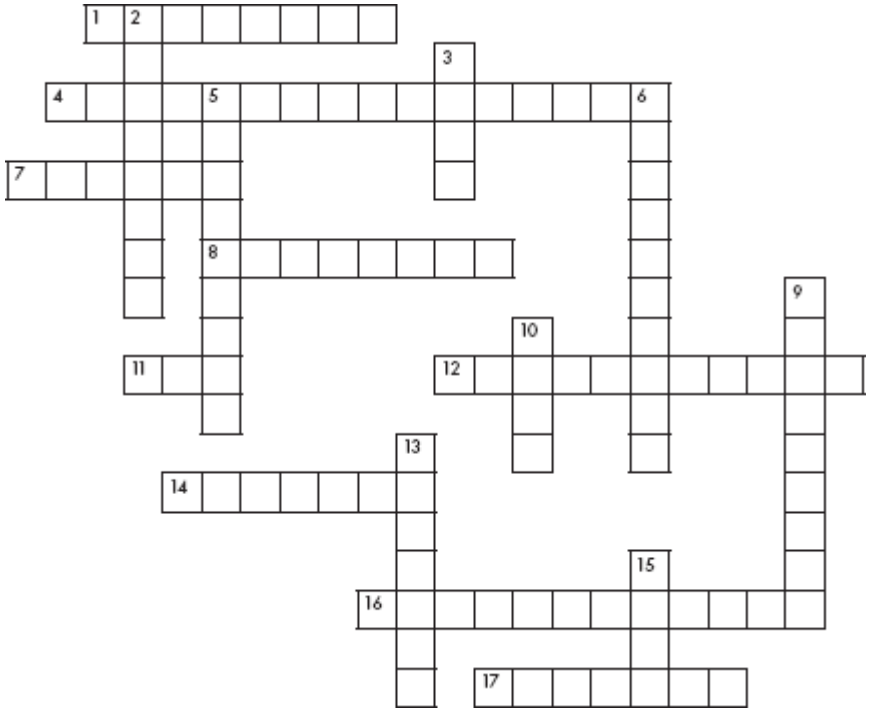
6. monomer of nucleic acid

9. monomer of protein

10. compound that forms hydrogen ions in solution

13. atom of an element that differs in the number of neutrons compared with other atoms of the same element

15. basic unit of matter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