Student Study Guide to Accompany

INTRODUCTION TO CHEMISTRY

MARTHA J. GILLELAND

Prepared by Rebecca Williams

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PREFACE

This study guide accompanies the text, INTRODUCTION TO CHEMISTRY, by Martha Gilleland. For each chapter in the text, the study guide contains the following sections

SUMMARY OUTLINE
SOLUTIONS TO SELECTED TEXT QUESTIONS AND PROBLEMS and PRACTICE PROBLEMS
SELF-TEST
ANSWERS TO PRACTICE PROBLEMS
ANSWERS TO SELF-TEST

The SUMMARY OUTLINE lists the headings for each section of the text followed by statements of key concepts. Fundamental relationships, rules, and guidelines are summarized using formulas, "maps", tables, and listings.

The second section, SOLUTIONS TO SELECTED TEXT QUESTIONS AND PROBLEMS ..., utilizes a format established in the text; an example problem with a detailed solution is followed by a practice problem. For the study guide example problems, I provided detailed solutions to a number of end-of-chapter text problems. (In most cases, these problems have answers in Appendix C in the text.) The solutions provide additional explanation, strategies for solving the problem, and a thorough treatment of the mathematics involved. Following these examples, similar problems are given for practice. Students can utilize the problem-solving strategies, assess understanding, and generalize concepts while solving the practice problems. Solutions to the practice problems are given at the end of each chapter in the study guide.

The Solutions/Practice Problem section of the study guide can be very helpful, if it is used correctly. I recommend that you read the text first, working examples and exercises as you read. Circle the number of the end-of-chapter exercises in the text that have detailed solutions in the study guide. As you work these problems, check your answers in Appendix C. Then, refer to the solution in the study guide. You can affirm the method that you used to solve the problem or get additional explanation in order to make corrections. Once you understand the method, work the practice problem and check your answer. Notice the similarities and differences in the example problem and the practice problem.

Calculator setups are introduced in the text's Math Tips and reinforced throughout the solutions shown in the study guide. I've shown many answers as they appear on the calculator, rounding them to the correct number of significant figures for the final answer. This was done to call attention to the need for analysis of the calculator answer.

The SELF-TEST section contains ten multiple-choice questions. These questions are typical questions and problems covering the text material. The Self-Test provides further opportunities for self-assessment and is suitable as a closure activity for the chapter. The final two sections of the study guide give solutions to the practice problems and the answers to the self-test questions.

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Dallas, Texas
November, 1985

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CHEMISTRY: ORIGINS AND SCOPE

CHAPTER 1

SUMMARY OUTLINE

1.1 The Origins of Chemistry

Chemistry had its beginnings in the ancient art of alchemy.

Alchemists' two major goals were to prolong life and to convert common, inexpensive metals into gold for use in the elixir of life.

1.2 The Nature of Chemistry

Chemistry is the study of matter and its transformations.

1.3 Studying Chemistry

Attend all class meetings.

Read assigned material before the lecture.

Take good notes.

Ask questions of yourself and your instructor.

Study every day.

1.4 States of Matter

Matter is anything that occupies space and has mass.

The physical states of matter are solid, liquid and gas.

When matter changes from one physical state to another, the change is called a change of state. A change of state does not change the identity of the substance.

1.5 Classification of Matter

A phase is a state of matter having clearly defined and distinguishable boundaries.

Homogeneous matter has the same properties and composition throughout. It consists of only one phase.

Heterogeneous matter has variable composition and properties throughout. It is a mixture of two or more phases.

1.6 Subclassification of Matter

Heterogeneous matter can be subclassified as a mixture of different substances in separate phases or as a mixture of different phases of the same substance.

Homogeneous matter can be subclassified as a homogeneous mixture of different substances in one phase or as a pure substance. A pure substance has a definite and constant composition.

1.7 Physical and Chemical Changes

A physical change does not alter the identity of a substance.

A chemical change alters the identity of a substance.

1.8 Properties of Matter

Identifying features and characteristics of matter are called properties.

Physical properties can be determined by observation and measurement of a substance without changing its identity.

Chemical properties can be determined by observation and measurement of a substance as it undergoes a chemical change.

1.9 Conservation of Mass in Chemical Reactions

The law of conservation of mass states that matter is neither created nor destroyed during a chemical change.

1.10 Energy

Energy is defined as the capacity to do work. Work is done when an object is moved a distance.

All energy can be classified as kinetic or potential energy.

Kinetic energy is possessed by a moving object. Potential energy is energy stored in an object due to its position, condition, or composition.

Energy can exist in many forms: heat, mechanical, electrical, chemical and light energy. Energy can be changed from one form to another. However, the law of conservation of energy states that energy cannot be created or destroyed.

1.11 Energy Changes in Chemical Reactions

Energy changes accompany all chemical reactions and many physical changes.

These energy changes take many different forms, including the release of heat energy (an exothermic process) and the absorption of heat energy (an endothermic process).

1.12 Energy and Matter

Einstein's equation is $E = mc^2$, where E = energy, m = mass and c = speed of light (3×10^{10} cm/sec).

Mass and energy are interchangeable. Since the square of the speed of light is a very large number, a small change in the amount of mass can produce enormous amounts of energy.

Chemical reactions involve negligible changes in mass. Nuclear reactions result in significant mass changes, and thus large energy changes.

Since mass and energy are interchangeable, the two laws of conservation can be combined into one. The total mass and energy of the universe remains constant.

SOLUTIONS TO SELECTED TEXT STUDY QUESTIONS AND PROBLEMS and PRACTICE PROBLEMS

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3. What is the physical state of each of the following?

The state of matter for a particular substance depends on the temperature and pressure at the time of the observation. Notice in the examples below that temperature is given. Pressure is understood to be 1 atmosphere, the average pressure at sea level.

c. Water at 500°F

At the boiling point of a substance, the liquid state changes to the gaseous state. Since water boils at 212°F, it will be a gas at 500°F.

d. Air at 200°F

At room temperature, 72°F, air exists in the gaseous state, so at even higher temperatures it will be a gas.

***Practice Problem A

What is the physical state of each substance at the following temperatures? Consult the table of melting points and boiling points given below. (Answer questions in the space provided).

a. -100°C

helium

magnesium

mercury

b. Room temperature, 22°C

helium

magnesium

mercury

c. 400°C

helium

magnesium

mercury

	melting point	boiling point
helium	-272.2°C	-268.6°C
magnesium	651°C	1107°C
mercury	-38.87°C	356.58°C

4. Give a name to each of the following processes.

Each process below represents a physical change because the identity of the substance is not altered. State changes are the most common physical changes. The state changes are melting (solid ⟶ liquid), freezing (liquid ⟶ solid), evaporation (liquid ⟶ gas), condensation (gas ⟶ liquid or gas ⟶ solid), and sublimation (solid ⟶ gas).

b. Water is changed to ice.

It is common to refer to liquid water as just water. The change implied here is liquid water ⟶ solid water, which is called freezing.

c. Alcohol spontaneously disappears from an open container.

Liquid alcohol changes to gaseous alcohol (also called alcohol vapor), which is evaporation.

e. Water bubbles vigorously when heated.

A state change occurs from liquid to gas. However evaporation occurs on the surface of the liquid. This process is more correctly identified as boiling. Boiling is a special form of evaporation in which the state change from liquid to gas occurs within the body of the liquid through bubble formation.

Consult Appendix C in the text for answers to parts a, d and f.

14. Classify each of the following as a heterogeneous mixture, a homogeneous mixture or a pure substance.

a. Alcohol dissolved in water.

Since the alcohol dissolves in the water, only one phase is present. This phase contains two substances, so alcohol in water is a homogeneous mixture.

b. Mist

Mist results from fine droplets of water in the air. Two phases exist containing different substances, so mist is a heterogeneous mixture.

e. Partially frozen pop.

Two phases are present, the liquid and solid pop. A mixture of different phases of the same substance is a heterogeneous mixture.

Consult Appendix C in the text for answers to parts c, d and f.

***Practice Problem B

Classify each of the following as a heterogeneous mixture, a homogeneous mixture, or a pure substance. Indicate how many

phases are present. (Answer questions in the space provided).

a. sugar

b. water and sugar

c. liquid and solid water

d. water and mineral oil

e. water, sugar and mineral oil

f. liquid and solid water and mineral oil

18. Classify each of the following as a physical or chemical change.

No new substances are formed when a physical change occurs. Common physical changes are state changes and changes in size or shape. A chemical change results in the formation of one or more new substances.

b. The crushing of grapes.

Crushing grapes changes the size and shape of the grapes, so a physical change has occurred.

d. The tarnishing of copper.

The new substance formed on the surface of copper when it tarnishes is the result of a chemical change.

e. The expansion of water when it freezes.

A state change occurs when water freezes, which is a physical change.

Consult Appendix C in the text for answers to parts a, c, and f.

22. Tell whether each of the following statements describes a physical or chemical property.

Physical properties are observable without changing the substance. Examples of physical properties are color, odor, size, shape, physical state, density, taste, melting point and boiling point. Chemical properties are observable only when a substance undergoes a chemical change. Chemical properties are often described by reference to other substances.

a. Sugar is a white solid at room temperature.

Two physical properties are mentioned, color and physical state.

b. Copper conducts electricity.

Electric current passing through a copper wire will not produce any new substances. Electrical conductivity is a physical property.

c. Metals are corroded by acid.

The word corroded means to wear away. The metal chemically combines with the acid to form new substances. The "disappearance" of the metal is one evidence of the chemical change. Another is the formation of hydrogen gas as bubbles on the surface of the metal. Since a chemical change occurs, metals being corroded by acid is a chemical property.

Consult Appendix C in the text for answers to parts d, e, and f.

***Practice Problem C

Classify the following properties of magnesium as physical or chemical properties. (Answer in the space provided).

a. burns with a dazzling white flame

b. melting point, 651°C

c. silvery white in color

d. tarnishes slightly in air

e. one third lighter than aluminum

30. Classify each of the following processes as exothermic or endothermic.

a. The boiling of water.

Heat must be added to liquid water before it will boil. The addition of heat in this physical change is an endothermic process.

c. The formation of ice crystals.

Heat must be removed to change liquid water into ice. The removal of heat is an exothermic process.

Consult Appendix C in the text for answers to parts b and d.

SELF-TEST

Circle the correct answer in the following multiple choice questions.

1. Which of the following correctly describes the liquid state of matter?

a. fixed volume, fixed shape
b. variable volume, variable shape
c. fixed volume, variable shape
d. variable volume, fixed shape

2. The melting point of acetic acid is 16.6°C and the boiling point of acetic acid is 118.5°C. Which of the following physical states is correct for the temperature given?

a. liquid, 15.0°C
b. gas, 101°C
c. solid, room temperature
d. liquid, 40°C

3. Which of the following correctly describes homogeneous mixtures?

a. one phase, one substance
b. one phase, two substances
c. two phases, one substance
d. two phases, two substances

4. Acetone has a melting point of -95.4°C and a boiling point of 56.2°C. Which of the following changes of state is correct for the temperature change given?

a. -90°to -96°C, freezing
b. 55° to 57°C, condensation
c. -96°to -90°C, sublimation
d. 0° to 57°C, melting

5. Which of the properties of potassium is correctly identified as a physical or chemical property?

a. reacts rapidly in air; physical property
b. soft, easily cut with a knife; chemical property
c. catches fire spontaneously on water; chemical property
d. produces hydrogen gas when mixed with water; physical property

6. Which of the following statements is true?

a. Matter and energy cannot be conserved in all reactions, either matter or energy is lost.
b. In a chemical change, matter can be conserved, but not energy.
c. No energy changes can occur in a physical change.
d. Chemical changes involve relatively small changes in energy when compared to nuclear reactions.

7. Which of the following changes is correctly identified as exothermic or endothermic?

a. salt + water = homogeneous mixture + energy; exothermic
b. energy + liquid mercury = gaseous mercury; exothermic
c. hydrogen + oxygen = water + energy; endothermic
d. liquid water = solid water + energy; endothermic

8. Which of the following statements is not true?

   a. as a ball rolls uphill, kinetic energy is converted to potential energy
   b. chemical energy cannot be converted to heat energy
   c. work is done only when an object is moved a distance
   d. certain substances contain potential energy due to their composition

9. In Einstein's equation, $E = mc^2$,

   a. c represents the number of calories of heat energy liberated when matter is converted to energy.
   b. a small loss of mass, m, will produce a large quantity of energy, E.
   c. m represents the length in meters that an object is moved when work is done.
   d. mass and energy are shown to be interchangeable, but mass increases always result in increases in energy.

10. Which of the following statements is true?

   a. heterogeneous matter must be uniform throughout
   b. heterogeneous matter must contain two different substances
   c. heterogeneous matter has variable composition
   d. heterogeneous matter cannot contain three phases

ANSWERS TO PRACTICE PROBLEMS

Practice Problem A

   a. helium, gas; magnesium, solid; mercury, solid
   b. helium, gas; magnesium, solid, mercury, liquid
   c, helium, gas; magnesium, solid, mercury, gas

Practice Problem B

   a. pure substance; one phase
   b. homogeneous mixture; one phase
   c. heterogeneous mixture; two phases
   d. heterogeneous mixture; two phases since water and mineral oil do not mix
   e. heterogeneous mixture; two phases, one containing sugar and water, the other containing mineral oil
   f. heterogeneous mixture; three phases

Practice Problem C

   a. chemical property
   b. physical property
   c. physical property
   d. chemical property
   e. physical property

ANSWERS TO SELF-TEST

1. c
2. d
3. b
4. a
5. c
6. d
7. a
8. b
9. b
10. c

SCIENTIFIC MEASUREMENTS

CHAPTER 2

SUMMARY OUTLINE

2.1 Precision and Accuracy

Repeated measurements of the same quantity are precise if the values are very close to each other.

A measurement is accurate if the value is very close to the true value.

2.2 Significant Figures

Significant figures are those digits in a measurement that are known with certainty plus one digit that is an estimate.

Numbers that are counted or defined have an infinite number of significant figures.

Calculations and Significant Figures

In multiplication and division, the answer must contain the same number of significant figures as the term with the least number of significant figures.

In addition and subtraction, the answer must contain the same number of decimal places as the term with the least number of decimal places.

2.3 Scientific Notation

A number written in scientific notation has the general form $N \times 10^{exponent}$, where N is a number between 1 and 10.