Introductory Chemistry v3 1st edition Ball Solutions Manual

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Chapter 1: What Is Chemistry?

INTRODUCTION

Teaching Tip

A discussion can be initiated regarding how chemistry is involved in our day-to-day life. This will help the students understand the significance of chemistry.

1.1 Some Basic Definitions

- **Learn the basic terms used to describe matter.**

Teaching Tip

A discussion can be initiated regarding the definition of matter and energy. It will help students understand what chemistry is.

- **Chemistry** is the study of matter and its interactions with other matter and energy.
- **Matter** is anything that has mass and takes up space.
    - Things that are not matter include thoughts, ideas, emotions, and hopes.

Example 1.1
Skill-Building Exercises

Which of the following is matter and not matter?
1. the moon
2. an idea for a new invention

Solution:
1. The moon takes up space, so it is matter.
2. The invention itself may be matter, but the idea for it is not.

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- **Physical properties** are characteristics that describe matter as it exists. For example, shape, color, size, and temperature.
- **Chemical properties** are characteristics of matter that describe how matter changes form in the presence of other matter.
- A **physical change** occurs when a sample of matter changes one or more of its physical properties.
- A **chemical change** is the process during which the chemical composition of the matter changes.

Example 1.2
Skill-Building Exercises

Identify each process as a physical change or a chemical change.
1. A fire is raging in a fireplace.
2. Water is warmed to make a cup of coffee.

Solution:
1. Because of the fire, chemical changes are occurring in the fire place. This is a chemical change.
2. Because water is just warmed in its liquid phase, the change is a physical change.

- A sample of matter that has the same physical and chemical properties throughout is called a **substance**. Chemistry recognizes two different types of substances: elements and compounds.
    - An **element** is the simplest type of chemical substance; it cannot be broken down into simpler chemical substances by ordinary chemical means. Examples of elements include iron, carbon, and gold.
    - A **compound** is a combination of more than one element. The physical and chemical properties of a compound are different from the physical and chemical properties of its constituent elements. Examples of compounds include water and sodium chloride (common table salt).
- Physical combinations of more than one substance are called **mixtures**.
    - A **heterogeneous mixture** is a mixture composed of two or more substances. It is easy to note that there is more than one substance present.

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- A **homogeneous mixture** is a combination of two or more substances that is so intimately mixed that the mixture behaves as a single substance. Another word for a homogeneous mixture is **solution**.

Example 1.3
Skill-Building Exercises

Are the following combinations homogeneous mixtures or heterogeneous mixtures?
1. the human body
2. an amalgam, a combination of some other metals dissolved in a small amount of mercury

Solution:
1. The human body as a whole contains many parts that are visible to the naked eye. Hence, it is a heterogeneous mixture.
2. Because an amalgam contains metals dissolved in mercury, an amalgam is a homogeneous mixture.

- A **metal** is an element that is solid at room temperature (although mercury is a well-known exception), is shiny and silvery, conducts electricity and heat well, can be pounded into thin sheets (a property called *malleability*), and can be drawn into thin wires (a property called *ductility*).
- A **nonmetal** is an element that is brittle when solid, does not conduct electricity or heat very well, and cannot be made into thin sheets or wires.
- Some elements have properties of both metals and nonmetals and are called **semimetals (or metalloids)**.

IN-CLASS ACTIVITY

Students can be asked to distinguish between metals and nonmetals.

Appropriate In-Class Use			
Discussion	**Team Activity**	**Class Time**	**Assign Ahead**
√	Not necessary	30 minutes	Not necessary

Concept Review Exercise
1. What is chemistry?

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Solution:
Chemistry is the study of matter and its interactions with other matter and energy.

Exercises

1. Identify each as either matter or not matter.
a. a book
b. hate
c. light
d. a car
e. a fried egg

Solution:
a. A book has a mass and occupies space. Hence, it is matter.
b. Hate is an emotion, which does not occupy space. Hence, it is not matter.
c. Light does not have a mass nor occupies space. Hence, it is not matter.
d. A car has a mass and occupies space. Hence, it is matter.
e. A fried egg has a mass and occupies space. Hence, it is matter.

2. Give an example of matter in each phase: solid, liquid, or gas.

Solution: solid: wood; liquid: water in a pond; gas: air in the atmosphere (answers will vary)

3. Does each statement represent a physical property or a chemical property?
a. Sulfur is yellow.
b. Steel wool burns when ignited by a flame.
c. A gallon of milk weighs over eight pounds.

Solution:
a. Physical property; physical characteristics of matter are shape, color, size, and temperature.
b. Chemical property; chemical properties are characteristics of matter that describe how matter changes form in the presence of other matter.
c. Physical property; physical characteristics of matter are shape, color, size, and temperature.

4. Does each statement represent a physical property or a chemical property?
a. A pile of leaves slowly rots in the backyard.
b. In the presence of oxygen, hydrogen can interact to make water.
c. Gold can be stretched into very thin wires.

Solution:
a. Chemical property; chemical properties are characteristics of matter that describe how matter changes form in the presence of other matter.
b. Chemical property; chemical properties are characteristics of matter that describe how matter changes form in the presence of other matter.

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c. Physical property; physical characteristics of matter are shape, color, size, and temperature.

5. Does each statement represent a physical change or a chemical change?
a. Water boils and becomes steam.
b. Food is converted into usable form by the digestive system.
c. The alcohol in many thermometers freezes at about −40 degrees Fahrenheit.

Solution:
a. Because water is going from a liquid phase to a gas phase, the change is a physical change.
b. Because of the food, chemical changes are occurring in the digestive system. This is a chemical change.
c. Because alcohol is going from a liquid phase to a solid phase, the change is a physical change.

6. Does each statement represent a physical change or a chemical change?
a. Graphite, a form of elemental carbon, can be turned into diamond, another form of carbon, at very high temperatures and pressures.
b. The house across the street has been painted a new color.
c. The elements sodium and chlorine come together to make a new substance called sodium chloride.

Solution:
a. Because graphite is going from a solid phase to another solid phase, the change is a physical change.
b. Physical change; physical characteristics of matter are shape, color, size, and temperature.
c. Chemical reaction takes place between sodium and chlorine when they come together to form sodium chloride. Hence, the change is a chemical change.

7. Distinguish between an element and a compound. About how many of each are known?

Solution: An element is a fundamental chemical part of a substance; there are about 118 known elements. A compound is a combination of elements that acts as a different substance; there are over 165 million known substances.

8. What is the difference between a homogeneous mixture and a heterogeneous mixture?

Solution: Homogeneous mixtures are the same throughout; heterogeneous mixtures are combinations of two or more substances that are relatively easy to identify as two or more substances.

9. Identify each as a heterogeneous mixture or a homogeneous mixture.
a. Salt is mixed with pepper.
b. Sugar is dissolved in water.
c. Pasta is cooked in boiling water.

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Solution:
a. When salt is mixed with pepper, both can be seen clearly. Hence, the mixture is heterogeneous.
b. Sugar completely dissolves in water. Hence, the mixture is homogeneous.
c. Pasta in water can be seen clearly. Hence, the mixture is heterogeneous.

10. Identify each as a heterogeneous mixture or a homogeneous mixture.
a. air
b. dirt
c. a television set

Solution:
a. Air is a mixture of many gases not visible to the naked eye. Hence, the mixture is homogeneous.
b. Dirt contains many visible particles. Hence, the mixture is heterogeneous.
c. A television set contains many parts visible to the naked eye. Hence, the mixture is heterogeneous.

11. In exercise 9, which choices are also solutions?

Solution: b. Sugar dissolved in water is a solution; another name for a homogenous mixture is solution.

12. In exercise 10, which choices are also solutions?

Solution: a. Air is a solution; another name for a homogenous mixture is solution.

13. Why is iron considered a metal?

Solution: Iron is a metal because it is solid, is shiny, and conducts electricity and heat well.

14. Why is oxygen considered a nonmetal?

Solution: Oxygen is a nonmetal because it does not conduct heat or electricity well and is not shiny.

15. Distinguish between a metal and a nonmetal.

Solution: Metals are typically shiny, conduct electricity and heat well, and are malleable and ductile; nonmetals are a variety of colors and phases, are brittle in the solid phase, and do not conduct heat or electricity well.

16. What properties do semimetals have?

Solution: Semimetals have properties of both metals and nonmetals.

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17. Elemental carbon is a black, dull-looking solid that conducts heat and electricity well. It is very brittle and cannot be made into thin sheets or long wires. Of these properties, how does carbon behave as a metal? How does carbon behave as a nonmetal?

Solution: Carbon behaves as a metal because it conducts heat and electricity well. It is a nonmetal because it is black and brittle and cannot be made into sheets or wires.

18. Pure silicon is shiny and silvery but does not conduct electricity or heat well. Of these properties, how does silicon behave as a metal? How does silicon behave as a nonmetal?

Solution: Silicon acts as a metal because it is shiny and silvery; it acts as a nonmetal because it does not conduct electricity or heat well.

1.2 Chemistry as a Science

- **Learn what science is and how it works.**

Teaching Tip

A discussion can be initiated regarding the definition of science. It will help the students understand what science is and how it works.

- Chemistry is a branch of science. **Science** is the process of knowing about the natural universe through observation and experiment.
- An educated guess about how the natural universe works is called a **hypothesis**.
- **Experiments** are tests of the natural universe to see if a guess (hypothesis) is correct.
- A **theory** is a general statement that explains a large number of observations.
- A specific statement that is thought to be never violated by the entire natural universe is called a **law**.

Example 1.4
Skill-Building Exercises

Which is part of science, and which is not?
1. dynamics, the study of systems that change over time
2. aesthetics, the concept of beauty

Solution:

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1. Dynamics is science.
2. Aesthetics is not science.

- Science can be either qualitative or quantitative.
    - **Qualitative** implies a description of the quality of an object.
    - A **quantitative** description represents the specific amount of something.

Example 1.5
Skill-Building Exercises

Are these qualitative or quantitative statements?
1. Roses are red, and violets are blue.
2. Four score and seven years ago….

Solution:
1. Because the statement describes a physical property of roses and violets, this statement is qualitative.
2. This statement mentions a specific amount, so it is quantitative.

IN-CLASS ACTIVITY

Students can be asked to explain what is a hypothesis.

Appropriate In-Class Use			
Discussion	**Team Activity**	**Class Time**	**Assign Ahead**
√	Not necessary	30 minutes	Not necessary

Concept Review Exercise
1. Briefly explain how science/scientists work.

Solution:
Building on previous knowledge, scientists make hypotheses about how the natural universe works. They then do experiments to test these hypotheses to see if they are correct or incorrect.

Exercises

1. Describe the scientific method.

Solution: Simply stated, the scientific method includes three steps: (1) stating a hypothesis, (2) testing the hypothesis, and (3) refining the hypothesis.

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2. What is the scientific definition of a hypothesis? Why is the phrase a *hypothesis is just a guess* an inadequate definition?

Solution: A hypothesis is a reasonable guess based on previous knowledge. Science does not use the word *hypothesis* to mean any random guess, but a reasonable one based on previous knowledge.

3. Why do scientists need to perform experiments?

Solution: Scientists perform experiments to test their hypotheses because sometimes the nature of natural universe is not obvious.

4. What is the scientific definition of a theory? How is this word misused in general conversation?

Solution: A theory is a general statement that explains a large number of observations. Many people improperly use the word *theory* to mean *hypothesis*.

5. What is the scientific definition of a law? How does it differ from the everyday definition of a law?

Solution: A scientific law is a specific statement that is thought to be never violated by the entire natural universe. Everyday laws are arbitrary limits that society puts on its members.

6. Name an example of a field that is not considered a science.

Solution: English is not a science (despite its importance; answers may vary).

7. Which of the following fields are studies of the natural universe?
a. biophysics (a mix of biology and physics)
b. art
c. business

Solution:
a. yes
b. no
c. no

8. Which of the following fields are studies of the natural universe?
a. accounting
b. geochemistry (a mix of geology and chemistry)
c. astronomy (the study of stars and planets [but not the earth])

Solution:
a. no
b. yes

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c. yes

9. Which of these statements are qualitative descriptions?
a. The *Titanic* was the largest passenger ship build at that time.
b. The population of the United States is about 306,000,000 people.
c. The peak of Mount Everest is 29,035 feet above sea level.

Solution:
a. Because the statement describes a physical property of the *Titanic*, this statement is qualitative.
b. This statement mentions a specific amount, so it is not qualitative.
c. This statement mentions a specific amount, so it is not qualitative.

10. Which of these statements are qualitative descriptions?
a. A regular movie ticket in Cleveland costs $6.00.
b. The weather in the Democratic Republic of the Congo is the wettest in all of Africa.
c. The deepest part of the Pacific Ocean is the Mariana Trench.

Solution:
a. This statement mentions a specific amount, so it is not qualitative.
b. Because the statement describes a physical property of the Democratic Republic of the Congo, this statement is qualitative.
c. Because the statement describes a physical property of the Pacific Ocean, this statement is qualitative.

11. Of the statements in exercise 9, which are quantitative?

Solution: b. The statement describing the population of United States as a specific quantity is quantitative.
c. The statement describing the height of Mount Everest as a specific quantity is quantitative.

12. Of the statements in exercise 10, which are quantitative?

Solution: a. The statement describing the price of the movie ticket in Cleveland as a specific quantity is quantitative.

Additional Exercises

1. Is this textbook that you are reading right now an example of matter? Explain your answer.

Solution: Whether you are holding a physical book or reading it with a device, the object you are holding has mass and takes up space. Therefore, it is matter.

2. Explain why it might be difficult to understand that air is matter.

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Solution: As a transparent gas, it is easy to ignore air and not consider it as matter. However, you breath it in and out, in the form of wind it can blow things around or knock them over, and if it gets cold enough it can turn in to a liquid or a solid. Therefore, air is matter.

3. The famous baseball player Babe Ruth once hit 60 home runs in a single baseball season. (a) What quantitative information does that statement contain? (b) Does that information refer to a piece of matter? (c) What qualitative information does that statement contain? (d) Does that information refer to a piece of matter?

Solution:
(a) The amount "60 home runs" is quantitative, as is "a single baseball season."
(b) The quantitative information refers to an activity rather than a piece of matter.
(c) The statement refers to Babe Ruth as a "famous baseball player."
(d) The piece of matter is, of course, Babe Ruth!

4. The chapter refers to solid, liquid, and gas as the three normal phases of matter. What familiar substance is easily observed in all three phases (not necessarily at the same time!)?

Solution: Water is commonly observed in all three phases.

5. Can you name a solution that exists in the gas phase? In the liquid phase?

Solution: Air is a solution in the gas phase. Salt water is a solution in the liquid phase. (Answers will vary.)

6. List some of the general properties of metals.

Solution: Metals are typically solid, shiny, they conduct electricity and heat easily, they are ductile and malleable.

7. List some of the general properties of nonmetals.

Solution: Nonmetals have various phases and colors, are brittle when solid, and do not conduct electricity or heat easily.

8. A colleague says, "I'll bet that if you place a stalk of celery in red-colored water, the celery will turn red." Is this statement a hypothesis, a theory, or a law?

Solution: Hypothesis.

9. A different colleague says, "I have demonstrated that most plastics will burn in air if you light them with a match." Is this statement a hypothesis, a theory, or a law?

Solution: Theory

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10. You may have heard of Newton's law of gravity. What does it mean when we call it a law in the scientific sense?

Solution: It means that the law of gravity is a concept that applies everywhere in the universe.

11. Murphy's law is a humorous statement sometimes expressed as "If anything can go wrong, it will." Is it *really* a law? Why or why not?

Solution: It is not a law in the scientific sense. It is merely a humorous statement that seemingly applies to a lot of human activities!

12. Science is not the only field that uses qualitative and quantitative observations. Assume that you were a banker, handling money all day. What qualitative and quantitative observations might you make during the course of your workday?

Solution: A banker has to count money (quantitative) and recognize different types of coins and paper bills (qualitative).

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