Pearson

Chapter Summary and Review

Key Learning Outcomes

CHAPTER OBJECTIVES	ASSESSMENT
Classify Matter by State and Composition (1.2)	• Exercises 35, 36, 37, 38, 39, 40, 41, 42
Distinguish between Laws and Theories (1.3)	• Exercises 43, 44
Apply the Law of Definite Proportions (1.5)	• Example 1.1 For Practice 1.1 Exercises 49, 50, 51, 52
Apply the Law of Multiple Proportions (1.5)	• Example 1.2 For Practice 1.2 Exercises 53, 54, 55, 56
Work with Atomic Numbers, Mass Numbers, and Isotope Symbols (1.8)	• Example 1.3 For Practice 1.3 Exercises 65, 66, 67, 68, 69, 70, 71, 72
Calculate Atomic Mass (1.9)	• Example 1.4 For Practice 1.4 Exercises 73, 74, 77, 78, 81, 82
Convert between Moles and Number of Atoms (1.10)	• Example 1.5 For Practice 1.5 Exercises 83, 84
Convert between Mass and Amount (Number of Moles) (1.10)	• Example 1.6 For Practice 1.6 For More Practice 1.6 Exercises 85, 86
Use the Mole Concept (1.10)	• Examples 1.7, 1.8 For Practice 1.7, 1.8 For More Practice 1.7, 1.8 Exercises 87, 88, 89, 90, 91, 92, 93, 94, 95, 96

Key Terms

Section 1.1

matter
atom
molecule
chemistry

Section 1.2

substance
state
composition
solid
liquid
gas
pure substance
mixture
element
compound
heterogeneous mixture
homogeneous mixture

Section 1.3

hypothesis
experiment
scientific law
law of conservation of mass
theory

Section 1.5

chemical reaction
law of definite proportions
law of multiple proportions
atomic theory

Section 1.6

cathode ray
cathode ray tube
electrical charge
electron

Section 1.7

radioactivity
nuclear theory
nucleus
proton
neutron

Section 1.8

atomic mass unit (amu)
atomic number (Z)
periodic table
chemical symbol
isotope
natural abundance

mass number (A)
ion
cation
anion

Section 1.9

atomic mass
mass spectrometry

Section 1.10

mole (mol)
Avogadro's number
molar mass

Key Concepts

Matter Is Particulate (1.1)

- All matter is composed of particles.
- The structure of the particles that compose matter determines the properties of matter.
- Chemistry is the science that investigates the properties of matter by examining the atoms and molecules that compose it.

Classifying Matter Based on the Particles That Compose It (1.2)

- We classify matter according to its state (which depends on the relative positions of interactions between particles) or according to its composition (which depends on the type of particles).
- Matter has three common states: solid, liquid, and gas.
- Matter can be a pure substance (one type of particle) or a mixture (more than one type of particle).
- A pure substance can either be an element, which cannot be chemically broken down into simpler substances, or a compound, which is composed of two or more elements in fixed proportions.
- A mixture can be either homogeneous, with the same composition throughout, or heterogeneous, with different compositions in different regions.

The Scientific Approach to Knowledge (1.3)

- Science begins with the observation of the physical world. A number of related observations can often be summarized in a statement or generalization called a scientific law.
- A hypothesis is a tentative interpretation or explanation of observations. One or more well-established hypotheses may prompt the development of a scientific theory, a model for nature that explains the underlying reasons for observations and laws.
- Laws, hypotheses, and theories all give rise to predictions that can be tested by experiments, carefully controlled procedures designed to produce critical new observations. If scientists cannot confirm the predictions, they must modify or replace the law, hypothesis, or theory.

Atomic Theory (1.5)

- Each element is composed of indestructible particles called atoms.
- All atoms of a given element have the same mass and other properties.
- Atoms combine in simple, whole-number ratios to form compounds.
- Atoms of one element cannot change into atoms of another element. In a chemical reaction, atoms change the way that they are bound together with other atoms to form a new substance.

The Electron (1.6)

- J. J. Thomson discovered the electron in the late 1800s through experiments with cathode rays. He deduced that electrons are negatively charged, and he measured their charge-to-mass ratio.
- Robert Millikan measured the charge of the electron, which—in conjunction with Thomson's results—led to calculation of the mass of an electron.

The Nuclear Atom (1.7)

- In 1909, Ernest Rutherford probed the inner structure of the atom by working with a form of radioactivity called alpha radiation and developed the nuclear theory of the atom.
- Nuclear theory states that the atom is mainly empty space, with most of its mass concentrated in a tiny region called the nucleus and most of its volume occupied by relatively light electrons.

Subatomic Particles (1.8)

- Atoms are composed of three fundamental particles: the proton (1 amu, +1 charge), the neutron (1 amu, 0 charge), and the electron (~0 amu, –1 charge).
- The number of protons in the nucleus of the atom is its atomic number (Z). The atomic number determines the charge of the nucleus and defines the element.
- The periodic table tabulates all known elements in order of increasing atomic number.
- The sum of the number of protons and neutrons is the mass number (A).
- Atoms of an element that have different numbers of neutrons (and therefore different mass numbers) are isotopes.
- Atoms that lose or gain electrons become charged and are called ions. Cations are positively charged and anions are negatively charged.

Atomic Mass (1.9)

- The atomic mass of an element, listed directly below its symbol in the periodic table, is a weighted average of the masses of the naturally occurring isotopes of the element.
- Atomic masses can be determined through mass spectrometry.

Atoms and the Mole (1.10)

- One mole of an element is the amount of that element that contains Avogadro's number (6.022×10^{23}) of atoms.
- Any sample of an element with a mass (in grams) that equals its atomic mass contains one mole of the element. For example, the atomic mass of carbon is 12.011 amu; therefore, 12.011 g of carbon contains 1 mol of carbon atoms.

Key Equations and Relationships

Relationship between Mass Number (A), Number of Protons (p), and Number of Neutrons (n) (1.8)

$$A = \text{number of protons (p)} + \text{number of neutrons (n)}$$

Atomic Mass (1.9)

$$\text{atomic mass} = \sum_n (\text{fraction of isotope } n) \times (\text{mass of isotope } n)$$

Avogadro's Number (1.10)

$$1 \text{ mol} = 6.0221421 \times 10^{23} \text{ particles}$$