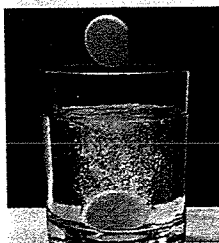


CHAPTER REVIEW

1.1 Chemistry and Chemicals

LEARNING GOAL Define the term chemistry and identify substances as chemicals.

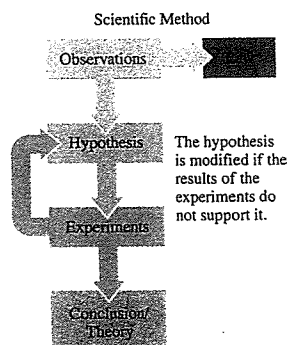
- Chemistry is the study of the composition, structure, properties, and reactions of matter.
- A chemical is any substance that always has the same composition and properties wherever it is found.



1.2 Scientific Method: Thinking Like a Scientist

LEARNING GOAL Describe the activities that are part of the scientific method.

- The scientific method is a process of explaining natural phenomena beginning with making observations, forming a hypothesis, and performing experiments.
- After repeated successful experiments, a hypothesis may become a theory.



1.3 Learning Chemistry: A Study Plan

LEARNING GOAL Develop a study plan for learning chemistry.

- A study plan for learning chemistry utilizes the features in the text and develops an active learning approach to study.



- By using the *Learning Goals* in the chapter and working the *Sample Problems*, *Study Checks*, and the *Questions and Problems* at the end of each section, you can successfully learn the concepts of chemistry.

1.4 Key Math Skills for Chemistry

LEARNING GOAL Review math concepts used in chemistry: place values, positive and negative numbers, percentages, solving equations, and interpreting graphs.

- Solving chemistry problems involves a number of math skills: identifying place values, using positive and negative numbers, calculating percentages, solving equations, and interpreting graphs.



1.5 Writing Numbers in Scientific Notation

LEARNING GOAL Write a standard number in scientific notation and vice versa.

- A number written in scientific notation has two parts, a coefficient and a power of 10.
- When a number greater than 1 is converted to scientific notation, the power of 10 is positive.
- When a number less than 1 is written in scientific notation, the power of 10 is negative.



$8 \times 10^{-6} \text{ m}$

KEY TERMS

chemical A substance that has the same composition and properties wherever it is found.

chemistry The study of the composition, structure, properties, and reactions of matter.

conclusion An explanation of an observation that has been validated by repeated experiments that support a hypothesis.

experiment A procedure that tests the validity of a hypothesis.

hypothesis An unverified explanation of a natural phenomenon.

observation Information determined by noting and recording a natural phenomenon.

scientific method The process of making observations, proposing a hypothesis, and testing the hypothesis; after repeated experiments validate the hypothesis, it may become a theory.

scientific notation A form of writing large and small numbers using a coefficient that is at least 1 but less than 10, followed by a power of 10.

theory An explanation for an observation supported by additional experiments that confirm the hypothesis.



KEY MATH SKILLS

The chapter section containing each Key Math Skill is shown in parentheses at the end of each heading.

Identifying Place Values (1.4)

- The place value identifies the numerical value of each digit in a number.

Example: Identify the place value for each of the digits in the number 456.78.

Answer:	Digit	Place Value
	4	hundreds
	5	tens
	6	ones
	7	tenths
	8	hundredths

Using Positive and Negative Numbers in Calculations (1.4)

- A *positive number* is any number that is greater than zero and has a positive sign (+). A *negative number* is any number that is less than zero and is written with a negative sign (-).
- When two positive numbers are added, multiplied, or divided, the answer is positive.
- When two negative numbers are multiplied or divided, the answer is positive. When two negative numbers are added, the answer is negative.
- When a positive and a negative number are multiplied or divided, the answer is negative.
- When a positive and a negative number are added, the smaller number is subtracted from the larger number and the result has the same sign as the larger number.
- When two numbers are subtracted, change the sign of the number to be subtracted then follow the rules for addition.

Example: Evaluate each of the following:

a. $-8 - 14 = \underline{\hspace{2cm}}$

b. $6 \times (-3) = \underline{\hspace{2cm}}$

Answer: a. $-8 - 14 = -22$

b. $6 \times (-3) = -18$

Calculating Percentages (1.4)

- A percentage is the part divided by the total (whole) multiplied by 100%.

Example: A drawer contains 6 white socks and 18 black socks. What is the percentage of white socks?

Answer: $\frac{6 \text{ white socks}}{24 \text{ total socks}} \times 100\% = 25\% \text{ white socks}$

Solving Equations (1.4)

An equation in chemistry often contains an unknown. To rearrange an equation to obtain the unknown factor by itself, you keep it balanced by performing matching mathematical operations on both sides of the equation.

- If you eliminate a number or symbol by subtracting, subtract that same number or symbol on the opposite side.
- If you eliminate a number or symbol by adding, add that same number or symbol on the opposite side.
- If you cancel a number or symbol by dividing, divide both sides by that same number or symbol.
- If you cancel a number or symbol by multiplying, multiply both sides by that same number or symbol.

Example: Solve the equation for a : $3a - 8 = 28$

Answer: Add 8 to both sides $3a - 8 + 8 = 28 + 8$

$$3a = 36$$

Divide both sides by 3 $\frac{3a}{3} = \frac{36}{3}$

$$a = 12$$

Check: $3(12) - 8 = 28$

$$36 - 8 = 28$$

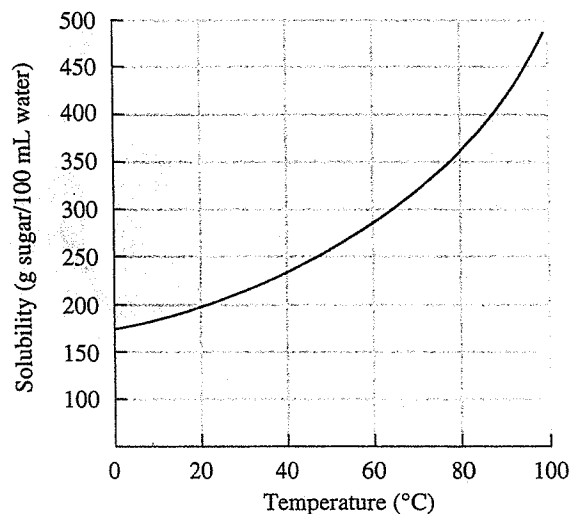
$$28 = 28$$

Your answer $a = 12$ is correct.

Interpreting Graphs (1.4)

- A graph represents the relationship between two variables.
- The quantities are plotted along two perpendicular axes, which are the x axis (horizontal) and y axis (vertical).
- The title indicates the components of the x and y axes.
- Numbers on the x and y axes show the range of values of the variables.
- The graph shows the relationship between the component on the y axis and that on the x axis.

Example: Solubility of Sugar in Water Versus Temperature



- Does the amount of sugar that dissolves in 100 mL of water increase or decrease when the temperature increases?
- How many grams of sugar dissolve in 100 mL of water at 70 °C?
- At what temperature (°C) will 275 g of sugar dissolve in 100 mL of water?

Answer: a. increase b. 320 g c. 55 °C

Converting between Standard Numbers and Scientific Notation (1.5)

- A number written in scientific notation consists of a coefficient and a power of 10.

A number is written in scientific notation by:

- Moving the decimal point to obtain a coefficient that is at least 1 but less than 10.
- Expressing the number of places moved as a power of 10. The power of 10 is positive if the decimal point is moved to the left, negative if the decimal point is moved to the right.
- The standard number is obtained by moving the decimal point for the same number of places as the power of 10.

Example: Write the number 28 000 in scientific notation.

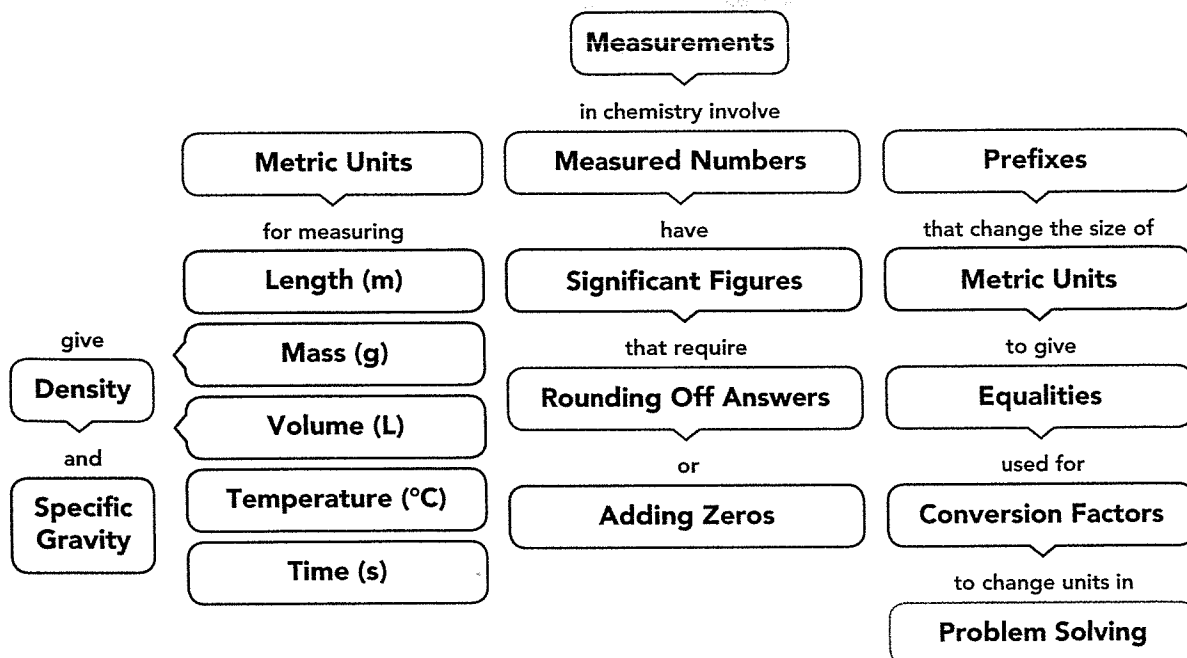
Answer: Moving the decimal point four places to the left gives a coefficient of 2.8 and a positive power of 10, 10^4 . The number 28 000 written in scientific notation is 2.8×10^4 .

Example: Write 5.6×10^{-5} as a standard number.

Answer: Moving the decimal point five places to the left and adding placeholder zeros needed gives 0.000 056.

CONCEPT MAP

CHEMISTRY AND MEASUREMENTS

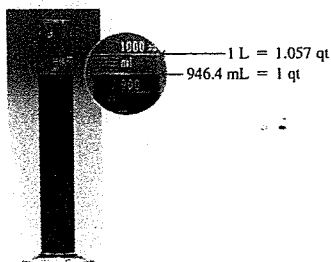


CHAPTER REVIEW

2.1 Units of Measurement

LEARNING GOAL Write the names and abbreviations for the metric or SI units used in measurements of length, volume, mass, temperature, and time.

- In science, physical quantities are described in units of the metric or International System of Units (SI).
- Some important units are meter (m) for length, liter (L) for volume, gram (g) and kilogram (kg) for mass, degree Celsius (°C) and kelvin (K) for temperature, and second (s) for time.



2.3 Significant Figures in Calculations

LEARNING GOAL Adjust calculated answers to give the correct number of significant figures.

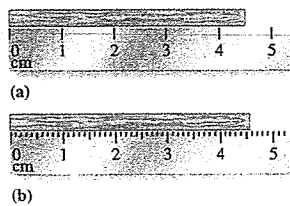
- In multiplication and division, the final answer is written so that it has the same number of significant figures as the measurement with the fewest significant figures.
- In addition and subtraction, the final answer is written so that it has the same number of decimal places as the measurement with the fewest decimal places.



2.2 Measured Numbers and Significant Figures

LEARNING GOAL Identify a number as measured or exact; determine the number of significant figures in a measured number.

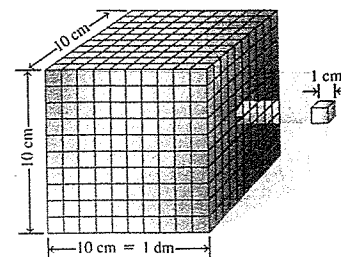
- A measured number is any number obtained by using a measuring device.
- An exact number is obtained by counting items or from a definition; no measuring device is needed.
- Significant figures are the numbers reported in a measurement including the estimated digit.
- Zeros in front of a decimal number or at the end of a nondecimal number are not significant.



2.4 Prefixes and Equalities

LEARNING GOAL Use the numerical values of prefixes to write a metric equality.

- A prefix placed in front of a metric or SI unit changes the size of the unit by factors of 10.
- Prefixes such as *centi*, *milli*, and *micro* provide smaller units; prefixes such as *kilo*, *mega*, and *tera* provide larger units.
- An equality shows the relationship between two units that measure the same quantity of length, volume, mass, or time.
- Examples of metric equalities are $1 \text{ m} = 100 \text{ cm}$, $1 \text{ L} = 1000 \text{ mL}$, $1 \text{ kg} = 1000 \text{ g}$, and $1 \text{ min} = 60 \text{ s}$.



2.5 Writing Conversion Factors

LEARNING GOAL Write a conversion factor for two units that describe the same quantity.



- Conversion factors are used to express a relationship in the form of a fraction.
- Two conversion factors can be written for any relationship in the metric or U.S. system.
- A percentage is written as a conversion factor by expressing matching units as the parts in 100 parts of the whole.
- Small ratios are expressed as parts per million (ppm) and parts per billion (ppb).

2.6 Problem Solving Using Unit Conversion

LEARNING GOAL Use conversion factors to change from one unit to another.



- Conversion factors are useful when changing a quantity expressed in one unit to a quantity expressed in another unit.

- In the problem-solving process, a given unit is multiplied by one or more conversion factors that cancel units until the needed answer is obtained.

2.7 Density

LEARNING GOAL Calculate the density of a substance; use the density to calculate the mass or volume of a substance.



- The density of a substance is a ratio of its mass to its volume, usually g/mL or g/cm^3 .
- The units of density can be used to write conversion factors that convert between the mass and volume of a substance.
- Specific gravity (sp gr) compares the density of a substance to the density of water, 1.00 g/mL .

KEY TERMS

Celsius ($^{\circ}\text{C}$) temperature scale A temperature scale on which water has a freezing point of 0°C and a boiling point of 100°C .

centimeter (cm) A unit of length in the metric system; there are 2.54 cm in 1 in.

conversion factor A ratio in which the numerator and denominator are quantities from an equality or given relationship. For example, the two conversion factors for the equality $1 \text{ kg} = 2.205 \text{ lb}$ are written as

$$\frac{2.205 \text{ lb}}{1 \text{ kg}} \quad \text{and} \quad \frac{1 \text{ kg}}{2.205 \text{ lb}}$$

cubic centimeter (cm^3 , cc) The volume of a cube that has 1-cm sides; 1 cm^3 is equal to 1 mL.

cubic meter (m^3) The volume of a cube that has sides that measure 1 m in length.

density The relationship of the mass of an object to its volume expressed as grams per cubic centimeter (g/cm^3), grams per milliliter (g/mL), or grams per liter (g/L).

equality A relationship between two units that measure the same quantity.

exact number A number obtained by counting or by definition.

gram (g) The metric unit used in measurements of mass.

International System of Units (SI) The official system of measurement throughout the world except for the United States that modifies the metric system.

Kelvin (K) temperature scale A temperature scale on which the lowest possible temperature is 0 K.

kilogram (kg) A metric mass of 1000 g, equal to 2.205 lb. The kilogram is the SI standard unit of mass.

liter (L) The metric unit for volume that is slightly larger than a quart.

mass A measure of the quantity of material in an object.

measured number A number obtained when a quantity is determined by using a measuring device.

meter (m) The metric unit for length that is slightly longer than a yard. The meter is the SI standard unit of length.

metric system A system of measurement used by scientists and in most countries of the world.

milliliter (mL) A metric unit of volume equal to one-thousandth of a liter (0.001 L).

prefix The part of the name of a metric unit that precedes the base unit and specifies the size of the measurement. All prefixes are related on a decimal scale.

second (s) A unit of time used in both the SI and metric systems.

SI See International System of Units (SI).

significant figures (SFs) The numbers recorded in a measurement.

specific gravity (sp gr) A relationship between the density of a substance and the density of water:

$$\text{sp gr} = \frac{\text{density of sample}}{\text{density of water}}$$

temperature An indicator of the hotness or coldness of an object.

volume (V) The amount of space occupied by a substance.



KEY MATH SKILL

The chapter section containing each Key Math Skill is shown in parentheses at the end of each heading.

Rounding Off (2.3)

Calculator displays are rounded off to give the correct number of significant figures.

- If the first digit to be dropped is 4 or less, then it and all following digits are simply dropped from the number.
- If the first digit to be dropped is 5 or greater, then the last retained digit of the number is increased by 1.



CORE CHEMISTRY SKILLS

The chapter section containing each Core Chemistry Skill is shown in parentheses at the end of each heading.

Counting Significant Figures (2.2)

The significant figures (SFs) are all the *measured* numbers including the last, estimated digit:

- All nonzero digits
- Zeros between nonzero digits
- Zeros within a decimal number
- All digits in a coefficient of a number written in scientific notation

An *exact* number is obtained from counting or a definition and has no effect on the number of significant figures in the final answer.

Example: State the number of significant figures in each of the following:

- | | |
|-------------------------|----------------------------|
| a. 0.003 045 mm | Answer: a. four SFs |
| b. 15 000 m | b. two SFs |
| c. 45.067 kg | c. five SFs |
| d. 5.30×10^3 g | d. three SFs |
| e. 2 cans of soda | e. exact |

Using Significant Figures in Calculations (2.3)

- In multiplication or division, the final answer is written so that it has the same number of significant figures as the measurement with the fewest SFs.
- In addition or subtraction, the final answer is written so that it has the same number of decimal places as the measurement having the fewest decimal places.

Example: Perform the following calculations using measured numbers and give answers with the correct number of SFs:

- | | |
|---|---|
| a. $4.05 \text{ m} \times 0.6078 \text{ m}$ | b. $\frac{4.50 \text{ g}}{3.27 \text{ mL}}$ |
| c. $0.758 \text{ g} + 3.10 \text{ g}$ | d. $13.538 \text{ km} - 8.6 \text{ km}$ |
- Answer:** a. 2.46 m^2 b. 1.38 g/mL
 c. 3.86 g d. 4.9 km

Using Prefixes (2.4)

- In the metric and SI systems of units, a prefix attached to any unit increases or decreases its size by some factor of 10.
- When the prefix *centi* is used with the unit meter, it becomes centimeter, a length that is one-hundredth of a meter (0.01 m).
- When the prefix *milli* is used with the unit meter, it becomes millimeter, a length that is one-thousandth of a meter (0.001 m).

One or more significant zeros are added when the calculator display has fewer digits than the needed number of significant figures.

Example: Round off each of the following to three significant figures:

- | | |
|--------------------|--------------------------|
| a. 3.608 92 L | Answer: a. 3.61 L |
| b. 0.003 870 298 m | b. 0.003 87 m |
| c. 6 g | c. 6.00 g |

Example: Complete the following statements with the correct prefix symbol:

- | | |
|--|--|
| a. $1000 \text{ m} = 1 \text{ _____ m}$ | b. $0.01 \text{ g} = 1 \text{ _____ g}$ |
|--|--|

Answer: a. $1000 \text{ m} = 1 \text{ km}$ b. $0.01 \text{ g} = 1 \text{ cg}$

Writing Conversion Factors from Equalities (2.5)

- A conversion factor allows you to change from one unit to another.
- Two conversion factors can be written for any equality in the metric, U.S., or metric–U.S. systems of measurement.
- Two conversion factors can be written for a relationship stated within a problem.

Example: Write two conversion factors for the equality:

$$1 \text{ L} = 1000 \text{ mL}$$

Answer: $\frac{1000 \text{ mL}}{1 \text{ L}}$ and $\frac{1 \text{ L}}{1000 \text{ mL}}$

Using Conversion Factors (2.6)

In problem solving, conversion factors are used to cancel the given unit and to provide the needed unit for the answer.

- State the given and needed quantities.
- Write a plan to convert the given unit to the needed unit.
- State the equalities and conversion factors.
- Set up the problem to cancel units and calculate the answer.

Example: A computer chip has a width of 0.75 in. What is that distance in millimeters?

$$\text{Answer: } 0.75 \text{ in.} \times \frac{2.54 \text{ cm}}{1 \text{ in.}} \times \frac{10 \text{ mm}}{1 \text{ cm}} = 19 \text{ mm}$$

Using Density as a Conversion Factor (2.7)

Density is an equality of mass and volume for a substance, which is written as the *density expression*.

$$\text{Density} = \frac{\text{mass of substance}}{\text{volume of substance}}$$

Density is useful as a conversion factor to convert between mass and volume.

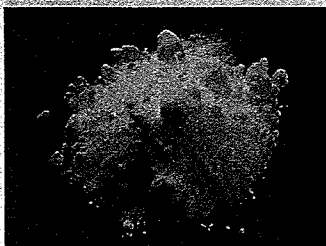
Example: The element tungsten used in light bulb filaments has a density of 19.3 g/cm^3 . What is the volume, in cubic centimeters, of 250 g of tungsten?

$$\text{Answer: } 250 \text{ g} \times \frac{1 \text{ cm}^3}{19.3 \text{ g}} = 13 \text{ cm}^3$$

CHAPTER REVIEW

4.1 Elements and Symbols

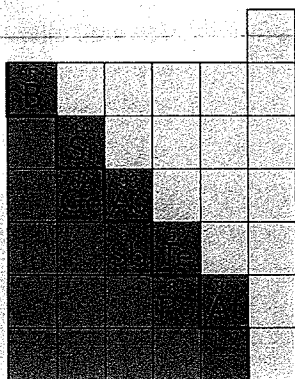
LEARNING GOAL Given the name of an element, write its correct symbol; from the symbol, write the correct name.



- Elements are the primary substances of matter.
- Chemical symbols are one- or two-letter abbreviations of the names of the elements.

4.2 The Periodic Table

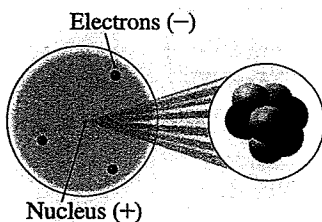
LEARNING GOAL Use the periodic table to identify the group and the period of an element; identify the element as a metal, a nonmetal, or a metalloid.



- The periodic table is an arrangement of the elements by increasing atomic number.
- A horizontal row is called a *period*.
- A vertical column on the periodic table containing elements with similar properties is called a *group*.
- Elements in Group 1A (1) are called the *alkali metals*; Group 2A (2), the *alkaline earth metals*; Group 7A (17), the *halogens*; and Group 8A (18), the *noble gases*.
- On the periodic table, *metals* are located on the left of the heavy zigzag line, and *nonmetals* are to the right of the heavy zigzag line.
- Except for aluminum, elements located along the heavy zigzag line are called *metalloids*.

4.3 The Atom

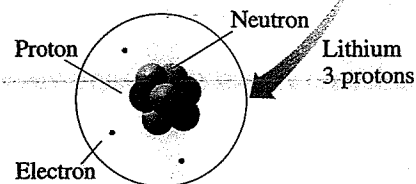
LEARNING GOAL Describe the electrical charge and location in an atom for a proton, a neutron, and an electron.



- An atom is the smallest particle that retains the characteristics of an element.
- Atoms are composed of three types of subatomic particles.
- Protons have a positive charge (+), electrons carry a negative charge (-), and neutrons are electrically neutral.
- The protons and neutrons are found in the tiny, dense nucleus; electrons are located outside the nucleus.

4.4 Atomic Number and Mass Number

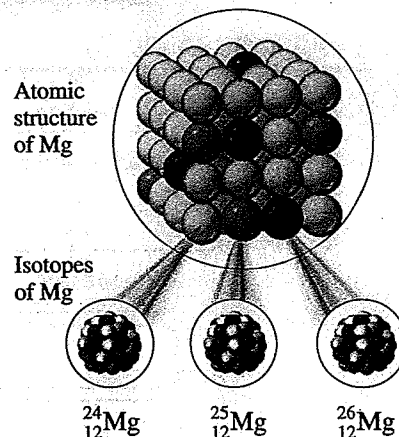
LEARNING GOAL Given the atomic number and the mass number of an atom, state the number of protons, neutrons, and electrons.



- The atomic number gives the number of protons in all the atoms of the same element.
- In a neutral atom, the number of protons and electrons is equal.
- The mass number is the total number of protons and neutrons in an atom.

4.5 Isotopes and Atomic Mass

LEARNING GOAL Determine the number of protons, neutrons, and electrons in one or more of the isotopes of an element; calculate the atomic mass of an element using the percent abundance and mass of its naturally occurring isotopes.



- Atoms that have the same number of protons but different numbers of neutrons are called *isotopes*.
- The atomic mass of an element is the weighted average mass of all the isotopes in a naturally occurring sample of that element.

KEY TERMS

alkali metal An element in Group 1A (1), except hydrogen.

alkaline earth metal An element in Group 2A (2).

atom The smallest particle of an element.

atomic mass The weighted average mass of all the naturally occurring isotopes of an element.

atomic mass unit (amu) A small mass unit used to describe the mass of extremely small particles such as atoms and subatomic particles; 1 amu is equal to one-twelfth the mass of a ^{12}C atom.

atomic number A number that is equal to the number of protons in an atom.

atomic symbol An abbreviation used to indicate the mass number and atomic number of an isotope.

chemical symbol An abbreviation that represents the name of an element.

electron A negatively charged subatomic particle having a minute mass that is usually ignored in mass calculations; its symbol is e^- .

- group** A vertical column in the periodic table that contains elements having similar physical and chemical properties.
- group number** A number that appears at the top of each vertical column (group) in the periodic table.
- halogen** An element in Group 7A (17).
- isotope** An atom that differs only in mass number from another atom of the same element. Isotopes have the same atomic number (number of protons), but different numbers of neutrons.
- mass number** The total number of protons and neutrons in the nucleus of an atom.
- metal** An element that is shiny, malleable, ductile, and a good conductor of heat and electricity. The metals are located to the left of the heavy zigzag line on the periodic table.
- metalloid** Elements with properties of both metals and nonmetals located along the heavy zigzag line on the periodic table.
- neutron** A neutral subatomic particle having a mass of about 1 amu and found in the nucleus of an atom; its symbol is n or n^0 .
- noble gas** An element in Group 8A (18) of the periodic table.
- nonmetal** An element with little or no luster that is a poor conductor of heat and electricity. The nonmetals are located to the right of the heavy zigzag line on the periodic table.

- nucleus** The compact, extremely dense center of an atom, containing the protons and neutrons of the atom.
- period** A horizontal row of elements in the periodic table.
- periodic table** An arrangement of elements by increasing atomic number such that elements having similar chemical behavior are grouped in vertical columns.
- proton** A positively charged subatomic particle having a mass of about 1 amu and found in the nucleus of an atom; its symbol is p or p^+ .
- representative element** An element in the first two columns on the left of the periodic table and the last six columns on the right that has a group number of 1A through 8A or 1, 2, and 13 through 18.
- subatomic particle** A particle within an atom; protons, neutrons, and electrons are subatomic particles.
- transition element** An element in the center of the periodic table that is designated with the letter "B" or the group number of 3 through 12.



CORE CHEMISTRY SKILLS

The chapter section containing each Core Chemistry Skill is shown in parentheses at the end of each heading.

Counting Protons and Neutrons (4.4)

- The atomic number of an element is equal to the number of protons in every atom of that element. The atomic number is the whole number that appears above the symbol of each element on the periodic table.

$$\text{Atomic number} = \text{number of protons in an atom}$$

- Because atoms are neutral, the number of electrons is equal to the number of protons. Thus, the atomic number gives the number of electrons.
- The mass number is the total number of protons and neutrons in the nucleus of an atom.

$$\text{Mass number} = \text{number of protons} + \text{number of neutrons}$$

- The number of neutrons is calculated from the mass number and atomic number.

$$\text{Number of neutrons} = \text{mass number} - \text{number of protons}$$

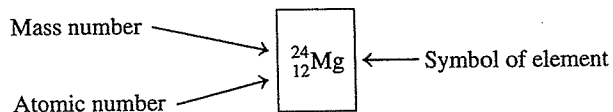
Example: Calculate the number of protons, neutrons, and electrons in a krypton atom with a mass number of 80.

Answer:

Element	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
Kr	36	80	equal to atomic number 36	equal to mass number minus number of protons $80 - 36 = 44$	equal to number of protons 36

Writing Atomic Symbols for Isotopes (4.5)

- Isotopes are atoms of the same element that have the same atomic number but different numbers of neutrons.
- An atomic symbol is written for a particular isotope, with its mass number (protons and neutrons) shown in the upper left corner and its atomic number (protons) shown in the lower left corner.



Example: Calculate the number of protons and neutrons in the cadmium isotope $^{112}_{48}\text{Cd}$.

Answer:

Atomic Symbol	Atomic Number	Mass Number	Number of Protons	Number of Neutrons
$^{112}_{48}\text{Cd}$	number in lower left corner 48	number in upper left corner 112	equal to atomic number 48	equal to mass number minus number of protons $112 - 48 = 64$



Simple Ionic Compounds

In ordinary chemical reactions, the nucleus of each atom (and thus the identity of the element) remains unchanged. Electrons, however, can be added to atoms by transfer from other atoms, lost by transfer to other atoms, or shared with other atoms. The transfer and sharing of electrons among atoms govern the chemistry of the elements. During the formation of some compounds, atoms gain or lose electrons, and form electrically charged particles called ions ([Figure 2](#)).

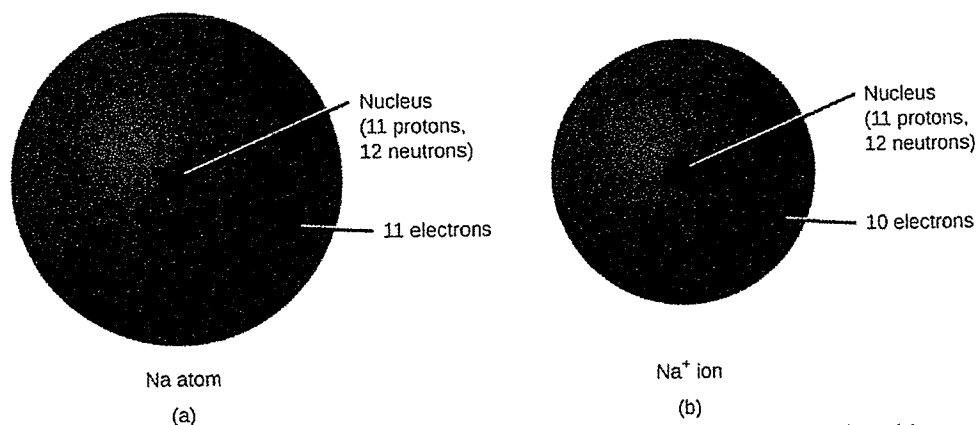


Figure 2. (a) A sodium atom (Na) has equal numbers of protons and electrons (11) and is uncharged. (b) A sodium cation (Na⁺) has lost an electron, so it has one more proton (11) than electrons (10), giving it an overall positive charge, signified by a superscript plus sign.

You can use the periodic table to predict whether an atom will form an anion or a cation, and you can often predict the charge of the resulting ion. Atoms of many main-group metals lose enough electrons to leave them with the same number of electrons as an atom of the preceding noble gas. To illustrate, an atom of an alkali metal (group 1) loses one electron and forms a cation with a 1+ charge; an alkaline earth metal (group 2) loses two electrons and forms a cation with a 2+ charge, and so on. For example, a neutral calcium atom, with 20 protons and 20 electrons, readily loses two electrons. This results in a cation with 20 protons, 18 electrons, and a 2+ charge. It has the same number of electrons as atoms of the preceding noble gas, argon, and is symbolized Ca²⁺. The name of a metal ion is the same as the name of the metal atom from which it forms, so Ca²⁺ is called a calcium ion.

Example 2

Composition of Ions

An ion found in some compounds used as antiperspirants contains 13 protons and 10 electrons. What is its symbol?

Solution

Because the number of protons remains unchanged when an atom forms an ion, the atomic number of the element must be 13. Knowing this lets us use the periodic table to identify the element as Al (aluminum). The Al atom has lost three electrons and thus has three more positive charges (13) than it has electrons (10). This is the aluminum cation, Al^{3+} .

Check Your Learning

Give the symbol and name for the ion with 34 protons and 36 electrons.

Answer:

Se^{2-} , the selenide ion

Example 3

Formation of Ions

Magnesium and nitrogen react to form an ionic compound. Predict which forms an anion, which forms a cation, and the charges of each ion. Write the symbol for each ion and name them.

Solution

Magnesium's position in the periodic table (group 2) tells us that it is a metal. Metals form positive ions (cations). A magnesium atom must lose two electrons to have the same number electrons as an atom of the previous noble gas, neon. Thus, a magnesium atom will form a cation with two fewer electrons than protons and a charge of $2+$. The symbol for the ion is Mg^{2+} , and it is called a magnesium ion.

Nitrogen's position in the periodic table (group 15) reveals that it is a nonmetal. Nonmetals form negative ions (anions). A nitrogen atom must gain three electrons to have the same number of electrons as an atom of the following noble gas, neon. Thus, a nitrogen atom will form an anion with three more electrons than protons and a charge of $3-$. The symbol for the ion is N^{3-} , and it is called a nitride ion.

Check Your Learning

Aluminum and carbon react to form an ionic compound. Predict which forms an anion, which forms a cation, and the charges of each ion.

Write the symbol for each ion and name them.

Answer:

Al will form a cation with a charge of 3+: Al^{3+} , an aluminum ion. Carbon will form an anion with a charge of 4-: C^{4-} , a carbide ion.

Naming Monatomic Ions

The name of a monatomic ion is based on the name of the atom from which it formed.

- Monatomic cations are simply identified by the name of the element. For example, K is a potassium atom and K^+ is a potassium ion.
- Monatomic anions are identified by dropping the end of the element's name and adding the suffix *-ide*. For example, Cl is a chlorine atom and Cl^- is a chloride ion.

READING CHECK

4. Tell whether the ion is a cation or an anion.

a. iron(II) ion

b. phosphide ion

Some Common Monatomic Ions

Main-group elements

1+		2+		3+	
lithium	Li^+	beryllium	Be^{2+}	aluminum	Al^{3+}
sodium	Na^+	magnesium	Mg^{2+}		
potassium	K^+	calcium	Ca^{2+}		
rubidium	Rb^+	strontium	Sr^{2+}		
cesium	Cs^+	barium	Ba^{2+}		
1-		2-		3-	
fluoride	F^-	oxide	O^{2-}	nitride	N^{3-}
chloride	Cl^-	sulfide	S^{2-}	phosphide	P^{3-}
bromide	Br^-	selenide	Se^{2-}		
iodide	I^-				

d-Block elements and others with multiple ions

1+		2+		3+		4+	
copper(I)	Cu^+	vanadium(II)	V^{2+}	vanadium(III)	V^{3+}	vanadium(IV)	V^{4+}
silver	Ag^+	chromium(II)	Cr^{2+}	chromium(III)	Cr^{3+}	tin(IV)	Sn^{4+}
gold(I)	Au^+	iron(II)	Fe^{2+}	iron(III)	Fe^{3+}	lead(IV)	Pb^{4+}
		cobalt(II)	Co^{2+}	cobalt(III)	Co^{3+}		
		copper(II)	Cu^{2+}	gold(III)	Au^{3+}		
		zinc	Zn^{2+}				
		cadmium	Cd^{2+}				
		tin(II)	Sn^{2+}				
		lead(II)	Pb^{2+}				
		mercury(II)	Hg^{2+}				

Some Polyatomic Ions

	1+		2+		
ammonium	NH_4^+	dimercury*	mercury (I)	Hg_2^{2+}	
	1-		2-		3-
acetate	CH_3COO^-	carbonate	CO_3^{2-}	arsenate	AsO_4^{3-}
bromate	BrO_3^-	chromate	CrO_4^{2-}	phosphate	PO_4^{3-}
chlorate	ClO_3^-	dichromate	$\text{Cr}_2\text{O}_7^{2-}$	phosphite	PO_3^{3-}
chlorite	ClO_2^-	hydrogen phosphate	HPO_4^{2-}		
cyanide	CN^-	oxalate	$\text{C}_2\text{O}_4^{2-}$		
dihydrogen phosphate	H_2PO_4^-	peroxide	O_2^{2-}		
hydrogen carbonate (bicarbonate)	HCO_3^-	sulfate	SO_4^{2-}		
hydrogen sulfate	HSO_4^-	sulfite	SO_3^{2-}		
hydroxide	OH^-	thiosulfate	$\text{S}_2\text{O}_3^{2-}$		
hypochlorite	ClO^-				
nitrate	NO_3^-				
nitrite	NO_2^-				
perchlorate	ClO_4^-				
permanganate	MnO_4^-				

*The mercury(I) cation exists as two Hg^+ ions joined together by a covalent bond and is written as Hg_2^{2+} .

Compounds Containing Polyatomic Ions

The table at the top of the page gives the names of some common polyatomic ions. Most of these ions are negatively charged. Most are also oxyanions, which are polyatomic anions that contain oxygen.

Elements That Form Two Oxyanions Note that some elements can combine with oxygen to form more than one polyatomic ion. For example, nitrogen can combine with oxygen to form NO_2^- and NO_3^- . The names of these ions are distinguished by the suffixes *-ate* and *-ite*. The ion that has the smaller number of oxygen atoms ends in *-ite*. The ion that has the greater number of oxygen atoms ends in *-ate*. For example, the two nitrogen-oxygen ions are

nitrite: NO_2^- nitrate: NO_3^-

LOOKING CLOSER

6. How do the roots that form the term oxyanion give a clue to the definition of the term?

Cambridge Chemistry Summer Assignment

I. Scientific Notation:

1. Write each of the following in scientific notation.

- | | |
|------------|-----------------|
| a. 120 000 | c. 0.000 000 34 |
| b. 0.066 | d. 2700 |

2. Write the following in standard form.

- | | |
|-------------------------|--------------------------|
| a. 2.6×10^{-5} | c. 1.44×10^3 |
| b. 3.7×10^5 | d. 5.31×10^{-1} |

II. Significant Figures:

3. the number of significant figures in the following numbers.

- | | |
|-----------|--------------------------|
| a. 100. | e. 0.00001345 |
| b. 1256 | f. 1.04×10^{-3} |
| c. 10456 | g. 2×10^5 |
| d. 134000 | h. 13.0 |

4. Round the following answers to the correct number of significant figures based on its mathematical operation.

- | | |
|--|---|
| a. $23.7 \times 3.8 =$ | d. $1.678 / 0.42 =$ |
| b. $32.567 + 135.0 + 1.4567 =$ | e. $658.0 - 23.5478 - 134 =$ |
| c. $1.25 \times 10^{-3} \times 9.2 \times 10^{-2} =$ | f. $4.50 \times 10^{22} / 6.022 \times 10^{23} =$ |

III. Dimensional Analysis: (Show ALL work)

5. A doctor orders 5.0mL of phenobarbital. If the phenobarbital is available as 30.mg per 7.5mL, how many milligrams is given to the patient?
6. To prevent a bacterial infection, a doctor orders 4 tables of amoxicillin per day for 10 days. If each tablet contains 250.mg of amoxicillin, how many ounces of the medicine are given in 10 days? (1 gram = 0.035274 ounces)

IV. Atomic Structure:

7. Copy the chart on to your answer sheet and complete

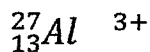
Element	Symbol	Atomic number	Mass number	Number of protons	Number of electrons	Number of neutrons
calcium						
potassium						
Potassium ion						
iron						
chlorine						
Chloride ion						

8. Answer the following question regarding the following isotope:



- a. What is its atomic number?
- b. What is its mass number?
- c. How many neutrons does this atom have?
- d. How many protons does this atom have?
- e. How many electrons does this atom have?

8. Answer the following question regarding the following isotope:



- a. What is its atomic number?
- b. What is its mass number?
- c. How many neutrons does this atom have?
- d. How many protons does this atom have?
- e. How many electrons does this atom have?

V. Elements and Periodic Table:

9. Why is the symbol of cobalt Co, not CO?

10. Give the group AND period number of the following elements

- | | |
|------------|-----------|
| a. Bromine | d. argon |
| b. Lithium | e. radium |
| c. Copper | f. Tin |

11. Give the symbol of the element described by each of the following:

- a. Group 14 (4A), Period 2
- b. The noble gas in Period 4
- c. The alkali metal in Period 3
- d. Group 2 (2A), Period 6

12. Identify the following element as a Metal, Metalloid, or Non-metal

- | | |
|---|----------------------------|
| a. Calcium | f. nitrogen |
| b. Oxygen | g. silver |
| c. A good conductor of heat and electricity | h. mercury |
| d. Bromine | i. gas at room temperature |
| e. Hydrogen | j. chlorine |



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What do you especially like about this Resource? Why would you recommend other students use it?

Is there anything you don't like about this resource? Explain.



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