

Glossary

absorption spectrum

A plot of the absorption of light of a sample of matter as a function of wavelength. (2.3)

accuracy

A term that refers to how close a measured value is to the actual value. (E.3)

acid

See *Arrhenius definitions (of acids and bases)*, *Brønsted–Lowry definitions (of acids and bases)*, and *Lewis acid*. (8.4)

acid ionization constant (K_a)

The equilibrium constant for the ionization reaction of a weak acid; used to compare the relative strengths of weak acids. (16.5)

acid–base reaction (neutralization reaction)

A reaction in which an acid reacts with a base and the two neutralize each other, producing water. (8.7)

acid–base titration

A laboratory procedure in which a basic (or acidic) solution of unknown concentration is reacted with an acidic (or basic) solution of known concentration, in order to determine the concentration of the unknown. (17.4)

acidic solution

A solution containing an acid that creates additional H_3O^+ ions, causing $[\text{H}_3\text{O}^+]$ to increase. (16.6)

activated complex (transition state)

A high-energy intermediate state between reactant and product. (14.6)

activation energy

An energy barrier in a chemical reaction that must be overcome for the reactants to be converted into products. (14.6)

active site

The specific area of an enzyme at which catalysis occurs. (14.8)

activity series of metals

A listing of metals in order of decreasing activity, decreasing ability to oxidize, and decreasing tendency to lose electrons. (8.9)

actual yield

The amount of product actually produced by a chemical reaction. (7.5)

addition polymer

A polymer in which the monomers simply link together without the elimination of any atoms. (21.14)

addition reaction

A type of organic reaction in which two substituents are added across a double bond. (21.6)

alcohol

A member of the family of organic compounds that contain a hydroxyl functional group ($-\text{OH}$). (21.9)

aldehyde

A member of the family of organic compounds that contain a carbonyl functional group ($\text{C}=\text{O}$) bonded to two R groups, one of which is a hydrogen atom. (21.10)

aliphatic hydrocarbon

An organic compound consisting of hydrogen and carbon atoms and containing no benzene rings; alkanes, alkenes, and alkynes are aliphatic hydrocarbons. (21.3)

alkali metals

Highly reactive metals in group 1A of the periodic table. (3.5)

alkaline battery

A dry-cell battery that employs half-reactions that differ slightly in a basic medium. (19.7)

alkaline earth metals

Fairly reactive metals in group 2A of the periodic table. (3.5)

alkaloid

Organic bases found in plants that are often poisonous. (16.2)

alkane

A hydrocarbon containing only single bonds. (21.3)

alkene

A hydrocarbon containing one or more carbon-carbon double bonds. (21.3)

alkyne

A hydrocarbon containing one or more carbon-carbon triple bonds. (21.3)

allotrope

One of two or more forms of the same element; each form has a different structure. (12.6)

alpha (α) decay

The form of radioactive decay that occurs when an unstable nucleus emits a particle composed of two protons and two neutrons. (20.3)

alpha (α) particle

A low-energy particle released during alpha decay; equivalent to a He-4 nucleus. (20.3)

amine

A member of a family of organic compounds containing nitrogen that are derived from ammonia with one or more of the hydrogen atoms replaced by alkyl groups. (21.13)

amorphous

Describes a solid in which atoms or molecules do not have any long-range order. (11.2)

ampere (A)

The SI unit for electrical current; $1 \text{ A} = 1 \text{ C/s}$ (19.3)

amphoteric

Able to act as either an acid or a base. (16.3)

amplitude

The vertical height of a crest (or depth of a trough) of a wave; a measure of wave intensity. (2.2)

angular momentum quantum number (l)

angular momentum quantum number (l)

An integer that determines the shape of an orbital. (2.5)

anion

A negatively charged ion. (1.8)

anode

The electrode in an electrochemical cell where oxidation occurs; electrons flow away from the anode. (19.3)

antibonding orbital

A molecular orbital that is higher in energy than any of the atomic orbitals from which it was formed. (6.4)

aqueous solution

A solution in which water acts as the solvent. (8.2, 13.2)

aromatic hydrocarbon

A hydrocarbon containing an aromatic (or benzene) ring. (21.3)

Arrhenius definitions (of acids and bases)

The definitions of an acid as a substance that produces H^+ ions in aqueous solution and a base as a substance that produces OH^- ions in aqueous solution. (8.7, 16.3)

Arrhenius equation

The equation that relates the rate constant of a reaction to the temperature, the activation energy, and the

frequency factor; $k = Ae^{\frac{-E_a}{RT}}$. (14.6)

Arrhenius plot

The plot of the natural log of the rate constant ($\ln k$) versus the inverse of the temperature in kelvins ($1/T$) that yields a straight line with a slope of $-E_a/R$ and a y -intercept of $\ln A$. (14.6)

atmosphere (atm)

A unit of pressure based on the average pressure of air at sea level; $1 \text{ atm} = 101,325 \text{ Pa}$. (10.3)

atom

A submicroscopic particle that constitutes the fundamental building block of ordinary matter; the smallest identifiable unit of an element. (1.1)

atomic mass (atomic weight)

The average mass in amu of the atoms of a particular element based on the relative abundance of the various isotopes; numerically equivalent to the mass in grams of one mole of the element. (1.9)

atomic mass unit (amu)

A unit used to express the masses of atoms and subatomic particles; defined as $1/12$ the mass of a carbon atom containing 6 protons and 6 neutrons. (1.8)

atomic number (Z)

The number of protons in an atom; the atomic number defines the element. (1.8)

atomic orbital (AO)

A mathematical function that represents a state of an electron in an atom. (6.2)

atomic radius

A set of average bonding radii determined from measurements on a large number of elements and compounds. (3.6)

atomic solids

Solids whose composite units are atoms; nonbonding atomic solids, metallic atomic solids, and network covalent solids are atomic solids. (12.4)

atomic theory

The theory that each element is composed of tiny indestructible particles called atoms, that all atoms of a given element have the same mass and other properties, and that atoms combine in simple, whole-number ratios to form compounds. (1.5)

aufbau principle

The principle that indicates the pattern of orbital filling in an atom. (3.3)

autoionization

The process by which water acts as an acid and a base with itself. (16.6)

Avogadro's law

The law that states that the volume of a gas is directly proportional to its amount in moles ($V \propto n$). (10.4)

Avogadro's number

The number of ^{12}C atoms in exactly 12 g of ^{12}C ; equal to 6.0221421×10^{23} . (1.10)

ball-and-stick molecular model

A representation of the arrangement of atoms in a molecule that shows how the atoms are bonded to each other and the overall shape of the molecule. (4.3)

band gap

An energy gap that exists between the valence band and conduction band of semiconductors and insulators. (12.8)

band theory

A model for bonding in atomic solids that comes from molecular orbital theory in which atomic orbitals combine and become delocalized over the entire crystal. (12.8)

barometer

An instrument used to measure atmospheric pressure. (10.3)

base

See Arrhenius definitions (of acids and bases), Brønsted–Lowry definitions (of acids and bases), and Lewis base. (8.7)

base ionization constant (K_b)

The equilibrium constant for the ionization reaction of a weak base; used to compare the relative strengths of weak bases. (16.8)

basic solution

A solution containing a base that creates additional OH^- ions, causing the $[\text{OH}^-]$ to increase. (16.6)

bent geometry

A molecular geometry in which three atoms bond in a nonlinear arrangement. (5.8)

beta (β) decay

The form of radioactive decay that occurs when an unstable nucleus emits an electron. (20.3)

beta (β) particle

A medium-energy particle released during beta decay; equivalent to an electron. (20.3)

bidentate

Describes ligands that donate two electron pairs to the central metal. (22.3)

bimolecular

An elementary step in a reaction that involves two particles, either the same species or different, that collide and go on to form products. (14.7)

binary acid

An acid composed of hydrogen and a nonmetal. (8.7)

binary compound

A compound that contains only two different elements. (4.6)

binding energy

Energy with which an electron is bound to the metal. (2.2)

biological effectiveness factor (RBE)

A correction factor multiplied by the dose of radiation exposure in rad to obtain the dose in rem. (20.11)

body-centered cubic

A unit cell that consists of a cube with one atom at each corner and one atom at the center of the cube. (12.3)

boiling point

The temperature at which the vapor pressure of a liquid equals the external pressure. (11.5)

boiling point elevation

The effect of a solute that causes a solution to have a higher boiling point than the pure solvent. (13.6)

bomb calorimeter

A piece of equipment designed to measure ΔE_{rxn} for combustion reactions at constant volume. (9.5)

bond energy

For a chemical bond, the energy required to break 1 mol of the bond in the gas phase. (5.6)

bond length

The average length of a bond between two particular atoms in a variety of compounds. (5.6)

bond order

For a molecule, the number of electrons in bonding orbitals minus the number of electrons in nonbonding orbitals divided by two; a positive bond order implies that the molecule is stable. (6.4)

bonding orbital

A molecular orbital that is lower in energy than any of the atomic orbitals from which it was formed. (6.4)

bonding pair

A pair of electrons shared between two atoms. (4.7)

Born-Haber cycle

A hypothetical series of steps based on Hess's law that represents the formation of an ionic compound from its constituent elements. (9.11)

borosilicate glass (Pyrex®)

A type of glass containing boric oxide (B_2O_3). Borosilicate glass expands less when heated and can withstand heating and cooling cycles without shattering. (12.7)

Boyle's law

The law that states that volume of a gas is inversely proportional to its pressure $\left(V \propto \frac{1}{P}\right)$ (10.4)

Brønsted-Lowry definitions (of acids and bases)

Brønsted-Lowry definitions (of acids and bases)

The definitions of an acid as a proton (H^+ ion) donor and a base as a proton acceptor. (16.3)

buffer

A solution containing significant amounts of both a weak acid and its conjugate base (or a weak base and its conjugate acid) that resists pH change by neutralizing added acid or added base. (17.2)

buffer capacity

The amount of acid or base that can be added to a buffer without destroying its effectiveness. (17.3)

calorie (cal)

A unit of energy defined as the amount of energy required to raise one gram of water 1°C ; equal to 4.184 J. (E.6, 9.2)

Calorie (Cal)

A unit of energy that is equivalent to 1000 lowercase "c" calories. (E.6)

calorimetry

The experimental procedure used to measure the heat evolved in a chemical reaction. (9.5)

capillary action

The ability of a liquid to flow against gravity up a narrow tube due to adhesive and cohesive forces. (11.4)

carbonyl group

A functional group consisting of a carbon atom double-bonded to an oxygen atom ($\text{C}=\text{O}$). (21.10)

carboxylic acid

An organic acid containing the functional group $-\text{COOH}$. (16.2, 21.11)

catalyst

A substance that is not consumed in a chemical reaction but increases the rate of the reaction by providing an alternate mechanism in which the rate-determining step has a smaller activation energy. (14.8)

cathode

The electrode in an electrochemical cell where reduction occurs; electrons flow toward the cathode. (19.3)

cathode ray

A stream of electrons produced when a high electrical voltage is applied between two electrodes within a partially evacuated tube. (1.6)

cathode ray tube

A partially evacuated tube equipped with electrodes to produce cathode rays. (1.6)

cation

A positively charged ion. (1.8)

cell potential (cell emf) (E_{cell})

The potential difference between the cathode and the anode in an electrochemical cell. (19.3)

Celsius ($^\circ\text{C}$) scale

The temperature scale most often used by scientists (and by most countries other than the United States), on which pure water freezes at 0°C and boils at 100°C (at atmospheric pressure). (E.2)

ceramics

Inorganic metallic solids that are prepared from powders usually mixed with water, formed in the desired shape, and then heated. (12.7)

chain reaction

A series of reactions in which previous reactions cause future ones; in a fission bomb, neutrons produced by the fission of one uranium nucleus induce fission in other uranium nuclei. (20.7)

Charles's law

The law that states that the volume of a gas is directly proportional to its temperature ($V \propto T$). (10.4)

chelate

A complex ion that contains either a bi- or polydentate ligand. (22.3)

chelating agent

The coordinating ligand of a chelate. (22.3)

chemical bond

The sharing or transfer of electrons to attain stable electron configurations for the bonding atoms. (4.2)

chemical change

A change that alters the molecular composition of a substance; see also *chemical reaction*. (7.2)

chemical energy

The energy associated with the relative positions of electrons and nuclei in atoms and molecules. (9.2)

chemical equation

A symbolic representation of a chemical reaction; a balanced equation contains equal numbers of the atoms of each element on both sides of the equation. (7.3)

chemical formula

A symbolic representation of a compound that indicates the elements present in the compound and the relative number of atoms of each. (4.3)

chemical property

A property that a substance displays only by changing its composition via a chemical change. (7.2)

chemical reaction

A process by which one or more substances are converted to one or more different substances; see also *chemical change*. (1.5, 7.3)

chemical symbol

A one- or two-letter abbreviation for an element that is listed directly below its atomic number on the periodic table. (1.8)

chemistry

The science that seeks to understand the properties of matter by studying the structure of the particles that compose matter. (1.1)

chiral

Describes a molecule that is not superimposable on its mirror image. (21.3)

Clausius–Clapeyron equation

The equation that displays the exponential relationship between vapor pressure and temperature;

$$\ln(P_{\text{vap}}) = \frac{-\Delta H_{\text{vap}}}{R} \left(\frac{1}{T} \right) + \ln b \quad (11.5)$$

clay

A powdered form of a mineral (such as an aluminosilicate) mixed with water. (12.7)

coffee-cup calorimeter

A piece of equipment designed to measure ΔH_{rxn} for reactions at constant pressure. (9.7)

colligative property

A property that depends on the amount of a solute but not on the type. (13.6)

collision frequency

In the gas phase, the number of collisions that occur per unit time between gaseous particles. (14.6)

collision model

A model of chemical reactions in which a reaction occurs after a sufficiently energetic collision between two reactant molecules. (14.6)

combustion analysis

A method of obtaining empirical formulas for unknown compounds, especially those containing carbon and hydrogen, by burning a sample of the compound in pure oxygen and analyzing the products of the combustion reaction. (4.11)

combustion reaction

A type of chemical reaction in which a substance combines with oxygen to form one or more oxygen-containing compounds; the reaction often causes the evolution of heat and light in the form of a flame. (7.6)

common ion effect

The tendency for a common ion to decrease the solubility of an ionic compound or to decrease the ionization of a weak acid or weak base. (17.2)

common name

A traditional name of a compound that gives little or no information about its chemical structure; for example, the common name of NaHCO_3 is "baking soda." (4.6)

complementary properties

Properties that exclude one another; that is, the more you know about one, the less you know about the other. For example, the wave nature and particle nature of the electron are complementary. (2.4)

complete ionic equation

An equation that lists individually all of the ions present as either reactants or products in a chemical reaction. (8.6)

complex ion

An ion that contains a central metal ion bound to one or more ligands. (17.7, 22.3)

composition

Refers to the type of particles that compose matter; by composition is one way to classify matter. (1.2)

compound

A substance composed of two or more elements in fixed, definite proportions. (1.2)

concentrated solution

A solution that contains a large amount of solute relative to the amount of solvent. (8.2, 13.5)

concrete

A mixture of Portland cement, sand, and pebbles. (12.7)

condensation

The phase transition from gas to liquid. (11.5)

condensation polymer

A polymer formed by elimination of an atom or small group of atoms (usually water) between pairs of monomers during polymerization. (12.9)

condensation reaction

A reaction in which two or more organic compounds are joined, often with the loss of water or some other small molecule. (21.11)

conduction band

In band theory, the band of energy levels that forms from antibonding molecular orbitals. (12.8)

conjugate acid

A base to which a proton has been added. (16.3)

conjugate acid–base pair

Two substances related to each other by the transfer of a proton. (16.3)

conjugate base

An acid from which a proton has been removed. (16.3)

constructive interference

The interaction of waves from two sources that align with overlapping crests, resulting in a wave of greater amplitude. (2.2)

conversion factor

A factor used to convert between two different units; a conversion factor can be constructed from any two quantities known to be equivalent. (E.7)

coordinate covalent bond

The bond formed when a ligand donates electrons to an empty orbital of a metal in a complex ion. (22.3)

coordination compound

A neutral compound made when a complex ion combines with one or more counterions. (22.3)

coordination isomers

Isomers of complex ions that occur when a coordinated ligand exchanges places with the uncoordinated counterion. (22.4)

coordination number

The number of atoms with which each atom in a crystal lattice is in direct contact. (12.3)

coordination number (secondary valence)

The number of molecules or ions directly bound to the metal atom in a complex ion. (22.3)

copolymer

A polymer composed of two different monomers. (12.9)

core electrons

Those electrons in a complete principal energy level and those in complete *d* and *f* sublevels. (3.4)

corrosion

The gradual, nearly always undesired, oxidation of metals that occurs when metals are exposed to oxidizing agents in the environment. (19.9)

Coulomb's law

The law that states that the potential energy (*E*) of two charged particles depends on their charges (*q*₁ and *q*₂)

and on their separation (*r*): $E = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$ (3.3)

covalent bond

A chemical bond in which two atoms share electrons that interact with the nuclei of both atoms, lowering the potential energy of each through electrostatic interactions. (4.2)

covalent radius (bonding atomic radius)

In nonmetals, one-half the distance between two atoms bonded together, and in metals, one-half the distance between two adjacent atoms in a crystal of the metal. (3.6)

critical mass

The amount of a radioactive isotope required to produce a self-sustaining fission reaction. (20.7)

critical point

The temperature and pressure above which a supercritical fluid exists. (11.6)

critical pressure (P_c)

The pressure required to bring about a transition to a liquid at the critical temperature. (11.5)

critical temperature (T_c)

The temperature above which a liquid cannot exist, regardless of pressure. (11.5)

crystal field theory

A bonding model for coordination compounds that focuses on the interactions between ligands and the central metal ion. (22.1)

crystalline

Describes a solid in which atoms, molecules, or ions are arranged in patterns with long-range, repeating order. (11.2)

crystalline lattice

The regular arrangement of atoms in a crystalline solid. (12.3)

cubic closest packing

A closest-packed arrangement in which the third layer of atoms is offset from the first; the same structure as the face-centered cubic. (12.3)

cyclotron

A particle accelerator in which a charged particle is accelerated in an evacuated ring-shaped tube by an alternating voltage applied to each semicircular half of the ring. (20.10)

Dalton's law of partial pressures

The law that states that the sum of the partial pressures of the components in a gas mixture must equal the total pressure. (10.7)

de Broglie relation

The observation that the wavelength of a particle is inversely proportional to its momentum $\lambda = \frac{h}{mv}$. (2.4)

degenerate

Describes two or more electron orbitals with the same value of n that have the same energy. (3.3)

density (d)

The ratio of an object's mass to its volume. (E.5)

deposition

The phase transition from gas to solid. (11.6)

derived unit

A unit that is a combination of other base units. For example, the SI unit for speed is meters per second (m/s), a derived unit. (E.2)

destructive interference

The interaction of waves from two sources that are aligned so that the crest of one overlaps the trough of the other, resulting in cancellation. (2.2)

deterministic

A characteristic of the classical laws of motion, which imply that present circumstances determine future events. (2.4)

dextrorotatory

Capable of rotating the plane of polarization of light clockwise. (21.3)

diamagnetic

The state of an atom or ion that contains only paired electrons and is, therefore, slightly repelled by an external magnetic field. (3.7)

diamond

An elemental form of carbon with a crystal structure that consists of carbon atoms connected to four other carbon atoms at the corners of a tetrahedron, creating a strong network covalent solid. (12.6)

diffraction

The phenomena by which a wave emerging from an aperture spreads out to form a new wave front. (2.2)

diffusion

The process by which a gas spreads through a space occupied by another gas. (10.9)

dilute solution

A solution that contains a very small amount of solute relative to the amount of solvent. (8.2, 13.5)

dimensional analysis

The use of units as a guide to solving problems. (E.7)

dimer

The product that forms from the reaction of two monomers. (12.9)

diode

A device that allows the flow of electrical current in only one direction. (12.8)

dipole moment (μ)

A measure of the separation of positive and negative charge in a molecule. (5.2)

dipole-dipole force

An intermolecular force exhibited by polar molecules that results from the uneven charge distribution. (11.3)

diprotic acid

An acid that contains two ionizable protons. (8.7, 16.5)

dispersion force (London force)

An intermolecular force exhibited by all atoms and molecules that results from fluctuations in the electron distribution. (11.3)

dose

The amount of energy absorbed by bodily tissues as a result of exposure to radiation. (20.11)

double bond

The bond that forms when two electrons are shared between two atoms. (4.7)

dry-cell battery

A battery that does not contain a large amount of liquid water, often using the oxidation of zinc and the reduction of MnO_2 to provide the electrical current. (19.7)

duet

A Lewis structure with two dots, signifying a filled outer electron shell for the elements H and He. (4.4)

dynamic equilibrium

The point at which the rate of the reverse reaction or process equals the rate of the forward reaction or process. (11.5, 13.4, 15.2)

effective nuclear charge (Z_{eff})

The actual nuclear charge experienced by an electron, defined as the charge of the nucleus plus the charge of the shielding electrons. (3.3)

effusion

The process by which a gas escapes from a container into a vacuum through a small hole. (10.9)

electrical charge

A fundamental property of certain particles that causes them to experience a force in the presence of electric fields. (1.6)

electrical current

The flow of electric charge. (19.3)

electrochemical cell

A device in which a chemical reaction either produces or is carried out by an electrical current. (19.3)

electrolysis

The process by which electrical current is used to drive an otherwise nonspontaneous redox reaction. (19.8)

electrolyte

A substance that dissolves in water to form solutions that conduct electricity. (8.4)

electrolytic cell

An electrochemical cell that uses electrical current to drive a nonspontaneous chemical reaction. (19.3)

electromagnetic radiation

A form of energy embodied in oscillating electric and magnetic fields. (2.2)

electromagnetic spectrum

The range of the wavelengths of all possible electromagnetic radiation. (2.2)

electromotive force (emf)

The force that results in the motion of electrons due to a difference in potential. (19.3)

electron

A negatively charged, low-mass particle found outside the nucleus of all atoms that occupies most of the atom's volume but contributes almost none of its mass. (1.6)

electron affinity (EA)

The energy change associated with the gaining of an electron by an atom in its gaseous state. (3.8)

electron capture

The form of radioactive decay that occurs when a nucleus assimilates an electron from an inner orbital. (20.3)

electron configuration

A notation that shows the particular orbitals that are occupied by electrons in an atom. (3.3)

electron geometry

The geometrical arrangement of electron groups in a molecule. (5.8)

electron groups

A general term for lone pairs, single bonds, multiple bonds, or lone electrons in a molecule. (5.7)

electron sea model

A model for bonding in metals in which the metal is viewed as an array of positive ions immersed in a sea of electrons. (12.4)

electron spin

A fundamental property of electrons; spin can have a value of $\pm 1/2$. (2.5)

electronegativity

The ability of an atom to attract electrons to itself in a covalent bond. (5.2)

element

A substance that cannot be chemically broken down into simpler substances. (1.2)

elementary step

An individual step in a reaction mechanism. (14.7)

elimination reaction

A reaction in which two molecules join together while eliminating a small molecule such as water. (21.9)

emission spectrum

The range of wavelengths emitted by a particular element; used to identify the element. (2.3)

empirical formula

A chemical formula that shows the simplest whole-number ratio of atoms in the compound. (4.3)

empirical formula molar mass

The sum of the masses of all the atoms in an empirical formula. (4.11)

enantiomers (optical isomers)

Two molecules that are nonsuperimposable mirror images of one another. (21.3)

endothermic

Describes a process that absorbs heat from its surroundings. (E.6)

endothermic reaction

A chemical reaction that absorbs heat from its surroundings; for an endothermic reaction, $\Delta H > 0$ (9.6)

endpoint

The point of pH change where an indicator changes color. (17.4)

energy

The capacity to do work. (E.6, 9.2)

English system

The system of units used in the United States and various other countries in which the inch is the unit of length.

the system of units used in the United States and various other countries in which the inch is the unit of length, the pound is the unit of force, and the ounce is the unit of mass. (E.2)

enthalpy (H)

The sum of the internal energy of a system and the product of its pressure and volume. (9.6)

enthalpy (heat) of reaction (ΔH_{rxn})

The heat that is emitted or absorbed during a chemical reaction under conditions of constant pressure. (9.6)

enthalpy of solution (ΔH_{soln})

The heat that is emitted or absorbed during a solution formation under conditions of constant pressure. (13.3)

entropy (S)

A thermodynamic function that is proportional to the number of energetically equivalent ways to arrange the components of a system to achieve a particular state; a measure of the energy randomization or energy dispersal in a system. (13.2, 18.3)

enzyme

A biochemical catalyst made of protein that increases the rates of biochemical reactions. (14.8)

equilibrium constant (K)

The ratio, at equilibrium, of the concentrations of the products of a reaction raised to their stoichiometric coefficients to the concentrations of the reactants raised to their stoichiometric coefficients. (15.3)

equivalence point

The point in a titration at which the added solute completely reacts with the solute present in the solution; for acid–base titrations, the point at which the amount of acid is stoichiometrically equal to the amount of base in solution. (8.7, 17.4)

ester

A member of the family of organic compounds with the general structure $\text{R}-\text{COO}-\text{R}$. (21.11)

ether

A member of the family of organic compounds of the form $\text{R}-\text{O}-\text{R}$. (21.12)

exact numbers

Numbers that have no uncertainty and thus do not limit the number of significant figures in any calculation. (E.4)

exothermic

Describes a process that releases heat to its surroundings. (E.5)

exothermic reaction

A chemical reaction that releases heat to its surroundings; for an exothermic reaction, $\Delta H < 0$ (9.6)

experiment

A highly controlled procedure designed to generate observations that may support a hypothesis or prove it wrong. (1.3)

exponential factor

A number between zero and one that represents the fraction of molecules that have enough energy to make it over the activation barrier on a given approach. (14.6)

exposure

The number of radioactive decay events to which a person is exposed. (20.11)

extensive property

A property that depends on the amount of a given substance, such as mass. (E.5)

face-centered cubic

A crystal structure in which the unit cell consists of a cube with one atom at each corner and one atom in the center of every face. (12.3)

family (group)

On the periodic table, one of the columns within the main group elements; a family or group of elements exhibits similar chemical properties. (3.2)

Faraday's constant (F)

The charge in coulombs of 1 mol of electrons: $F = \frac{96,485 \text{ C}}{\text{mol e}^-}$ (19.5)

first law of thermodynamics

The law that states that the total energy of the universe is constant. (9.3)

formal charge

The charge that an atom in a Lewis structure would have if all the bonding electrons were shared equally between the bonded atoms. (5.4)

formation constant (K_f)

The equilibrium constant associated with reactions for the formation of complex ions. (17.7)

formula mass

The average mass of a molecule of a compound in amu. (4.9)

formula unit

The smallest, electrically neutral collection of ions in an ionic compound. (4.5)

free energy of formation (ΔG_f°)

The change in free energy when 1 mol of a compound forms from its constituent elements in their standard states. (18.8)

free energy change of a reaction under nonstandard conditions

The change in free energy when 1 mol of a compound in its standard state forms from its constituent elements in their standard states; the free energy of formation of pure elements in their standard states is zero. (18.8)

free radical

A molecule or ion with an odd number of electrons in its Lewis structure. (5.5)

freezing

The phase transition from liquid to solid. (11.6)

freezing point depression

The effect of a solute that causes a solution to have a lower melting point than the pure solvent. (13.6)

frequency (ν)

For waves, the number of cycles (or complete wavelengths) that pass through a stationary point in one second. (2.2)

frequency factor (A)

The number of times that reactants approach the activation energy per unit time. (14.6)

fuel cell

A voltaic cell that uses the oxidation of hydrogen and the reduction of oxygen, forming water, to provide electrical current. (19.7)

fullerenes

Carbon clusters, such as C_{60} , bonded in roughly spherical shapes containing from 36 to over 100 carbon atoms. (12.6)

functional group

A characteristic atom or group of atoms that imparts certain chemical properties to an organic compound. (21.8)

gamma (γ) ray

The form of electromagnetic radiation with the shortest wavelength and highest energy. (2.2, 18.3)

gamma (γ) ray emission

The form of radioactive decay that occurs when an unstable nucleus emits extremely high-frequency electromagnetic radiation. (20.3)

gas

The state of matter in which atoms or molecules have a great deal of space between them and are free to move relative to one another; lacking a definite shape or volume, a gas conforms to the shape and volume of its container. (1.2)

gas-evolution reaction

A reaction in which two aqueous solutions are mixed and a gas forms, resulting in bubbling. (8.8)

Geiger-Müller counter

A device used to detect radioactivity that uses argon atoms, which become ionized in the presence of energetic particles to produce an electrical signal. (20.5)

geometric (cis-trans) isomerism

A form of stereoisomerism involving the orientation of functional groups in a molecule that contains bonds incapable of rotating. (21.5)

geometric isomers

For complex ions, isomers that result when the ligands bonded to the metal have a different spatial arrangement. (22.4)

Gibbs free energy (G)

A thermodynamic state function related to enthalpy and entropy by the equation $G = H - TS$; chemical systems tend toward lower Gibbs free energy, also called the *chemical potential*. (18.6)

glass

An amorphous form of silica. (12.7)

Graham's law of effusion

The law that states the ratio of effusion of two different gases is inversely proportional to the square root of the ratio of their molar masses. (10.9)

graphene

A fullerene consisting of bonded carbon atoms in sheet form one atom thick. (12.1)

graphite

An elemental form of carbon consisting of flat sheets of carbon atoms, bonded together as interconnected hexagonal rings held together by intermolecular forces, that can easily slide past each other. (12.6)

ground state

The lowest energy state of an atom or molecule. (3.3)

half-cell

One half of an electrochemical cell in which either oxidation or reduction occurs. (19.3)

half-life ($t_{1/2}$)

The time required for the concentration of a reactant or the amount of a radioactive isotope to fall to one-half of its initial value. (14.5)

halogen

One of the highly reactive nonmetals in group 7A of the periodic table. (3.5)

heat (q)

The flow of energy caused by a temperature difference. (9.2)

heat capacity (C)

The quantity of heat required to change a system's temperature by 1 °C. (9.4)

heat of fusion (ΔH_{fus})

The amount of heat required to melt 1 mole of a solid. (11.6)

heat of hydration ($\Delta H_{\text{hydration}}$)

The enthalpy change that occurs when 1 mole of gaseous solute ions is dissolved in water. (13.3)

heat (or enthalpy) of reaction (ΔH_{rxn})

The enthalpy change for a chemical reaction. (9.6)

heat (or enthalpy) of vaporization (ΔH_{vap})

The amount of heat required to vaporize one mole of a liquid to a gas. (11.5)

Heisenberg's uncertainty principle

The principle stating that due to the wave-particle duality, it is fundamentally impossible to precisely determine both the position and velocity of a particle at a given moment in time. (2.4)

Henderson-Hasselbalch equation

The equation used to easily calculate the pH of a buffer solution from the initial concentrations of the buffer components, assuming that the "x is small" approximation is valid; $\text{pH} = \text{p}K_{\text{a}} + \log \frac{[\text{base}]}{[\text{acid}]}$ (17.2)

Henry's law

The equation that expresses the relationship between solubility of a gas and pressure; $S_{\text{gas}} = k_{\text{H}}P_{\text{gas}}$ (13.4)

Hess's law

The law stating that if a chemical equation can be expressed as the sum of a series of steps, then ΔH_{rxn} for the overall equation is the sum of the heats of reactions for each step. (9.8)

heterogeneous catalysis

Catalysis in which the catalyst and the reactants exist in different phases. (14.8)

heterogeneous mixture

A mixture in which the composition varies from one region to another. (1.2)

hexagonal closest packing

A closest-packed arrangement in which the atoms of the third layer align exactly over those in the first layer. (12.3)

high-spin complex

A complex ion with weak field ligands that have the same number of unpaired electrons as the free metal ion. (22.5)

homogeneous catalysis

Catalysis in which the catalyst exists in the same phase as the reactants. (14.8)

homogeneous mixture

A mixture with the same composition throughout. (1.2)

Hund's rule

The principle stating that when electrons fill degenerate orbitals, they first fill them singly with parallel spins. (3.3)

hybrid orbitals

Orbitals that form from the combination of standard atomic orbitals and that correspond more closely to the actual distribution of electrons in a chemically bonded atom. (6.3)

hybridization

A mathematical procedure in which standard atomic orbitals are combined to form new, hybrid orbitals. (6.3)

hydrate

An ionic compound that contains a specific number of water molecules associated with each formula unit. (4.6)

hydrocarbon

An organic compound that contains only carbon and hydrogen. (4.12)

hydrogen bond

A strong dipole-dipole attractive force between a hydrogen bonded to O, N, or F and one of these electronegative atoms on a neighboring molecule. (11.3)

hydrogen bonding

The forming of a hydrogen bond. (11.3)

hydrogenation

The catalyzed addition of hydrogen to alkene double bonds to make single bonds. (14.8)

hydronium ion

H_3O^+ , the ion formed from the association of a water molecule with an H^+ ion donated by an acid. (8.7, 16.3)

hydroxyl group

In organic chemistry, an $-\text{OH}$ group. (21.9)

hypothesis

A tentative interpretation or explanation of an observation. A good hypothesis is *falsifiable*. (1.3)

hypoxia

A physiological condition caused by low levels of oxygen, marked by dizziness, headache, shortness of breath, and eventually unconsciousness or even death in severe cases. (10.7)

ideal gas

A gas in which interactions between particles and particles size are both negligible; a gas that behaves as described by the ideal gas law. (10.5)

ideal gas constant

The proportionality constant of the ideal gas law, R , equal to $8.314 \text{ J/mol} \cdot \text{K}$ or $0.08206 \text{ L} \cdot \text{atm/mol} \cdot \text{K}$. (10.5)

ideal gas law

The law that combines the relationships of Boyle's, Charles's, and Avogadro's laws into one comprehensive equation of state with the proportionality constant R in the form $PV = nRT$ (10.5)

Equation of state with the proportionality constant k in the form $p = nRT/V + a(n/V)^2$

ideal solution

A solution that follows Raoult's law at all concentrations for both solute and solvent. (13.6)

indeterminacy

The principle stating that present circumstances do not necessarily determine future events in the quantum-mechanical realm. (2.4)

indicator

A dye whose color depends on the pH of the solution in which it is dissolved; often used to detect the endpoint of a titration. (8.7, 17.4)

infrared (IR) radiation

Electromagnetic radiation emitted from warm objects, with wavelengths slightly larger than those of visible light. (2.2)

insoluble

Describes a compound that is incapable of dissolving in water or is extremely difficult to dissolve in water. (8.4)

integrated rate law

A relationship between the concentrations of the reactants in a chemical reaction and time. (14.5)

intensive property

A property such as density that is independent of the amount of a given substance. (E.5)

interference

The superposition of two or more waves overlapping in space, resulting in either an increase in amplitude (constructive interference) or a decrease in amplitude (destructive interference). (2.2)

internal energy (E)

The sum of the kinetic and potential energies of all the particles that compose a system. (9.3)

International System of Units (SI)

The standard unit system used by scientists, based on the metric system. (E.2)

ion

An atom or molecule with a net charge caused by the loss or gain of electrons. (1.8)

ion product constant for water (K_w)

The equilibrium constant for the autoionization of water. (16.6)

ion-dipole force

An intermolecular force between an ion and the oppositely charged end of a polar molecule. (11.3)

ionic bond

A chemical bond formed between two oppositely charged ions, generally a metallic cation and a nonmetallic anion, that are attracted to one another by electrostatic forces. (4.2)

ionic compound

A compound composed of cations and anions bound together by electrostatic attraction. (4.2)

ionic solid

A solid whose composite units are ions; ionic solids generally have high melting points. (12.4)

ionization energy (IE)

The energy required to remove an electron from an atom or ion in its gaseous state. (3.7)

ionizing power

The ability of radiation to ionize molecules and atoms. (20.3)

isomer

One of two or more molecules with the same chemical formula, but with a different structure. (6.3)

isotope

One of two or more atoms of the same element with the same number of protons but different numbers of neutrons and consequently different masses. (1.8)

joule (J)

The SI unit for energy: equal to $1 \text{ kg} \cdot \text{m}^2/\text{s}^2$ (E.6)

kelvin (K)

The SI standard unit of temperature. (E.2)

Kelvin scale

The temperature scale that assigns 0 K (-273°C or -459°F) to the coldest temperature possible, absolute zero, which is the temperature at which molecular motion virtually stops: $1 \text{ K} = 1^\circ\text{C}$ (E.2)

ketone

A member of the family of organic compounds that contain a carbonyl functional group ($\text{C}=\text{O}$) bonded to two R groups, neither of which is a hydrogen atom. (21.10)

kilogram (kg)

The SI standard unit of mass defined as the mass of a block of metal kept at the International Bureau of Weights and Measures at Sèvres, France. (E.2)

kilowatt-hour (kWh)

An energy unit used primarily to express large amounts of energy produced by the flow of electricity; equal to $3.60 \times 10^6 \text{ J}$ (E.6)

kinetic energy

The energy associated with motion of an object. (E.6, 9.2)

kinetic molecular theory

A model of an ideal gas as a collection of point particles in constant motion undergoing completely elastic collisions. (10.2)

lanthanide contraction

The trend toward leveling off in size of the atoms in the third and fourth transition rows due to the ineffective shielding of the *f* sublevel electrons. (22.2)

lattice energy

The energy associated with forming a crystalline lattice from gaseous ions. (4.5)

law

See *scientific law*.

law of conservation of energy

The law stating that energy can neither be created nor destroyed, only converted from one form to another. (E.6, 9.2)

law of conservation of mass

The law stating that matter is neither created nor destroyed in a chemical reaction. (1.3)

law of definite proportions

The law stating that all samples of a given compound have the same proportions of their constituent elements. (1.5)

law of mass action

The relationship between the balanced chemical equation and the expression of the equilibrium constant. (15.3)

law of multiple proportions

The law stating that when two elements (A and B) form two different compounds, the masses of element B that combine with one gram of element A can be expressed as a ratio of small whole numbers. (1.5)

Le Châtelier's principle

The principle stating that when a chemical system at equilibrium is disturbed, the system shifts in a direction that minimizes the disturbance. (15.9)

lead-acid storage battery

A battery that uses the oxidation of lead and the reduction of lead(IV) oxide in sulfuric acid to provide electrical current. (19.7)

leaded glass

A type of glass (often called *crystal*) that contains PbO. This type of glass has a higher index of refraction (it bends light more than ordinary glass), which results in more brilliant-looking glassware. (12.7)

levorotatory

Capable of rotating the polarization of light counterclockwise. (21.3)

Lewis acid

An atom, ion, or molecule that is an electron pair acceptor. (16.11)

Lewis base

An atom, ion, or molecule that is an electron pair donor. (16.11)

Lewis electron-dot structure (Lewis structure)

A drawing of a molecule that represents chemical bonds between atoms as shared or transferred electrons; the valence electrons of atoms are represented as dots. (4.4)

Lewis model

A simple model of chemical bonding that uses diagrams to represent bonds between atoms as lines or pairs of dots. In this model, atoms bond together to obtain stable octets (eight valence electrons). (4.4)

Lewis symbol

A symbol of an element in which dots represent valence electrons. (4.4)

ligand

A neutral molecule or an ion that acts as a Lewis base with the central metal ion in a complex ion. (17.7, 22.3)

limiting reactant

The reactant that has the smallest stoichiometric amount in a reactant mixture and consequently limits the amount of product in a chemical reaction. (7.5)

linear accelerator

A particle accelerator in which a charged particle is accelerated in an evacuated tube by a potential difference between the ends of the tube or by alternating charges in sections of the tube. (20.10)

linear geometry

The molecular geometry of three atoms that form a 180° bond angle which results from the repulsion of two

electron groups. (5.7)

linkage isomers

Isomers of complex ions that occur when some ligands coordinate to the metal in different ways. (22.4)

liquid

The state of matter in which atoms or molecules pack about as closely as they do in solid matter but are free to move relative to each other, resulting in a fixed volume but not a fixed shape. (1.2)

liter (L)

A unit of volume equal to 1000 cm³ or 1.057 qt. (E.2)

lithium ion battery

A battery that produces electrical current in the form of motion of lithium ions from the anode to the cathode. (19.7)

lone pair (nonbonding electrons)

A pair of electrons associated with only one atom. (4.7)

low-spin complex

A complex ion that has strong field ligands and has fewer unpaired electrons relative to the free metal ion. (22.5)

macrostate

The overall state of a system as defined by a given set of conditions (such as P , V , and T). (18.3)

magic numbers

Certain numbers of nucleons (N or $Z = 2, 8, 20, 28, 50, 82$ and $N = 126$) that confer unique stability. (20.4)

magnetic quantum number (m_l)

An integer that specifies the orientation of an orbital. (2.5)

main-group element

One of the elements found in the s or p block of the periodic table, whose properties tend to be predictable based on their position in the table. (3.2)

manometer

An instrument used to determine the pressure of a gaseous sample, consisting of a liquid-filled U-shaped tube with one end exposed to the ambient pressure and the other end connected to the sample. (10.3)

mass

A measure of the quantity of matter making up an object. (E.2)

mass defect

The difference in mass between the nucleus of an atom and the sum of the separated particles that make up that nucleus. (20.8)

mass number (A)

The sum of the number of protons and neutrons in an atom. (1.8)

mass percent composition (mass percent)

An element's percentage of the total mass of a compound containing the element. (4.10)

mass spectrometry

An experimental method of determining the precise mass and relative abundance of isotopes in a given sample using an instrument called a *mass spectrometer*. (1.9)

matter

Anything that occupies space and has mass. (1.1)

mean free path

The average distance that a molecule in a gas travels between collisions. (10.9)

melting (fusion)

The phase transition from solid to liquid. (11.6)

melting point

The temperature at which the molecules of a solid have enough thermal energy to overcome intermolecular forces and become a liquid. (11.6)

metal

A member of a large class of elements that are generally good conductors of heat and electricity, are malleable, ductile, and lustrous, and tend to lose electrons during chemical changes. (3.5)

metallic atomic solid

An atomic solid held together by metallic bonds; metallic atomic solids have variable melting points. (12.4)

metalloid

A member of a category of elements found on the boundary between the metals and nonmetals of the periodic table, with properties intermediate between those of both groups; metalloids are also called *semimetals*. (3.5)

meter (m)

The SI standard unit of length; equivalent to 39.37 inches. (E.2)

metric system

The system of measurements used in most countries in which the meter is the unit of length, the kilogram is the unit of mass, and the second is the unit of time. (E.2)

microstate

The exact distribution of internal energy at any one instant among the particles that compose a system. (18.3)

microwaves

Electromagnetic radiation with wavelengths slightly longer than those of infrared radiation; used for radar and in microwave ovens. (2.2)

milliliter (mL)

A unit of volume equal to 10^{-3} L or 1 cm^3 . (E.2)

millimeter of mercury (mmHg)

A common unit of pressure referring to the air pressure required to push a column of mercury to a height of 1 mm in a barometer; $760\text{ mmHg} = 1\text{ atm}$. (10.2)

miscibility

The ability of substances to mix without separating into two phases. (11.3)

miscible

The ability of two or more substances to be soluble in each other in all proportions. (13.2)

mixture

A substance composed of two or more different types of atoms or molecules that can be combined in variable proportions. (1.3)

molality (m)

A means of expressing solution concentration as the number of moles of solute per kilogram of solvent. (12.5)

A means of expressing solution concentration as the number of moles of solute per kilogram of solvent. (13.5)

molar heat capacity

The amount of heat required to raise the temperature of one mole of a substance by 1 °C. (9.4)

molar mass

The mass in grams of one mole of atoms of an element; numerically equivalent to the atomic mass of the element in amu. (1.10)

molar solubility

The solubility of a compound in units of moles per liter. (17.5)

molar volume

The volume occupied by one mole of a gas; the molar volume of an ideal gas at STP is 22.4 L. (10.6)

molarity (*M*)

A means of expressing solution concentration as the number of moles of solute per liter of solution. (8.2, 13.5)

mole (mol)

A unit defined as the amount of material containing 6.0221421×10^{23} (Avogadro's number) particles. (1.10)

mole fraction (χ_A)

The number of moles of a component in a mixture divided by the total number of moles in the mixture; a means of expressing solution concentration as the amount of solute in moles per total amount of solute and solvent in moles. (10.7, 13.5)

mole percent (mol %)

A means of expressing solution concentration as the mole fraction multiplied by 100%. (13.5)

molecular compound

A compound composed of two or more covalently bonded nonmetals. (4.2)

molecular element

One of a group of elements that exist in nature with diatomic or polyatomic molecules as their basic unit. (2.4)

molecular equation

An equation showing the complete neutral formula for each compound in a reaction. (8.6)

molecular formula

A chemical formula that shows the actual number of atoms of each element in a molecule of a compound. (4.3)

molecular geometry

The geometrical arrangement of atoms in a molecule. (5.8)

molecular orbital (MO)

A mathematical function that represents a state of an electron in a molecule. (6.4)

molecular orbital (MO) diagram

An energy diagram showing the atomic orbitals of the atoms that compose a molecule, the molecular orbitals of the molecule, their relative energies, and the placement of the valence electrons in the molecular orbitals. (6.4)

molecular orbital (MO) theory

An advanced model of chemical bonding in which electrons reside in molecular orbitals delocalized over the entire molecule. In the simplest version, the molecular orbitals are simply linear combinations of atomic orbitals. (6.4)

molecular solid

A solid whose composite units are molecules; molecular solids generally have low melting points. (12.4)

molecularity

The number of reactant particles involved in an elementary step. (14.7)

molecule

Two or more atoms joined chemically in a specific geometrical arrangement. (1.1)

monodentate

Describes ligands that donate only one electron pair to the central metal. (22.3)

monomer

A repeating unit in a polymer. (12.9)

monoprotic acid

An acid that contains only one ionizable proton. (16.5)

nanotube

A long, tubular structure consisting of interconnected C₆ rings. (12.7)

natural abundance

The relative percentage of a particular isotope in a naturally occurring sample with respect to other isotopes of the same element. (1.8)

Nernst equation

The equation relating the cell potential of an electrochemical cell to the standard cell potential and the reaction quotient; $E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0592 \text{ V}}{n} \log Q$ (19.6)

net ionic equation

An equation that shows only the species that actually change during a reaction. (8.6)

network covalent atomic solid

An atomic solid held together by covalent bonds; network covalent atomic solids have high melting points. (12.4)

neutral

Describes the state of a solution in which the concentrations of H₃O⁺ and OH⁻ are equal. (16.6)

neutron

An electrically neutral subatomic particle found in the nucleus of an atom, with a mass almost equal to that of a proton. (1.7)

nickel-cadmium (NiCad) battery

A battery that consists of an anode composed of solid cadmium and a cathode composed of NiO(OH)(s) in a KOH solution. (19.7)

nickel-metal hydride (NiMH) battery

A battery that uses the same cathode reaction as the NiCad battery but a different anode reaction, the oxidation of hydrogens in a metal alloy. (19.7)

nitrogen narcosis

A physiological condition caused by an increased partial pressure of nitrogen, resulting in symptoms similar to those of intoxication. (10.7)

noble gas

One of the group 8A elements, which are largely unreactive (inert) due to their stable filled *p* orbitals. (3.5)

node

A point where the wave function (ψ), and therefore the probability density (ψ^2) and radial distribution function, all go through zero. (2.6)

nonbonding atomic solid

An atomic solid held together by dispersion forces; nonbonding atomic solids have low melting points. (12.4)

nonbonding orbital

An orbital whose electrons remain localized on an atom. (6.4)

nonelectrolyte

A compound that does not dissociate into ions when dissolved in water. (8.4)

nonmetal

A member of a class of elements that tend to be poor conductors of heat and electricity and usually gain electrons during chemical reactions. (3.5)

nonvolatile

Not easily vaporized. (11.5)

normal boiling point

The temperature at which the vapor pressure of a liquid equals 1 atm. (11.5)

n-type semiconductor

A semiconductor that employs negatively charged electrons in the conduction band as the charge carriers. (12.8)

nuclear binding energy

The amount of energy required to break apart the nucleus into its component nucleons. (20.8)

nuclear equation

An equation that represents nuclear processes such as radioactivity. (20.3)

nuclear fission

The splitting of the nucleus of an atom, which results in a tremendous release of energy. (20.7)

nuclear fusion

The combination of two light nuclei to form a heavier one. (20.9)

nuclear theory

The theory that most of the atom's mass and all of its positive charge are contained in a small, dense nucleus. (1.7)

nucleon

One of the particles that compose the nucleus, which are protons and neutrons. (20.4)

nucleus

The very small, dense core of the atom that contains most of the atom's mass and all of its positive charge; the nucleus is composed of protons and neutrons. (1.7)

nuclide

A particular isotope of an atom. (20.3)

octahedral geometry

The molecular geometry of seven atoms with 90° bond angles. (5.7)

octahedral hole

A space that exists in the middle of six atoms on two adjacent close-packed sheets of atoms in a crystal lattice. (22.4)

octet

A Lewis symbol with eight dots, signifying a filled outer electron shell for *s* and *p* block elements. (4.4)

octet rule

The tendency for most bonded atoms to possess or share eight electrons in their outer shell in order to obtain stable electron configurations and lower their potential energy. (4.4)

optical isomers

Two molecules that are nonsuperimposable mirror images of one another; enantiomers. (21.3, 22.4)

orbital

A probability distribution map, based on the quantum-mechanical model of the atom, used to describe the likely position of an electron in an atom; also an allowed energy state for an electron. (2.5)

orbital diagram

A diagram similar to an electron configuration that symbolizes an electron as an arrow in a box representing an orbital, with the arrow's direction denoting the electron's spin. (3.3)

organic chemistry

The study of carbon-based compounds. (21.1)

organic compound

A compound containing carbon combined with several other elements including hydrogen, nitrogen, oxygen, or sulfur. (4.12)

organic molecule

A molecule containing carbon combined with several other elements including hydrogen, nitrogen, oxygen, or sulfur. (21.1)

orientation factor

In collision theory, a variable that is a measure of how specific the orientation of the colliding molecules must be. A large orientation factor (near 1) indicates that the colliding molecules can have virtually any orientation and the reaction will still occur. A small orientation factor indicates that the colliding molecules must have a highly specific orientation for the reaction to occur. (14.6)

osmosis

The flow of solvent from a solution of lower solute concentration to one of higher solute concentration. (13.6)

osmotic pressure

The pressure required to stop osmotic flow. (13.6)

overall order

The sum of the orders of all reactants in a chemical reaction. (14.4)

oxidation

The loss of one or more electrons; also the gaining of oxygen or the loss of hydrogen. (8.9)

oxidation state (oxidation number)

A positive or negative whole number that represents the "charge" that an atom in a compound would have if all shared electrons were assigned to the atom that holds a greater attraction for those electrons. (8.9)

oxidation-reduction (redox) reaction

A reaction in which electrons are transferred from one reactant to another and the oxidation states of certain

atoms are changed. (8.9)

oxidizing agent

A substance that causes the oxidation of another substance; an oxidizing agent gains electrons and is reduced. (8.9)

oxyacid

An acid composed of hydrogen and an oxyanion. (8.7)

oxyanion

A polyatomic anion containing a nonmetal covalently bonded to one or more oxygen atoms. (4.6)

oxygen toxicity

A physiological condition caused by an increased level of oxygen in the blood, resulting in muscle twitching, tunnel vision, and convulsions. (10.7)

packing efficiency

The percentage of volume of a unit cell occupied by the atoms, assumed to be spherical. (12.3)

paramagnetic

The state of an atom or ion that contains unpaired electrons and is, therefore, attracted by an external magnetic field. (3.7)

partial pressure (P_n)

The pressure due to any individual component in a gas mixture. (10.7)

parts by mass

A unit for expressing solution concentration as the mass of the solute divided by the mass of the solution multiplied by a multiplication factor. (13.5)

parts by volume

A unit for expressing solution concentration as the volume of the solute divided by the volume of the solution multiplied by a multiplication factor. (13.5)

parts per billion (ppb)

A unit for expressing solution concentration in parts by mass in which the multiplication factor is 10^9 . (13.5)

parts per million (ppm)

A unit for expressing solution concentration in parts by mass in which the multiplication factor is 10^6 . (13.5)

pascal (Pa)

The SI unit of pressure, defined as 1 N/M^2 . (10.2)

Pauli exclusion principle

The principle stating that no two electrons in an atom can have the same four quantum numbers. (3.3)

penetrating power

The ability of radiation to penetrate matter. (20.3)

penetration

The phenomenon in which some higher-level atomic orbitals have significant amounts of probability within the space occupied by orbitals of lower energy level. For example, the 2s orbital penetrates into the 1s orbital. (3.3)

percent by mass

A unit for expressing solution concentration in parts by mass with a multiplication factor of 100%. (13.5)

percent ionic character

The ratio of a bond's actual dipole moment to the dipole moment it would have if the electron were transferred completely from one atom to the other, multiplied by 100%. (5.2)

percent ionization

The concentration of ionized acid in a solution divided by the initial concentration of acid multiplied by 100%. (16.7)

percent yield

The percentage of the theoretical yield of a chemical reaction that is actually produced; the ratio of the actual yield to the theoretical yield multiplied by 100%. (7.5)

periodic law

The law based on the observation that when the elements are arranged in order of increasing mass, certain sets of properties recur periodically. (3.2)

periodic property

A property of an element that is predictable based on an element's position in the periodic table. (3.1)

periodic table

The table that arranges all known elements in order of increasing atomic number; elements with similar properties generally fall into columns on the periodic table. (1.8)

permanent dipole

A permanent separation of charge; a molecule with a permanent dipole always has a slightly negative charge at one end and a slightly positive charge at the other. (11.3)

pH

The negative log of the concentration of H_3O^+ in a solution; the pH scale is a compact way to specify the acidity of a solution. (16.6)

phase

With regard to waves and orbitals, the sign of the amplitude of the wave, which can be positive or negative. (2.6)

phase diagram

A map of the state (or phase) of a substance as a function of pressure and temperature. (11.8)

phenyl group

A benzene ring treated as a substituent. (21.7)

phosphorescence

The long-lived emission of light that sometimes follows the absorption of light by certain atoms and molecules. (20.2)

photoelectric effect

The observation that many metals emit electrons when light falls upon the metal. (2.2)

photon (quantum)

The smallest possible packet of electromagnetic radiation with an energy equal to $h\nu$. (2.2)

physical change

A change that alters the state or appearance of a substance but not its chemical composition. (7.2)

physical property

A property that a substance displays without changing its chemical composition. (7.2)

p orbital bond

The bond that forms between two p orbitals that overlap side to side. (6.3)

p-n junctions

Tiny areas in electronic circuits that have p-type semiconductors on one side and n-type on the other. (12.8)

polar covalent bond

A covalent bond between two atoms with significantly different electronegativities, resulting in an uneven distribution of electron density. (5.2)

polyatomic ion

An ion composed of two or more atoms. (4.6)

polydentate

Describes ligands that donate more than one electron pair to the central metal. (22.3)

polymer

A long chain-like molecule composed of many repeating units. (12.9)

polyprotic acid

An acid that contains more than one ionizable proton and releases them sequentially. (8.7, 16.8)

Portland cement

A powdered mixture consisting mostly of limestone (CaCO_3) and silica (SiO_2), with smaller amounts of alumina (Al_2O_3), iron(III) oxide (Fe_2O_3) and gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). (12.7)

positron

The particle released in positron emission; equal in mass to an electron but opposite in charge. (20.3)

positron emission

The form of radioactive decay that occurs when an unstable nucleus emits a positron. (20.3)

positron emission tomography (PET)

A specialized imaging technique that employs positron-emitting nuclides, such as fluorine-18, as a radiotracer. (20.12)

potential difference

A measure of the difference in potential energy (usually in joules) per unit of charge (coulombs). (19.3)

potential energy

The energy associated with the position or composition of an object. (E.6, 9.2)

precipitate

A solid, insoluble ionic compound that forms in, and separates from, a solution. (8.5)

precipitation reaction

A reaction in which a solid, insoluble product forms upon mixing two solutions. (8.5)

precision

A term that refers to how close a series of measurements are to one another or how reproducible they are. (E.3)

prefix multipliers

Multipliers that change the value of the unit by powers of ten. (E.2)

pressure

A measure of force exerted per unit area; in chemistry, most commonly the force exerted by gas molecules as they strike the surfaces around them. (10.1)

pressure-volume work

The work that occurs when a volume change takes place against an external pressure. (9.4)

primary valence

The oxidation state on the central metal atom in a complex ion. (22.3)

principal level (shell)

The group of orbitals with the same value of n . (2.5)

principal quantum number (n)

An integer that specifies the overall size and energy of an orbital; the higher the quantum number n , the greater the average distance between the electron and the nucleus and the higher its energy. (2.5)

probability density

The probability (per unit volume) of finding the electron at a point in space as expressed by a three-dimensional plot of the wave function squared (ψ^2). (2.6)

product

A substance produced in a chemical reaction; products appear on the right-hand side of a chemical equation. (7.3)

proton

A positively charged subatomic particle found in the nucleus of an atom. (1.7)

p-type semiconductor

A semiconductor that employs positively charged "holes" in the valence band as the charge carriers. (12.8)

pure substance

A substance composed of only one type of atom or molecule. (1.2)

quantum number

One of four interrelated numbers that determine the shape and energy of orbitals, as specified by a solution of the Schrödinger equation. (2.5)

quantum-mechanical model

A model that explains the behavior of absolutely small particles such as electrons and photons. (2.1)

quartz

A silicate crystal that has a formula unit of SiO_2 . (12.6)

racemic mixture

An equimolar mixture of two optical isomers that does not rotate the plane of polarization of light at all. (21.3)

radial distribution function

A mathematical function that represents the total probability of finding the electron within a thin spherical shell at a distance r from the nucleus in an atom. (2.6)

radio wave

The form of electromagnetic radiation with the longest wavelengths and smallest energy. (2.2)

radioactive

Describes the state of unstable atoms that emit subatomic particles or high-energy electromagnetic radiation. (20.1)

radioactivity

The emission of subatomic particles or high-energy electromagnetic radiation by the unstable nuclei of certain atoms. (1.7, 20.1)

radiocarbon dating

A form of radiometric dating based on the C-14 isotope. (20.6)

radiometric dating

A technique used to estimate the age of rocks, fossils, or artifacts that depends on the presence of radioactive isotopes and the predictable decay of those isotopes over time. (20.6)

radiotracer

A radioactive nuclide attached to a compound or introduced into a mixture in order to track the movement of the compound or mixture within the body. (20.12)

random error

Error that has equal probability of being too high or too low. (E.3)

Raoult's law

The equation used to determine the vapor pressure of a solution; $P_{\text{soln}} = X_{\text{solv}} P_{\text{solv}}^{\circ}$ (13.6)

rate constant (k)

The constant of proportionality in the rate law. (14.4)

rate law

The relationship between the rate of a reaction and the concentration of the reactants. (14.4)

rate-determining step

The step in a reaction mechanism that occurs more slowly than any of the other steps. (14.7)

reactant

A starting substance in a chemical reaction; reactants appear on the left-hand side of a chemical equation. (7.3)

reaction intermediate

Species that forms in one step of a reaction mechanism and is consumed in another. (14.7)

reaction mechanism

A series of individual chemical steps by which an overall chemical reaction occurs. (14.7)

reaction order (n)

The value in the rate law that determines how the rate depends on the concentration of the reactants. (14.4)

reaction quotient (Q_c)

The ratio, at any point in the reaction, of the concentrations of the products of a reaction raised to their stoichiometric coefficients to the concentrations of the reactants raised to their stoichiometric coefficients. (15.7)

recrystallization

A technique used to purify solids in which the solid is put into hot solvent until the solution is saturated; when the solution cools, the purified solute comes out of solution. (13.4)

reducing agent

A substance that causes the reduction of another substance; a reducing agent loses electrons and is oxidized. (8.9)

reduction

The gaining of one or more electrons; also the gaining of hydrogen or the loss of oxygen. (8.9)

rem

The unit of radiation exposure that stands for roentgen equivalent man; a roentgen is the amount of radiation that produces 2.58×10^{-4} C of charge per kg of air. (20.11)

resonance hybrid

The actual structure of a molecule that is intermediate between two or more resonance structures. (5.4)

resonance structure

One of two or more valid Lewis structures shown with double-headed arrows between them to indicate that the actual structure of the molecule is intermediate between them. (5.4)

reversible

As applied to a reaction, describes the ability to proceed in either the forward or the reverse direction. (15.2)

reversible process

A process that reverses direction upon an infinitesimally small change in some property. (18.4)

salt

An ionic compound formed in a neutralization reaction by the replacement of an H^+ ion from the acid with a cation from the base. (8.7)

salt bridge

An inverted, U-shaped tube containing a strong electrolyte such as KNO_3 that connects two half-cells, allowing a flow of ions that neutralizes charge buildup. (19.3)

saturated hydrocarbon

A hydrocarbon containing no double bonds in the carbon chain. (21.4)

saturated solution

A solution in which the dissolved solute is in dynamic equilibrium with any undissolved solute; any added solute will not dissolve. (13.4)

scientific law

A brief statement or equation that summarizes past observations and predicts future ones. (1.3)

scintillation counter

A device for the detection of radioactivity that includes a material that emits ultraviolet or visible light in response to excitation by energetic particles. (20.5)

second (s)

The SI standard unit of time, defined as the duration of 9,192,631,770 periods of the radiation emitted from a certain transition in a cesium-133 atom. (E.2)

second law of thermodynamics

The law stating that for any spontaneous process, the entropy of the universe increases ($\Delta S_{\text{univ}} > 0$) (18.3)

secondary valence

The number of molecules or ions directly bound to the metal atom in a complex ion; also called the *coordination number*. (22.3)

seesaw geometry

The molecular geometry of a molecule with trigonal bipyramidal electron geometry and one lone pair in an axial position. (5.8)

selective precipitation

A process involving the addition of a reagent to a solution that forms a precipitate with one of the dissolved ions but not the others. (17.6)

semiconductor

A material with intermediate electrical conductivity that can be changed and controlled. (3.5)

semipermeable membrane

A membrane that selectively allows some substances to pass through but not others. (13.6)

shielding

The effect on an electron of repulsion by electrons in lower-energy orbitals that screen it from the full effects of nuclear charge. (3.3)

sigma (σ) bond

The bond that forms between a combination of any two s , p , or hybridized orbitals that overlap end to end. (6.3)

significant figures (significant digits)

In any reported measurement, the non-place-holding digits that indicate the precision of the measured quantity. (E.4)

silica

A silicate crystal that has a formula unit of SiO_2 , also called *quartz*. (12.6)

silicate

A covalent atomic solid that contains silicon, oxygen, and various metal atoms. (12.6)

simple cubic

A unit cell that consists of a cube with one atom at each corner. (12.3)

soda-lime glass

A type of glass that is about 70% SiO_2 with the balance being mostly Na_2O and CaO . This type of glass is transparent to visible light (not ultraviolet) and has a high thermal expansion, but it is less expensive to make and form into desired shapes than vitreous silica. (12.7)

solid

The state of matter in which atoms or molecules are packed close to one another in fixed locations with definite volume. (1.2)

solubility

The amount of a substance that will dissolve in a given amount of solvent. (13.2)

solubility product constant (K_{sp})

The equilibrium expression for a chemical equation representing the dissolution of a slightly to moderately soluble ionic compound. (17.5)

soluble

Describes a compound that is able to dissolve to a significant extent, usually in water. (8.4)

solute

The minority component of a solution. (8.2, 13.1)

solution

A homogeneous mixture of two substances. (8.2, 13.1)

solvent

The majority component of a solution. (8.2, 13.1)

space-filling molecular model

A representation of a molecule that shows how the atoms fill the space between them. (4.3)

specific heat capacity (C_s)

The amount of heat required to raise the temperature of 1 g of a substance by 1 °C (9.4)

spectator ion

An ion in a complete ionic equation that does not participate in the reaction and therefore remains in solution. (8.6)

spin quantum number (m_s)

The fourth quantum number, which denotes the electron's spin as either 1/2 (up arrow) or -1/2 (down arrow). (2.5)

spontaneous process

A process that occurs without ongoing outside intervention. (18.2)

square planar geometry

The molecular geometry of a molecule with octahedral electron geometry and two lone pairs. (5.8)

square pyramidal geometry

The molecular geometry of a molecule with octahedral electron geometry and one lone pair. (5.8)

standard cell potential (standard emf) (E_{cell}°)

The cell potential for a system in standard states (solute concentration of 1 M and gaseous reactant partial pressure of 1 atm). (19.3)

standard change in free energy ($\Delta G_{\text{rxn}}^\circ$)

The change in free energy for a process when all reactants and products are in their standard states. (18.8)

standard electrode potential

A measure of the potential energy experienced by charged particles at an electrode in an electrochemical cell; the standard cell potential is the difference between the standard electrode potentials of the anode and cathode. (19.4)

standard enthalpy change (ΔH°)

The change in enthalpy for a process when all reactants and products are in their standard states. (9.10)

standard enthalpy (or heat) of formation (ΔH_f°)

The change in enthalpy when 1 mol of a compound forms from its constituent elements in their standard states. (9.10)

standard entropy change for a reaction ($\Delta S_{\text{rxn}}^\circ$)

The change in entropy for a process in which all reactants and products are in their standard states. (18.7)

standard hydrogen electrode (SHE)

A half-cell consisting of an inert platinum electrode immersed in 1 M HCl with hydrogen gas at 1 atm bubbling through the solution; used as the standard of a cell potential of zero. (19.4)

standard molar entropy (S°)

The measure of the energy dispersed into one mole of a substance at a particular temperature. (18.7)

standard state

For a gas the standard state is the pure gas at a pressure of exactly 1 atm; for a liquid or solid the standard state is the pure substance in its most stable form at a pressure of 1 atm and the temperature of interest (often taken to be 25 °C); for a substance in solution the standard state is a concentration of exactly 1 M. (9.10)

standard temperature and pressure (STP)

Conditions of $T = 0\text{ }^{\circ}\text{C}$ (273 K) and $P = 1$ used primarily in reference to a gas. (10.6)

state

A classification of a form of matter as a solid, liquid, or gas. (1.2)

state function

A function whose value depends only on the state of the system, not on how the system got to that state. (9.3)

stereoisomers

Molecules in which the atoms are bonded in the same order but have a different spatial arrangement. (21.3, 22.4)

stock solution

A highly concentrated form of a solution used in laboratories to make less concentrated solutions via dilution. (8.2)

stoichiometry

The numerical relationships between amounts of reactants and products in a balanced chemical equation. (7.4)

strong acid

An acid that completely ionizes in solution. (8.4, 16.3)

strong base

A base that completely dissociates in solution. (16.3)

strong electrolyte

A substance that completely dissociates into ions when dissolved in water. (8.4)

strong force

Of the four fundamental forces of physics, the one that is the strongest but acts over the shortest distance; the strong force is responsible for holding the protons and neutrons together in the nucleus of an atom. (20.4)

strong-field complex

A complex ion in which the crystal field splitting is large. (22.5)

structural formula

A molecular formula that shows how the atoms in a molecule are connected or bonded to each other. (4.3, 21.3)

structural isomers

Molecules with the same molecular formula but different structures. (21.3, 22.4)

sublevel (subshell)

Those orbitals in the same principal level with the same value of n and l . (2.5)

sublimation

The phase transition from solid to gas. (11.6)

substance

A specific instance of matter. (1.2)

substitution reaction

A chemical reaction in which one atom or group of atoms takes the place of another atom or group of atoms. (21.6)

substrate

The reactant molecule of a biochemical reaction that binds to an enzyme at the active site. (14.8)

supersaturated solution

An unstable solution in which more than the equilibrium amount of solute is dissolved. (13.4)

surface tension

The energy required to increase the surface area of a liquid by a unit amount; responsible for the tendency of liquids to minimize their surface area, giving rise to a membrane-like surface. (11.4)

surroundings

In thermodynamics, everything in the universe that exists outside the system under investigation. (9.2)

system

In thermodynamics, the portion of the universe that is singled out for investigation. (9.2)

systematic error

Error that tends toward being consistently either too high or too low. (E.3)

systematic name

The official name based on well-established rules for a compound, which can be determined by examining its chemical structure. (4.6)

temperature

A measure of the average kinetic energy of the atoms or molecules that compose a sample of matter. (E.6)

termolecular

Describes an elementary step of a reaction in which three particles collide and go on to form products. (14.7)

tetrahedral geometry

The molecular geometry of five atoms with 109.5° bond angles. (5.7)

tetrahedral hole

A space that exists directly above the center point of three closest-packed metal atoms in one plane and a fourth metal located directly above the center point in the adjacent plane in a crystal lattice. (12.4)

theoretical yield

The greatest possible amount of product that can be produced in a chemical reaction based on the amount of limiting reactant. (7.5)

theory

A proposed explanation for observations and laws, based on well-established and tested hypotheses; a theory presents a model of the way nature works and predicts behavior beyond the observations and laws on which it was based. (1.3)

thermal energy

The type of kinetic energy associated with the temperature of an object, arising from the motion of individual atoms or molecules in the object; see also *heat*. (E.6, 9.2)

thermal equilibrium

The point at which there is no additional net transfer of heat between a system and its surroundings. (9.4)

thermochemistry

The study of the relationship between chemistry and energy. (9.1)

thermodynamics

The general study of energy and its interconversions. (9.3)

thermoluminescent dosimeter

thermoluminescent dosimeter

A device used to measure the dose of radiation to which a person is exposed. (20.5)

third law of thermodynamics

The law stating that the entropy of a perfect crystal at absolute zero (0 K) is zero. (18.7)

titration

A laboratory procedure in which a substance in a solution of known concentration is reacted with another substance in a solution of unknown concentration in order to determine the unknown concentration; see also *acid-base titration*. (8.7)

torr

A unit of pressure equivalent to 1/760 of an atmosphere (atm); named after Evangelista Torricelli. (10.3)

transition element (transition metal)

One of the elements found in the *d* block of the periodic table whose properties tend to be less predictable based simply on their position in the table. (3.2)

transmutation

The transformation of one element into another as a result of nuclear reactions. (20.10)

trigonal bipyramidal geometry

The molecular geometry of six atoms with 120° bond angles between the three equatorial electron groups and 90° bond angles between the two axial electron groups and the trigonal plane. (5.7)

trigonal planar geometry

The molecular geometry of four atoms with 120° bond angles in a plane. (5.7)

trigonal pyramidal geometry

The molecular geometry of a molecule with tetrahedral electron geometry and one lone pair. (5.8)

triple bond

A bond that forms when three electron pairs are shared between two atoms. (4.7)

triple point

The unique set of conditions at which all three phases of a substance are equally stable and in equilibrium. (11.8)

triprotic acid

An acid that contains three ionizable protons. (16.5)

T-shaped geometry

The molecular geometry of a molecule with trigonal bipyramidal electron geometry and two lone pairs in axial positions. (5.8)

ultraviolet (UV) radiation

Electromagnetic radiation with slightly smaller wavelengths than visible light. (2.2)

unimolecular

Describes a reaction that involves only one particle that goes on to form products. (14.7)

unit

A standard quantity used to specify measurements. (E.1)

unit cell

The smallest divisible unit of a crystal that, when repeated in three dimensions, reproduces the entire crystal lattice. (12.3)

unsaturated hydrocarbon

A hydrocarbon that includes one or more double or triple bonds. (21.5)

unsaturated solution

A solution containing less than the equilibrium amount of solute; any added solute will dissolve until equilibrium is reached. (13.4)

valence band

In band theory, the band of energy levels that forms from bonding molecular orbitals. (12.8)

valence bond theory

An advanced model of chemical bonding in which electrons reside in quantum-mechanical orbitals localized on individual atoms that are a hybridized blend of standard atomic orbitals; chemical bonds result from an overlap of these orbitals. (6.2)

valence electrons

The electrons that are important in chemical bonding. For main-group elements, the valence electrons are those in the outermost principal energy level. (3.4)

valence shell electron pair repulsion (VSEPR) theory

A theory that allows prediction of the shapes of molecules based on the idea that electrons—either as lone pairs or as bonding pairs—repel one another. (5.7)

van der Waals equation

The extrapolation of the ideal gas law that considers the effects of intermolecular forces and particle volume in a nonideal gas; $P + a\left(\frac{n}{V}\right)^2 \times (V - nb) = nRT$ (10.11)

van der Waals radius (nonbonding atomic radius)

One-half the distance between the centers of adjacent, nonbonding atoms in a crystal. (3.6)

van't Hoff factor (*i*)

The ratio of moles of particles in a solution to moles of formula units dissolved. (13.7)

vapor pressure

The partial pressure of a vapor that is in dynamic equilibrium with its liquid. (10.7, 11.5)

vaporization

The phase transition from liquid to gas. (11.5)

viscosity

A measure of the resistance of a liquid to flow. (11.4)

visible light

Electromagnetic radiation with frequencies that can be detected by the human eye. (2.2)

vitreous silica (fused silica)

A type of glass that is hard, resists high temperatures, has a low thermal expansion, and is transparent to both visible light and ultraviolet light. (12.7)

volatile

Tending to vaporize easily. (11.5)

voltaic (galvanic) cell

An electrochemical cell that produces electrical current from a spontaneous chemical reaction. (19.3)

volt (V)

The SI unit used to measure potential difference; equivalent to 1 J/C. (19.3)

volume (V)

A measure of space. Any unit of length, when cubed (raised to the third power), becomes a unit of volume. (E.2)

wave function (ψ)

The mathematical function that describes the wavelike nature of the electron. (2.5)

wavelength (λ)

The distance between adjacent crests of a wave. (2.2)

weak acid

An acid that does not completely ionize in water. (8.4, 16.3)

weak base

A base that only partially ionizes in water. (16.3)

weak electrolyte

A substance that does not completely ionize in water and only weakly conducts electricity in solution. (8.4)

weak-field complex

A complex ion in which the crystal field splitting is small. (22.5)

work (w)

The result of a force acting through a distance. (E.6, 9.2)

X-ray

Electromagnetic radiation with wavelengths slightly longer than those of gamma rays; used to image bones and internal organs. (2.2)

X-ray diffraction

A powerful laboratory technique that allows for the determination of the arrangement of atoms in a crystal and the measuring of the distance between them. (12.2)

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