

Glossary

- Accuracy** the agreement of a particular value with the true value. (1.4)
- Acid** a substance that produces hydrogen ions in solution; a proton donor. (2.8; 4.2; 4.8)
- Acid–base indicator** a substance that marks the end point of an acid–base titration by changing color. (15.5)
- Acid dissociation constant (K_a)** the equilibrium constant for a reaction in which a proton is removed from an acid by H_2O to form the conjugate base and H_3O^+ . (14.1)
- Acid rain** a result of air pollution by sulfur dioxide. (5.10)
- Acidic oxide** a covalent oxide that dissolves in water to give an acidic solution. (14.10)
- Actinide series** a group of 14 elements following actinium in the periodic table, in which the $5f$ orbitals are being filled. (7.11; 19.1)
- Activated complex (transition state)** the arrangement of atoms found at the top of the potential energy barrier as a reaction proceeds from reactants to products. (12.7)
- Activation energy** the threshold energy that must be overcome to produce a chemical reaction. (12.7)
- Addition polymerization** a type of polymerization in which the monomers simply add together to form the polymer, with no other products. (22.5)
- Addition reaction** a reaction in which atoms add to a carbon–carbon multiple bond. (22.2)
- Adsorption** the collection of one substance on the surface of another. (12.8)
- Air pollution** contamination of the atmosphere, mainly by the gaseous products of transportation and production of electricity. (5.10)
- Alcohol** an organic compound in which the hydroxyl group is a substituent on a hydrocarbon. (22.4)
- Aldehyde** an organic compound containing the carbonyl group bonded to at least one hydrogen atom. (22.4)
- Alkali metal** a Group 1A metal. (2.7; 19.2)
- Alkaline earth metal** a Group 2A metal. (2.7; 19.4)
- Alkane** a saturated hydrocarbon with the general formula C_nH_{2n+2} . (22.1)
- Alkene** an unsaturated hydrocarbon containing a carbon–carbon double bond. The general formula is C_nH_{2n} . (22.2)
- Alkyne** an unsaturated hydrocarbon containing a triple carbon–carbon bond. The general formula is C_nH_{2n-2} . (22.2)
- Alloy** a substance that contains a mixture of elements and has metallic properties. (10.4)
- Alloy steel** a form of steel containing carbon plus other metals such as chromium, cobalt, manganese, and molybdenum. (21.8)
- Alpha (α) particle** a helium nucleus. (18.1)
- Alpha-particle production** a common mode of decay for radio-active nuclides in which the mass number changes. (18.1)
- Amine** an organic base derived from ammonia in which one or more of the hydrogen atoms are replaced by organic groups. (14.6; 22.4)
- α -Amino acid** an organic acid in which an amino group and an R group are attached to the carbon atom next to the carboxyl group. (22.6)
- Amorphous solid** a solid with considerable disorder in its structure. (10.3)
- Ampere** the unit of electric current equal to one coulomb of charge per second. (17.7)
- Amphoteric substance** a substance that can behave either as an acid or as a base. (14.2)
- Angular momentum quantum number (ℓ)** the quantum number relating to the shape of an atomic orbital, which can assume any integral value from 0 to $n - 1$ for each value of n . (7.6)
- Anion** a negative ion. (2.6)
- Anode** the electrode in a galvanic cell at which oxidation occurs. (17.1)
- Antibonding molecular orbital** an orbital higher in energy than the atomic orbitals of which it is composed. (9.2)
- Aqueous solution** a solution in which water is the dissolving medium or solvent. (4)
- Aromatic hydrocarbon** one of a special class of cyclic unsaturated hydrocarbons, the simplest of which is benzene. (22.3)
- Arrhenius concept** a concept postulating that acids produce hydrogen ions in aqueous solution, while bases produce hydroxide ions. (14.1)
- Arrhenius equation** the equation representing the rate constant as $k = Ae^{-E_a/RT}$, where A represents the product of the collision frequency and the steric factor, and $e^{-E_a/RT}$ is the fraction of collisions with sufficient energy to produce a reaction. (12.7)
- Atactic chain** a polymer chain in which the substituent groups such as CH_3 are randomly distributed along the chain. (22.5)
- Atmosphere** the mixture of gases that surrounds the earth's surface. (5.10)
- Atomic number** the number of protons in the nucleus of an atom. (2.5; 18)
- Atomic radius** half the distance between the nuclei in a molecule consisting of identical atoms. (7.12)
- Atomic solid** a solid that contains atoms at the lattice points. (10.3)
- Atomic weight** the weighted average mass of the atoms in a naturally occurring element. (2.3)
- Aufbau principle** the principle stating that as protons are added one by one to the nucleus to build up the elements, electrons are similarly added to hydrogen-like orbitals. (7.11)
- Autoionization** the transfer of a proton from one molecule to another of the same substance. (14.2)
- Avogadro's law** equal volumes of gases at the same temperature and pressure contain the same number of particles. (5.2)
- Avogadro's number** the number of atoms in exactly 12 grams of pure ^{12}C , equal to 6.022×10^{23} . (3.3)
- Ball-and-stick model** a molecular model that distorts the sizes of atoms but shows bond relationships clearly. (2.6)
- Band model** a molecular model for metals in which the electrons are assumed to travel around the metal crystal in molecular orbitals formed from the valence atomic orbitals of the metal atoms. (10.4)

- Barometer** a device for measuring atmospheric pressure. (5.1)
- Base** a substance that produces hydroxide ions in aqueous solution, a proton acceptor. (4.8)
- Basic oxide** an ionic oxide that dissolves in water to produce a basic solution. (14.10)
- Basic oxygen process** a process for producing steel by oxidizing and removing the impurities in iron using a high-pressure blast of oxygen. (21.8)
- Battery** a group of galvanic cells connected in series. (17.5)
- Beta (β) particle** an electron produced in radioactive decay. (18.1)
- Beta-particle production** a decay process for radioactive nuclides in which the mass number remains constant and the atomic number changes. The net effect is to change a neutron to a proton. (18.1)
- Bidentate ligand** a ligand that can form two bonds to a metal ion. (21.3)
- Bimolecular step** a reaction involving the collision of two molecules. (12.6)
- Binary compound** a two-element compound. (2.8)
- Binding energy (nuclear)** the energy required to decompose a nucleus into its component nucleons. (18.5)
- Biomolecule** a molecule responsible for maintaining and/or reproducing life. (22)
- Blast furnace** a furnace in which iron oxide is reduced to iron metal by using a very strong blast of hot air to produce carbon monoxide from coke, and then using this gas as a reducing agent for the iron. (21.8)
- Bond energy** the energy required to break a given chemical bond. (8.1)
- Bond length** the distance between the nuclei of the two atoms connected by a bond; the distance where the total energy of a diatomic molecule is minimal. (8.1)
- Bond order** the difference between the number of bonding electrons and the number of antibonding electrons, divided by two. It is an index of bond strength. (9.2)
- Bonding molecular orbital** an orbital lower in energy than the atomic orbitals of which it is composed. (9.2)
- Bonding pair** an electron pair found in the space between two atoms. (8.9)
- Borane** a covalent hydride of boron. (19.5)
- Boyle's law** the volume of a given sample of gas at constant temperature varies inversely with the pressure. (5.2)
- Breeder reactor** a nuclear reactor in which fissionable fuel is produced while the reactor runs. (18.6)
- Brønsted–Lowry model** a model proposing that an acid is a proton donor, and a base is a proton acceptor. (14.1)
- Buffered solution** a solution that resists a change in its pH when either hydroxide ions or protons are added. (15.2)
- Buffering capacity** the ability of a buffered solution to absorb protons or hydroxide ions without a significant change in pH; determined by the magnitudes of $[HA]$ and $[A^-]$ in the solution. (15.3)
- Calorimetry** the science of measuring heat flow. (6.2)
- Capillary action** the spontaneous rising of a liquid in a narrow tube. (10.2)
- Carbohydrate** a polyhydroxyl ketone or polyhydroxyl aldehyde or a polymer composed of these. (22.6)
- Carbon steel** an alloy of iron containing up to about 1.5% carbon. (21.8)
- Carboxyhemoglobin** a stable complex of hemoglobin and carbon monoxide that prevents normal oxygen uptake in the blood. (21.7)
- Carboxyl group** the $-\text{COOH}$ group in an organic acid. (14.2; 22.4)
- Carboxylic acid** an organic compound containing the carboxyl group; an acid with the general formula RCOOH . (22.4)
- Catalyst** a substance that speeds up a reaction without being consumed. (12.8)
- Cathode** the electrode in a galvanic cell at which reduction occurs. (17.1)
- Cathode rays** the “rays” emanating from the negative electrode (cathode) in a partially evacuated tube; a stream of electrons. (2.4)
- Cathodic protection** a method in which an active metal, such as magnesium, is connected to steel to protect it from corrosion. (17.6)
- Cation** a positive ion. (2.6)
- Cell potential (electromotive force)** the driving force in a galvanic cell that pulls electrons from the reducing agent in one compartment to the oxidizing agent in the other. (17.1)
- Ceramic** a nonmetallic material made from clay and hardened by firing at high temperature; it contains minute silicate crystals suspended in a glassy cement. (10.5)
- Chain reaction (nuclear)** a self-sustaining fission process caused by the production of neutrons that proceed to split other nuclei. (18.6)
- Charles's law** the volume of a given sample of gas at constant pressure is directly proportional to the temperature in kelvins. (5.2)
- Chelating ligand (chelate)** a ligand having more than one atom with a lone pair that can be used to bond to a metal ion. (21.3)
- Chemical bond** the force or, more accurately, the energy, that holds two atoms together in a compound. (2.6)
- Chemical change** the change of substances into other substances through a reorganization of the atoms; a chemical reaction. (1.9)
- Chemical equation** a representation of a chemical reaction showing the relative numbers of reactant and product molecules. (3.7)
- Chemical equilibrium** a dynamic reaction system in which the concentrations of all reactants and products remain constant as a function of time. (13)
- Chemical formula** the representation of a molecule in which the symbols for the elements are used to indicate the types of atoms present and subscripts are used to show the relative numbers of atoms. (2.6)
- Chemical kinetics** the area of chemistry that concerns reaction rates. (12)
- Chemical stoichiometry** the calculation of the quantities of material consumed and produced in chemical reactions. (3)
- Chirality** the quality of having nonsuperimposable mirror images. (21.4)
- Chlor–alkali process** the process for producing chlorine and sodium hydroxide by electrolyzing brine in a mercury cell. (17.8)
- Chromatography** the general name for a series of methods for separating mixtures by employing a system with a mobile phase and a stationary phase. (1.9)
- Coagulation** the destruction of a colloid by causing particles to aggregate and settle out. (11.8)
- Codons** organic bases in sets of three that form the genetic code. (22.6)
- Colligative properties** properties of a solution that depend only on the number, and not on the identity, of the solute particles. (11.5)
- Collision model** a model based on the idea that molecules must collide to react; used to account for the observed characteristics of reaction rates. (12.7)

- Colloid (colloidal dispersion)** a suspension of particles in a dispersing medium. (11.8)
- Combustion reaction** the vigorous and exothermic reaction that takes place between certain substances, particularly organic compounds, and oxygen. (22.1)
- Common ion effect** the shift in an equilibrium position caused by the addition or presence of an ion involved in the equilibrium reaction. (15.1)
- Complete ionic equation** an equation that shows all substances that are strong electrolytes as ions. (4.6)
- Complex ion** a charged species consisting of a metal ion surrounded by ligands. (15.8; 21.1)
- Compound** a substance with constant composition that can be broken down into elements by chemical processes. (1.9)
- Concentration cell** a galvanic cell in which both compartments contain the same components, but at different concentrations. (17.4)
- Condensation** the process by which vapor molecules reform a liquid. (10.8)
- Condensation polymerization** a type of polymerization in which the formation of a small molecule, such as water, accompanies the extension of the polymer chain. (22.5)
- Condensation reaction** a reaction in which two molecules are joined, accompanied by the elimination of a water molecule. (20.3)
- Condensed states of matter** liquids and solids. (10.1)
- Conjugate acid** the species formed when a proton is added to a base. (14.1)
- Conjugate acid–base pair** two species related to each other by the donating and accepting of a single proton. (14.1)
- Conjugate base** what remains of an acid molecule after a proton is lost. (14.1)
- Continuous spectrum** a spectrum that exhibits all the wavelengths of visible light. (7.3)
- Control rods** rods in a nuclear reactor composed of substances that absorb neutrons. These rods regulate the power level of the reactor. (18.6)
- Coordinate covalent bond** a metal–ligand bond resulting from the interaction of a Lewis base (the ligand) and a Lewis acid (the metal ion). (21.3)
- Coordination compound** a compound composed of a complex ion and counter ions sufficient to give no net charge. (21.3)
- Coordination isomerism** isomerism in a coordination compound in which the composition of the coordination sphere of the metal ion varies. (21.4)
- Coordination number** the number of bonds formed between the metal ion and the ligands in a complex ion. (21.3)
- Copolymer** a polymer formed from the polymerization of more than one type of monomer. (22.5)
- Core electron** an inner electron in an atom; one not in the outermost (valence) principal quantum level. (7.11)
- Corrosion** the process by which metals are oxidized in the atmosphere. (17.6)
- Coulomb's law** $E = 2.31 \times 10^{-19} \left(\frac{Q_1 Q_2}{r} \right)$, where E is the energy of interaction between a pair of ions, expressed in joules; r is the distance between the ion centers in nm; and Q_1 and Q_2 are the numerical ion charges. (8.1)
- Counterions** anions or cations that balance the charge on the complex ion in a coordination compound. (21.3)
- Covalent bonding** a type of bonding in which electrons are shared by atoms. (2.6; 8.1)
- Critical mass** the mass of fissionable material required to produce a self-sustaining chain reaction. (18.6)
- Critical point** the point on a phase diagram at which the temperature and pressure have their critical values; the end point of the liquid–vapor line. (10.9)
- Critical pressure** the minimum pressure required to produce liquefaction of a substance at the critical temperature. (10.9)
- Critical reaction (nuclear)** a reaction in which exactly one neutron from each fission event causes another fission event, thus sustaining the chain reaction. (18.6)
- Critical temperature** the temperature above which vapor cannot be liquefied no matter what pressure is applied. (10.9)
- Crosslinking** the existence of bonds between adjacent chains in a polymer, thus adding strength to the material. (22.5)
- Crystal field model** a model used to explain the magnetism and colors of coordination complexes through the splitting of the d orbital energies. (21.6)
- Crystalline solid** a solid with a regular arrangement of its components. (10.3)
- Cubic closest packed (ccp) structure** a solid modeled by the closest packing of spheres with an $abcabc$ arrangement of layers; the unit cell is face-centered cubic. (10.4)
- Cyanidation** a process in which crushed gold ore is treated with an aqueous cyanide solution in the presence of air to dissolve the gold. Pure gold is recovered by reduction of the ion to the metal. (21.8)
- Cyclotron** a type of particle accelerator in which an ion introduced at the center is accelerated in an expanding spiral path by the use of alternating electrical fields in the presence of a magnetic field. (18.3)
- Cytochromes** a series of iron-containing species composed of heme and a protein. Cytochromes are the principal electron-transfer molecules in the respiratory chain. (21.7)
- Dalton's law of partial pressures** for a mixture of gases in a container, the total pressure exerted is the sum of the pressures that each gas would exert if it were alone. (5.5)
- Degenerate orbitals** a group of orbitals with the same energy. (7.7)
- Dehydrogenation reaction** a reaction in which two hydrogen atoms are removed from adjacent carbons of a saturated hydrocarbon, giving an unsaturated hydrocarbon. (22.1)
- Denaturation** the breaking down of the three-dimensional structure of a protein resulting in the loss of its function. (22.6)
- Denitrification** the return of nitrogen from decomposed matter to the atmosphere by bacteria that change nitrates to nitrogen gas. (20.2)
- Density** a property of matter representing the mass per unit volume. (1.8)
- Deoxyribonucleic acid (DNA)** a huge nucleotide polymer having a double-helical structure with complementary bases on the two strands. Its major functions are protein synthesis and the storage and transport of genetic information. (22.6)
- Desalination** the removal of dissolved salts from an aqueous solution. (11.6)
- Dialysis** a phenomenon in which a semipermeable membrane allows transfer of both solvent molecules and small solute molecules and ions. (11.6)
- Diamagnetism** a type of magnetism, associated with paired electrons, that causes a substance to be repelled from the inducing magnetic field. (9.3)
- Differential rate law** an expression that gives the rate of a reaction as a function of concentrations; often called the rate law. (12.2)

- Diffraction** the scattering of light from a regular array of points or lines, producing constructive and destructive interference. (7.2)
- Diffusion** the mixing of gases. (5.7)
- Dilution** the process of adding solvent to lower the concentration of solute in a solution. (4.3)
- Dimer** a molecule formed by the joining of two identical monomers. (22.5)
- Dipole–dipole attraction** the attractive force resulting when polar molecules line up so that the positive and negative ends are close to each other. (10.1)
- Dipole moment** a property of a molecule whose charge distribution can be represented by a center of positive charge and a center of negative charge. (8.3)
- Direct reduction furnace** a furnace in which iron oxide is reduced to iron metal using milder reaction conditions than in a blast furnace. (21.8)
- Disaccharide** a sugar formed from two monosaccharides joined by a glycoside linkage. (22.6)
- Disproportionation reaction** a reaction in which a given element is both oxidized and reduced. (20.7)
- Distillation** a method for separating the components of a liquid mixture that depends on differences in the ease of vaporization of the components. (1.9)
- Disulfide linkage** an S—S bond that stabilizes the tertiary structure of many proteins. (22.6)
- Double bond** a bond in which two pairs of electrons are shared by two atoms. (8.8)
- Downs cell** a cell used for electrolyzing molten sodium chloride. (17.8)
- Dry cell battery** a common battery used in calculators, watches, radios, and tape players. (17.5)
- Dual nature of light** the statement that light exhibits both wave and particulate properties. (7.2)
- Effusion** the passage of a gas through a tiny orifice into an evacuated chamber. (5.7)
- Electrical conductivity** the ability to conduct an electric current. (4.2)
- Electrochemistry** the study of the interchange of chemical and electrical energy. (17)
- Electrolysis** a process that involves forcing a current through a cell to cause a nonspontaneous chemical reaction to occur. (17.7)
- Electrolyte** a material that dissolves in water to give a solution that conducts an electric current. (4.2)
- Electrolytic cell** a cell that uses electrical energy to produce a chemical change that would otherwise not occur spontaneously. (17.7)
- Electromagnetic radiation** radiant energy that exhibits wavelike behavior and travels through space at the speed of light in a vacuum. (7.1)
- Electron** a negatively charged particle that moves around the nucleus of an atom. (2.4)
- Electron affinity** the energy change associated with the addition of an electron to a gaseous atom. (7.12)
- Electron capture** a process in which one of the inner-orbital electrons in an atom is captured by the nucleus. (18.1)
- Electron spin quantum number** a quantum number representing one of the two possible values for the electron spin; either $+\frac{1}{2}$ or $-\frac{1}{2}$. (7.8)
- Electronegativity** the tendency of an atom in a molecule to attract shared electrons to itself. (8.2)
- Element** a substance that cannot be decomposed into simpler substances by chemical or physical means. (1.9)
- Elementary step** a reaction whose rate law can be written from its molecularity. (12.6)
- $E = mc^2$** Einstein's equation proposing that energy has mass; E is energy, m is mass, and c is the speed of light. (7.2)
- Empirical formula** the simplest whole number ratio of atoms in a compound. (3.6)
- Enantiomers** isomers that are nonsuperimposable mirror images of each other. (21.4)
- Endpoint** the point in a titration at which the indicator changes color. (4.8)
- Endothermic** refers to a reaction where energy (as heat) flows into the system. (6.1)
- Energy** the capacity to do work or to cause heat flow. (6.1)
- Enthalpy** a property of a system equal to $E + PV$, where E is the internal energy of the system, P is the pressure of the system, and V is the volume of the system. At constant pressure the change in enthalpy equals the energy flow as heat. (6.2)
- Enthalpy (heat) of fusion** the enthalpy change that occurs to melt a solid at its melting point. (10.8)
- Entropy** a thermodynamic function that measures randomness or disorder. (16.1)
- Enzyme** a large molecule, usually a protein, that catalyzes biological reactions. (12.8)
- Equilibrium constant** the value obtained when equilibrium concentrations of the chemical species are substituted in the equilibrium expression. (13.2)
- Equilibrium expression** the expression (from the law of mass action) obtained by multiplying the product concentrations and dividing by the multiplied reactant concentrations, with each concentration raised to a power represented by the coefficient in the balanced equation. (13.2)
- Equilibrium point (thermodynamic definition)** the position where the free energy of a reaction system has its lowest possible value. (16.8)
- Equilibrium position** a particular set of equilibrium concentrations. (13.2)
- Equivalence point (stoichiometric point)** the point in a titration when enough titrant has been added to react exactly with the substance in solution being titrated. (4.9; 15.4)
- Ester** an organic compound produced by the reaction between a carboxylic acid and an alcohol. (22.4)
- Exothermic** refers to a reaction where energy (as heat) flows out of the system. (6.1)
- Exponential notation** expresses a number as $N \times 10^M$, a convenient method for representing a very large or very small number and for easily indicating the number of significant figures. (1.5)
- Faraday** a constant representing the charge on one mole of electrons; 96,485 coulombs. (17.3)
- Filtration** a method for separating the components of a mixture containing a solid and a liquid. (1.9)
- First law of thermodynamics** the energy of the universe is constant; same as the law of conservation of energy. (6.1)
- Fission** the process of using a neutron to split a heavy nucleus into two nuclei with smaller mass numbers. (18.6)
- Flotation process** a method of separating the mineral particles in an ore from the gangue that depends on the greater wettability of the mineral pieces. (21.8)

- Formal charge** the charge assigned to an atom in a molecule or polyatomic ion derived from a specific set of rules. (8.12)
- Formation constant (stability constant)** the equilibrium constant for each step of the formation of a complex ion by the addition of an individual ligand to a metal ion or complex ion in aqueous solution. (15.8)
- Formula equation** an equation representing a reaction in solution showing the reactants and products in undissociated form, whether they are strong or weak electrolytes. (4.6)
- Fossil fuel** coal, petroleum, or natural gas; consists of carbon-based molecules derived from decomposition of once-living organisms. (6.5)
- Frasch process** the recovery of sulfur from underground deposits by melting it with hot water and forcing it to the surface by air pressure. (20.6)
- Free energy** a thermodynamic function equal to the enthalpy (H) minus the product of the entropy (S) and the Kelvin temperature (T); $G = H - TS$. Under certain conditions the change in free energy for a process is equal to the maximum useful work. (16.4)
- Free radical** a species with an unpaired electron. (22.5)
- Frequency** the number of waves (cycles) per second that pass a given point in space. (7.1)
- Fuel cell** a galvanic cell for which the reactants are continuously supplied. (17.5)
- Functional group** an atom or group of atoms in hydrocarbon derivatives that contains elements in addition to carbon and hydrogen. (22.4)
- Fusion** the process of combining two light nuclei to form a heavier, more stable nucleus. (18.6)
- Galvanic cell** a device in which chemical energy from a spontaneous redox reaction is changed to electrical energy that can be used to do work. (17.1)
- Galvanizing** a process in which steel is coated with zinc to prevent corrosion. (17.6)
- Gamma (γ) ray** a high-energy photon. (18.1)
- Gangue** the impurities (such as clay or sand) in an ore. (21.8)
- Geiger–Müller counter (Geiger counter)** an instrument that measures the rate of radioactive decay based on the ions and electrons produced as a radioactive particle passes through a gas-filled chamber. (18.4)
- Gene** a given segment of the DNA molecule that contains the code for a specific protein. (22.6)
- Geometrical (*cis*–*trans*) isomerism** isomerism in which atoms or groups of atoms can assume different positions around a rigid ring or bond. (21.4; 22.2)
- Glass** an amorphous solid obtained when silica is mixed with other compounds, heated above its melting point, and then cooled rapidly. (10.5)
- Glass electrode** an electrode for measuring pH from the potential difference that develops when it is dipped into an aqueous solution containing H^+ ions. (17.4)
- Glycoside linkage** a C—O—C bond formed between the rings of two cyclic monosaccharides by the elimination of water. (22.6)
- Graham's law of effusion** the rate of effusion of a gas is inversely proportional to the square root of the mass of its particles. (5.7)
- Greenhouse effect** a warming effect exerted by the earth's atmosphere (particularly CO_2 and H_2O) due to thermal energy retained by absorption of infrared radiation. (6.5)
- Ground state** the lowest possible energy state of an atom or molecule. (7.4)
- Group (of the periodic table)** a vertical column of elements having the same valence electron configuration and showing similar properties. (2.7)
- Haber process** the manufacture of ammonia from nitrogen and hydrogen, carried out at high pressure and high temperature with the aid of a catalyst. (3.10; 20.2)
- Half-life (of a radioactive sample)** the time required for the number of nuclides in a radioactive sample to reach half of the original value. (18.2)
- Half-life (of a reactant)** the time required for a reactant to reach half of its original concentration. (12.4)
- Half-reactions** the two parts of an oxidation–reduction reaction, one representing oxidation, the other reduction. (4.10; 17.1)
- Halogen** a Group 7A element. (2.7; 20.7)
- Halogenation** the addition of halogen atoms to unsaturated hydrocarbons. (22.2)
- Hard water** water from natural sources that contains relatively large concentrations of calcium and magnesium ions. (19.4)
- Heat** energy transferred between two objects due to a temperature difference between them. (6.1)
- Heat capacity** the amount of energy required to raise the temperature of an object by one degree Celsius. (6.2)
- Heat of fusion** the enthalpy change that occurs to melt a solid at its melting point. (10.8)
- Heat of hydration** the enthalpy change associated with placing gaseous molecules or ions in water; the sum of the energy needed to expand the solvent and the energy released from the solvent–solute interactions. (11.2)
- Heat of solution** the enthalpy change associated with dissolving a solute in a solvent; the sum of the energies needed to expand both solvent and solute in a solution and the energy released from the solvent–solute interactions. (11.2)
- Heat of vaporization** the energy required to vaporize one mole of a liquid at a pressure of one atmosphere. (10.8)
- Heating curve** a plot of temperature versus time for a substance where energy is added at a constant rate. (10.8)
- Heisenberg uncertainty principle** a principle stating that there is a fundamental limitation to how precisely both the position and momentum of a particle can be known at a given time. (7.5)
- Heme** an iron complex. (21.7)
- Hemoglobin** a biomolecule composed of four myoglobin-like units (proteins plus heme) that can bind and transport four oxygen molecules in the blood. (21.7)
- Henderson–Hasselbalch equation** an equation giving the relationship between the pH of an acid–base system and the concentrations of base and acid: $pH = pK_a + \log \left(\frac{[base]}{[acid]} \right)$. (15.2)
- Henry's law** the amount of a gas dissolved in a solution is directly proportional to the pressure of the gas above the solution. (11.3)
- Hess's law** in going from a particular set of reactants to a particular set of products, the enthalpy change is the same whether the reaction takes place in one step or in a series of steps; in summary, enthalpy is a state function. (6.3)
- Heterogeneous equilibrium** an equilibrium involving reactants and/or products in more than one phase. (13.4)

Hexagonal closest packed (hcp) structure a structure composed of closest packed spheres with an *ababab* arrangement of layers; the unit cell is hexagonal. (10.4)

Homogeneous equilibrium an equilibrium system where all reactants and products are in the same phase. (13.4)

Homopolymer a polymer formed from the polymerization of only one type of monomer. (22.5)

Hund's rule the lowest energy configuration for an atom is the one having the maximum number of unpaired electrons allowed by the Pauli exclusion principle in a particular set of degenerate orbitals, with all unpaired electrons having parallel spins. (7.11)

Hybrid orbitals a set of atomic orbitals adopted by an atom in a molecule different from those of the atom in the free state. (9.1)

Hybridization a mixing of the native orbitals on a given atom to form special atomic orbitals for bonding. (9.1)

Hydration the interaction between solute particles and water molecules. (4.1)

Hydride a binary compound containing hydrogen. The hydride ion, H^- , exists in ionic hydrides. The three classes of hydrides are covalent, interstitial, and ionic. (19.3)

Hydrocarbon a compound composed of carbon and hydrogen. (22.1)

Hydrocarbon derivative an organic molecule that contains one or more elements in addition to carbon and hydrogen. (22.4)

Hydrogen bonding unusually strong dipole-dipole attractions that occur among molecules in which hydrogen is bonded to a highly electronegative atom. (10.1)

Hydrogenation reaction a reaction in which hydrogen is added, with a catalyst present, to a carbon-carbon multiple bond. (22.2)

Hydrohalic acid an aqueous solution of a hydrogen halide. (20.7)

Hydrometallurgy a process for extracting metals from ores by use of aqueous chemical solutions. Two steps are involved: selective leaching and selective precipitation. (21.8)

Hydronium ion the H_3O^+ ion; a hydrated proton. (14.1)

Hypothesis one or more assumptions put forth to explain the observed behavior of nature. (1.2)

Ideal gas law an equation of state for a gas, where the state of the gas is its condition at a given time; expressed by $PV = nRT$, where P = pressure, V = volume, n = moles of the gas, R = the universal gas constant, and T = absolute temperature. This equation expresses behavior approached by real gases at high T and low P . (5.3)

Ideal solution a solution whose vapor pressure is directly proportional to the mole fraction of solvent present. (11.4)

Indicator a chemical that changes color and is used to mark the end point of a titration. (4.8; 15.5)

Integrated rate law an expression that shows the concentration of a reactant as a function of time. (12.2)

Interhalogen compound a compound formed by the reaction of one halogen with another. (20.7)

Intermediate a species that is neither a reactant nor a product but that is formed and consumed in the reaction sequence. (12.6)

Intermolecular forces relatively weak interactions that occur between molecules. (10.1)

Internal energy a property of a system that can be changed by a flow of work, heat or both; $\Delta E = q + w$, where ΔE is the change in the internal energy of the system, q is heat, and w is work. (6.1)

Ion an atom or a group of atoms that has a net positive or negative charge. (2.6)

Ion exchange (water softening) the process in which an ion-exchange resin removes unwanted ions (for example, Ca^{2+} and Mg^{2+}) and replaces them with Na^+ ions, which do not interfere with soap and detergent action. (19.4)

Ion pairing a phenomenon occurring in solution when oppositely charged ions aggregate and behave as a single particle. (11.7)

Ion-product (dissociation) constant (K_w) the equilibrium constant for the auto-ionization of water; $K_w = [\text{H}^+][\text{OH}^-]$. At 25°C , K_w equals 1.0×10^{-14} . (14.2)

Ion-selective electrode an electrode sensitive to the concentration of a particular ion in solution. (17.4)

Ionic bonding the electrostatic attraction between oppositely charged ions. (2.6; 8.1)

Ionic compound (binary) a compound that results when a metal reacts with a nonmetal to form a cation and an anion. (8.1)

Ionic solid (salt) a solid containing cations and anions that dissolves in water to give a solution containing the separated ions which are mobile and thus free to conduct electrical current. (2.6; 10.3)

Irreversible process any real process. When a system undergoes the changes State 1 \rightarrow State 2 \rightarrow State 1 by any real pathway, the universe is different than before the cyclic process took place in the system. (16.9)

Isoelectronic ions ions containing the same number of electrons. (8.4)

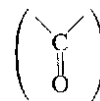
Isomers species with the same formula but different properties. (21.4)

Isotactic chain a polymer chain in which the substituent groups such as CH_3 are all arranged on the same side of the chain. (22.5)

Isotonic solutions solutions having identical osmotic pressures. (11.6)

Isotopes atoms of the same element (the same number of protons) with different numbers of neutrons. They have identical atomic numbers but different mass numbers. (2.5; 18)

Ketone an organic compound containing the carbonyl group bonded



to two carbon atoms. (22.4)

Kinetic energy ($\frac{1}{2}mv^2$) energy due to the motion of an object; dependent on the mass of the object and the square of its velocity. (6.1)

Kinetic molecular theory (KMT) a model that assumes that an ideal gas is composed of tiny particles (molecules) in constant motion. (5.6)

Lanthanide contraction the decrease in the atomic radii of the lanthanide series elements, going from left to right in the periodic table. (21.1)

Lanthanide series a group of 14 elements following lanthanum in the periodic table, in which the $4f$ orbitals are being filled. (7.11; 19.1; 21.1)

Lattice a three-dimensional system of points designating the positions of the centers of the components of a solid (atoms, ions, or molecules). (10.3)

Lattice energy the energy change occurring when separated gaseous ions are packed together to form an ionic solid. (8.5)

Law of conservation of energy energy can be converted from one form to another but can be neither created nor destroyed. (6.1)

Law of conservation of mass mass is neither created nor destroyed. (1.2; 2.2)

- Law of definite proportion** a given compound always contains exactly the same proportion of elements by mass. (2.2)
- Law of mass action** a general description of the equilibrium condition; it defines the equilibrium constant expression. (13.2)
- Law of multiple proportions** a law stating that when two elements form a series of compounds, the ratios of the masses of the second element that combine with one gram of the first element can always be reduced to small whole numbers. (2.2)
- Leaching** the extraction of metals from ores using aqueous chemical solutions. (21.8)
- Lead storage battery** a battery (used in cars) in which the anode is lead, the cathode is lead coated with lead dioxide, and the electrolyte is a sulfuric acid solution. (17.5)
- Le Châtelier's principle** if a change is imposed on a system at equilibrium, the position of the equilibrium will shift in a direction that tends to reduce the effect of that change. (13.7)
- Lewis acid** an electron-pair acceptor. (14.11)
- Lewis base** an electron-pair donor. (14.11)
- Lewis structure** a diagram of a molecule showing how the valence electrons are arranged among the atoms in the molecule. (8.10)
- Ligand** a neutral molecule or ion having a lone pair of electrons that can be used to form a bond to a metal ion; a Lewis base. (21.3)
- Lime-soda process** a water-softening method in which lime and soda ash are added to water to remove calcium and magnesium ions by precipitation. (14.6)
- Limiting reactant (limiting reagent)** the reactant that is completely consumed when a reaction is run to completion. (3.10)
- Line spectrum** a spectrum showing only certain discrete wavelengths. (7.3)
- Linear accelerator** a type of particle accelerator in which a changing electrical field is used to accelerate a positive ion along a linear path. (18.3)
- Linkage isomerism** isomerism involving a complex ion where the ligands are all the same but the point of attachment of at least one of the ligands differs. (21.4)
- Liquefaction** the transformation of a gas into a liquid. (19.1)
- Localized electron (LE) model** a model which assumes that a molecule is composed of atoms that are bound together by sharing pairs of electrons using the atomic orbitals of the bound atoms. (8.9)
- London dispersion forces** the forces, existing among noble gas atoms and nonpolar molecules, that involve an accidental dipole that induces a momentary dipole in a neighbor. (10.1)
- Lone pair** an electron pair that is localized on a given atom; an electron pair not involved in bonding. (8.9)
- Magnetic quantum number** m_ℓ , the quantum number relating to the orientation of an orbital in space relative to the other orbitals with the same ℓ quantum number. It can have integral values between ℓ and $-\ell$, including zero. (7.6)
- Main-group (representative) elements** elements in the groups labeled 1A, 2A, 3A, 4A, 5A, 6A, 7A, and 8A in the periodic table. The group number gives the sum of the valence s and p electrons. (7.11; 18.1)
- Major species** the components present in relatively large amounts in a solution. (14.3)
- Manometer** a device for measuring the pressure of a gas in a container. (5.1)
- Mass** the quantity of matter in an object. (1.3)
- Mass defect** the change in mass occurring when a nucleus is formed from its component nucleons. (18.5)
- Mass number** the total number of protons and neutrons in the atomic nucleus of an atom. (2.5; 18)
- Mass percent** the percent by mass of a component of a mixture (11.1) or of a given element in a compound. (3.5)
- Mass spectrometer** an instrument used to determine the relative masses of atoms by the deflection of their ions on a magnetic field. (3.2)
- Matter** the material of the universe. (1.9)
- Messenger RNA (mRNA)** a special RNA molecule built in the cell nucleus that migrates into the cytoplasm and participates in protein synthesis. (22.6)
- Metal** an element that gives up electrons relatively easily and is lustrous, malleable, and a good conductor of heat and electricity. (2.7)
- Metalloids (semimetals)** elements along the division line in the periodic table between metals and nonmetals. These elements exhibit both metallic and nonmetallic properties. (7.13; 19.1)
- Metallurgy** the process of separating a metal from its ore and preparing it for use. (19.1; 21.8)
- Millimeters of mercury (mmHg)** a unit of pressure, also called a torr, $760 \text{ mm Hg} = 760 \text{ torr} = 101,325 \text{ Pa} = 1 \text{ standard atmosphere}$. (5.1)
- Mineral** a relatively pure compound as found in nature. (21.8)
- Model (theory)** a set of assumptions put forth to explain the observed behavior of matter. The models of chemistry usually involve assumptions about the behavior of individual atoms or molecules. (1.2)
- Moderator** a substance used in a nuclear reactor to slow down the neutrons. (18.6)
- Molal boiling-point elevation constant** a constant characteristic of a particular solvent that gives the change in boiling point as a function of solution molality; used in molecular weight determinations. (11.5)
- Molal freezing-point depression constant** a constant characteristic of a particular solvent that gives the change in freezing point as a function of the solution molality; used in molecular weight determinations (11.5)
- Molality** the number of moles of solute per kilogram of solvent in a solution. (11.1)
- Molar heat capacity** the energy required to raise the temperature of one mole of a substance by one degree Celsius. (6.2)
- Molar mass** the mass in grams of one mole of molecules or formula units of a substance; also called *molecular weight*. (3.4)
- Molar volume** the volume of one mole of an ideal gas; equal to 22.42 liters at STP. (5.4)
- Molarity** moles of solute per volume of solution in liters. (4.3; 11.1)
- Mole (mol)** the number equal to the number of carbon atoms in exactly 12 grams of pure ^{12}C : Avogadro's number. One mole represents 6.022×10^{23} units. (3.3)
- Mole fraction** the ratio of the number of moles of a given component in a mixture to the total number of moles in the mixture. (5.5; 11.1)
- Mole ratio (stoichiometry)** the ratio of moles of one substance to moles of another substance in a balanced chemical equation. (3.9)
- Molecular formula** the exact formula of a molecule, giving the types of atoms and the number of each type. (3.6)
- Molecular orbital (MO) model** a model that regards a molecule as a collection of nuclei and electrons, where the electrons are assumed to occupy orbitals much as they do in atoms, but having the orbitals extend over the entire molecule. In this model the electrons are assumed to be delocalized rather than always located between a given pair of atoms. (9.2; 10.4)

Molecular orientations (kinetics) orientations of molecules during collisions, some of which can lead to reaction while others cannot. (12.7)

Molecular solid a solid composed of neutral molecules at the lattice points. (10.3)

Molecular structure the three-dimensional arrangement of atoms in a molecule. (8.13)

Molecularity the number of species that must collide to produce the reaction represented by an elementary step in a reaction mechanism. (12.6)

Molecule a bonded collection of two or more atoms of the same or different elements. (2.6)

Monodentate (unidentate) ligand a ligand that can form one bond to a metal ion. (21.3)

Monoprotic acid an acid with one acidic proton. (14.2)

Monosaccharide (simple sugar) a polyhydroxy ketone or aldehyde containing from three to nine carbon atoms. (22.6)

Myoglobin an oxygen-storing biomolecule consisting of a heme complex and a proton. (21.7)

Natural law a statement that expresses generally observed behavior. (1.2)

Nernst equation an equation relating the potential of an electrochemical cell to the concentrations of the cell components:

$$\mathcal{E} = \mathcal{E}^\circ - \frac{0.0591}{n} \log(Q) \text{ at } 25^\circ\text{C} \quad (17.4)$$

Net ionic equation an equation for a reaction in solution, where strong electrolytes are written as ions, showing only those components that are directly involved in the chemical change. (4.6)

Network solid an atomic solid containing strong directional covalent bonds. (10.5)

Neutralization reaction an acid–base reaction. (4.8)

Neutron a particle in the atomic nucleus with mass virtually equal to the proton's but with no charge. (2.5; 18)

Nitrogen cycle the conversion of N_2 to nitrogen-containing compounds, followed by the return of nitrogen gas to the atmosphere by natural decay processes. (20.2)

Nitrogen fixation the process of transforming N_2 to nitrogen-containing compounds useful to plants. (20.2)

Nitrogen-fixing bacteria bacteria in the root nodules of plants that can convert atmospheric nitrogen to ammonia and other nitrogen-containing compounds useful to plants. (20.2)

Noble gas a Group 8A element. (2.7; 20.8)

Node an area of an orbital having zero electron probability. (7.7)

Nonelectrolyte a substance that, when dissolved in water, gives a nonconducting solution. (4.2)

Nonmetal an element not exhibiting metallic characteristics. Chemically, a typical nonmetal accepts electrons from a metal. (2.7)

Normal boiling point the temperature at which the vapor pressure of a liquid is exactly one atmosphere. (10.8)

Normal melting point the temperature at which the solid and liquid states have the same vapor pressure under conditions where the total pressure on the system is one atmosphere. (10.8)

Normality the number of equivalents of a substance dissolved in a liter of solution. (11.1)

Nuclear atom an atom having a dense center of positive charge (the nucleus) with electrons moving around the outside. (2.4)

Nuclear transformation the change of one element into another. (18.3)

Nucleon a particle in an atomic nucleus, either a neutron or a proton. (18)

Nucleotide a monomer of the nucleic acids composed of a five-carbon sugar, a nitrogen-containing base, and phosphoric acid. (22.6)

Nucleus the small, dense center of positive charge in an atom. (2.4)

Nuclide the general term applied to each unique atom; represented by ${}^A_Z\text{X}$, where X is the symbol for a particular element. (18)

Octet rule the observation that atoms of nonmetals tend to form the most stable molecules when they are surrounded by eight electrons (to fill their valence orbitals). (8.10)

Open hearth process a process for producing steel by oxidizing and removing the impurities in molten iron using external heat and a blast of air or oxygen. (21.8)

Optical isomerism isomerism in which the isomers have opposite effects on plane-polarized light. (21.4)

Orbital a specific wave function for an electron in an atom. The square of this function gives the probability distribution for the electron. (7.5)

d-Orbital splitting a splitting of the *d* orbitals of the metal ion in a complex such that the orbitals pointing at the ligands have higher energies than those pointing between the ligands. (21.6)

Order (of reactant) the positive or negative exponent, determined by experiment, of the reactant concentration in a rate law. (12.2)

Organic acid an acid with a carbon-atom backbone; often contains the carboxyl group. (14.2)

Organic chemistry the study of carbon-containing compounds (typically chains of carbon atoms) and their properties. (22)

Osmosis the flow of solvent into a solution through a semipermeable membrane. (11.6)

Osmotic pressure (π) the pressure that must be applied to a solution to stop osmosis; $\pi = MRT$. (11.6)

Ostwald process a commercial process for producing nitric acid by the oxidation of ammonia. (20.2)

Oxidation an increase in oxidation state (a loss of electrons). (4.9; 17.1)

Oxidation–reduction (redox) reaction a reaction in which one or more electrons are transferred. (4.9; 17.1)

Oxidation states a concept that provides a way to keep track of electrons in oxidation–reduction reactions according to certain rules. (4.9; 21.3)

Oxidizing agent (electron acceptor) a reactant that accepts electrons from another reactant. (4.9; 17.1)

Oxyacid an acid in which the acidic proton is attached to an oxygen atom. (14.2)

Ozone O_3 , the form of elemental oxygen in addition to the much more common O_2 . (20.5)

Paramagnetism a type of induced magnetism, associated with unpaired electrons, that causes a substance to be attracted into the inducing magnetic field. (9.3)

Partial pressures the independent pressures exerted by different gases in a mixture. (5.5)

Particle accelerator a device used to accelerate nuclear particles to very high speeds. (18.3)

Pascal the SI unit of pressure; equal to newtons per meter squared. (5.1)

Pauli exclusion principle in a given atom no two electrons can have the same set of four quantum numbers. (7.8)

Peptide linkage the bond resulting from the condensation reaction between amino acids; represented by:



Percent dissociation the ratio of the amount of a substance that is dissociated at equilibrium to the initial concentration of the substance in a solution, multiplied by 100. (14.5)

Percent yield the actual yield of a product as a percentage of the theoretical yield. (3.10)

Periodic table a chart showing all the elements arranged in columns with similar chemical properties. (2.7)

pH curve (titration curve) a plot showing the pH of a solution being analyzed as a function of the amount of titrant added. (15.4)

pH scale a log scale based on 10 and equal to $-\log[\text{H}^+]$; a convenient way to represent solution acidity. (14.3)

Phase diagram a convenient way of representing the phases of a substance in a closed system as a function of temperature and pressure. (10.9)

Phenyl group the benzene molecule minus one hydrogen atom. (22.3)

Photochemical smog air pollution produced by the action of light on oxygen, nitrogen oxides, and unburned fuel from auto exhaust to form ozone and other pollutants. (5.10)

Photon a quantum of electromagnetic radiation. (7.2)

Physical change a change in the form of a substance, but not in its chemical composition; chemical bonds are not broken in a physical change. (1.9)

Pi (π) bond a covalent bond in which parallel *p* orbitals share an electron pair occupying the space above and below the line joining the atoms. (9.1)

Planck's constant the constant relating the change in energy for a system to the frequency of the electromagnetic radiation absorbed or emitted; equal to 6.626×10^{-34} J s. (7.2)

Polar covalent bond a covalent bond in which the electrons are not shared equally because one atom attracts them more strongly than the other. (8.1)

Polar molecule a molecule that has a permanent dipole moment. (4.1)

Polyatomic ion an ion containing a number of atoms. (2.6)

Polyelectronic atom an atom with more than one electron. (7.9)

Polymer a large, usually chainlike molecule built from many small molecules (monomers). (22.5)

Polymerization a process in which many small molecules (monomers) are joined together to form a large molecule. (22.2)

Polypeptide a polymer formed from amino acids joined together by peptide linkages. (22.6)

Polyprotic acid an acid with more than one acidic proton. It dissociates in a stepwise manner, one proton at a time. (14.7)

Porous disk a disk in a tube connecting two different solutions in a galvanic cell that allows ion flow without extensive mixing of the solutions. (17.1)

Porphyrin a planar ligand with a central ring structure and various substituent groups at the edges of the ring. (21.7)

Positional probability a type of probability that depends on the number of arrangements in space that yield a particular state. (16.1)

Positron production a mode of nuclear decay in which a particle is formed having the same mass as an electron but opposite charge. The net effect is to change a proton to a neutron. (18.1)

Potential energy energy due to position or composition. (6.1)

Precipitation reaction a reaction in which an insoluble substance forms and separates from the solution. (4.5)

Precision the degree of agreement among several measurements of the same quantity; the reproducibility of a measurement. (1.4)

Primary structure (of a protein) the order (sequence) of amino acids in the protein chain. (22.6)

Principal quantum number (*n*) the quantum number relating to the size and energy of an orbital; it can have any positive integer value. (7.6)

Probability distribution the square of the wave function indicating the probability of finding an electron at a particular point in space. (7.5)

Product a substance resulting from a chemical reaction. It is shown to the right of the arrow in a chemical equation. (3.7)

Protein a natural high-molecular-weight polymer formed by condensation reactions between amino acids. (22.6)

Proton a positively charged particle in an atomic nucleus. (2.5; 18)

Pure substance a substance with constant composition. (1.9)

Pyrometallurgy recovery of a metal from its ore by treatment at high temperatures. (21.8)

Quantization the concept that energy can occur only in discrete units called *quanta*. (7.2)

Rad a unit of radiation dosage corresponding to 10^{-2} J of energy deposited per kilogram of tissue (from radiation absorbed dose). (18.7)

Radioactive decay (radioactivity) the spontaneous decomposition of a nucleus to form a different nucleus. (2.4; 18.1)

Radiocarbon dating (carbon-14 dating) a method for dating ancient wood or cloth based on the rate of radioactive decay of the nuclide $^{14}_6\text{C}$. (18.4)

Radiotracer a radioactive nuclide, introduced into an organism for diagnostic purposes, whose pathway can be traced by monitoring its radioactivity. (18.4)

Random error an error that has an equal probability of being high or low. (1.4)

Raoult's law the vapor pressure of a solution is directly proportional to the mole fraction of solvent present. (11.4)

Rate constant the proportionality constant in the relationship between reaction rate and reactant concentrations. (12.2)

Rate of decay the change in the number of radioactive nuclides in a sample per unit time. (18.2)

Rate-determining step the slowest step in a reaction mechanism, the one determining the overall rate. (12.6)

Rate law (differential rate law) an expression that shows how the rate of reaction depends on the concentration of reactants. (12.2)

Reactant a starting substance in a chemical reaction. It appears to the left of the arrow in a chemical equation. (3.7)

Reaction mechanism the series of elementary steps involved in a chemical reaction. (12.6)

Reaction quotient, *Q* a quotient obtained by applying the law of mass action to initial concentrations rather than to equilibrium concentrations. (13.5)

Reaction rate the change in concentration of a reactant or product per unit time. (12.1)

Reactor core the part of a nuclear reactor where the fission reaction takes place. (18.6)

Reducing agent (electron donor) a reactant that donates electrons to another substance to reduce the oxidation state of one of its atoms. (4.9; 17.1)

- Reduction** a decrease in oxidation state (a gain of electrons). (4.9; 17.1)
- Rem** a unit of radiation dosage that accounts for both the energy of the dose and its effectiveness in causing biological damage (from roentgen equivalent for *man*). (18.7)
- Resonance** a condition occurring when more than one valid Lewis structure can be written for a particular molecule. The actual electronic structure is not represented by any one of the Lewis structures but by the average of all of them. (8.12)
- Reverse osmosis** the process occurring when the external pressure on a solution causes a net flow of solvent through a semipermeable membrane from the solution to the solvent. (11.6)
- Reversible process** a cyclic process carried out by a hypothetical pathway, which leaves the universe exactly the same as it was before the process. No real process is reversible. (16.9)
- Ribonucleic acid (RNA)** a nucleotide polymer that transmits the genetic information stored in DNA to the ribosomes for protein synthesis. (22.6)
- Roasting** a process of converting sulfide minerals to oxides by heating in air at temperatures below their melting points. (21.8)
- Root mean square velocity** the square root of the average of the squares of the individual velocities of gas particles. (5.6)
- Salt** an ionic compound. (14.8)
- Salt bridge** a U-tube containing an electrolyte that connects the two compartments of a galvanic cell, allowing ion flow without extensive mixing of the different solutions. (17.1)
- Scientific method** the process of studying natural phenomena, involving observations, forming laws and theories, and testing of theories by experimentation. (1.2)
- Scintillation counter** an instrument that measures radioactive decay by sensing the flashes of light produced in a substance by the radiation. (18.4)
- Second law of thermodynamics** in any spontaneous process, there is always an increase in the entropy of the universe. (16.2)
- Secondary structure (of a protein)** the three-dimensional structure of the protein chain (for example, α -helix, random coil, or pleated sheet). (22.6)
- Selective precipitation** a method of separating metal ions from an aqueous mixture by using a reagent whose anion forms a precipitate with only one or a few of the ions in the mixture. (4.7; 15.7)
- Semiconductor** a substance conducting only a slight electrical current at room temperature, but showing increased conductivity at higher temperatures. (10.5)
- Semipermeable membrane** a membrane that allows solvent but not solute molecules to pass through. (11.6)
- SI system** International System of units based on the metric system and units derived from the metric system. (1.3)
- Side chain (of amino acid)** the hydrocarbon group on an amino acid represented by H, CH₃, or a more complex substituent. (22.6)
- Sigma (σ) bond** a covalent bond in which the electron pair is shared in an area centered on a line running between the atoms. (9.1)
- Significant figures** the certain digits and the first uncertain digit of a measurement. (1.4)
- Silica** the fundamental silicon–oxygen compound, which has the empirical formula SiO₂, and forms the basis of quartz and certain types of sand. (10.5)
- Silicates** salts that contain metal cations and polyatomic silicon–oxygen anions that are usually polymeric. (10.5)
- Single bond** a bond in which one pair of electrons is shared by two atoms. (8.8)
- Smelting** a metallurgical process that involves reducing metal ions to the free metal. (21.8)
- Solubility** the amount of a substance that dissolves in a given volume of solvent at a given temperature. (4.2)
- Solubility product constant** the constant for the equilibrium expression representing the dissolving of an ionic solid in water. (15.6)
- Solute** a substance dissolved in a liquid to form a solution. (4.2; 11.1)
- Solution** a homogeneous mixture. (1.9)
- Solvent** the dissolving medium in a solution. (4.2)
- Somatic damage** radioactive damage to an organism resulting in its sickness or death. (18.7)
- Space-filling model** a model of a molecule showing the relative sizes of the atoms and their relative orientations. (2.6)
- Specific heat capacity** the energy required to raise the temperature of one gram of a substance by one degree Celsius. (6.2)
- Spectator ions** ions present in solution that do not participate directly in a reaction. (4.6)
- Spectrochemical series** a listing of ligands in order based on their ability to produce *d*-orbital splitting. (21.6)
- Spontaneous fission** the spontaneous splitting of a heavy nuclide into two lighter nuclides. (18.1)
- Spontaneous process** a process that occurs without outside intervention. (16.1)
- Standard atmosphere** a unit of pressure equal to 760 mm Hg. (5.1)
- Standard enthalpy of formation** the enthalpy change that accompanies the formation of one mole of a compound at 25°C from its elements, with all substances in their standard states at that temperature. (6.4)
- Standard free energy change** the change in free energy that will occur for one unit of reaction if the reactants in their standard states are converted to products in their standard states. (16.6)
- Standard free energy of formation** the change in free energy that accompanies the formation of one mole of a substance from its constituent elements with all reactants and products in their standard states. (16.6)
- Standard hydrogen electrode** a platinum conductor in contact with 1 M H⁺ ions and bathed by hydrogen gas at one atmosphere. (17.2)
- Standard reduction potential** the potential of a half-reaction under standard state conditions, as measured against the potential of the standard hydrogen electrode. (17.2)
- Standard solution** a solution whose concentration is accurately known. (4.3)
- Standard state** a reference state for a specific substance defined according to a set of conventional definitions. (6.4)
- Standard temperature and pressure (STP)** the condition 0°C and 1 atmosphere of pressure. (5.4)
- Standing wave** a stationary wave as on a string of a musical instrument; in the wave mechanical model, the electron in the hydrogen atom is considered to be a standing wave. (7.5)
- State function (property)** a property that is independent of the pathway. (6.1)
- States of matter** the three different forms in which matter can exist; solid, liquid, and gas. (1.9)
- Stereoisomerism** isomerism in which all the bonds in the isomers are the same but the spatial arrangements of the atoms are different. (21.4)
- Steric factor** the factor (always less than 1) that reflects the fraction of collisions with orientations that can produce a chemical reaction. (12.7)

- Stoichiometric quantities** quantities of reactants mixed in exactly the correct amounts so that all are used up at the same time. (3.10)
- Strong acid** an acid that completely dissociates to produce an H^+ ion and the conjugate base. (4.2; 14.2)
- Strong base** a metal hydroxide salt that completely dissociates into its ions in water. (4.2; 14.6)
- Strong electrolyte** a material that, when dissolved in water, gives a solution that conducts an electric current very efficiently. (4.2)
- Structural formula** the representation of a molecule in which the relative positions of the atoms are shown and the bonds are indicated by lines. (2.6)
- Structural isomerism** isomerism in which the isomers contain the same atoms but one or more bonds differ. (21.4; 22.1)
- Subcritical reaction (nuclear)** a reaction in which less than one neutron causes another fission event and the process dies out. (18.6)
- Sublimation** the process by which a substance goes directly from the solid to the gaseous state without passing through the liquid state. (10.8)
- Subshell** a set of orbitals with a given azimuthal quantum number. (7.6)
- Substitution reaction (hydrocarbons)** a reaction in which an atom, usually a halogen, replaces a hydrogen atom in a hydrocarbon. (22.1)
- Supercooling** the process of cooling a liquid below its freezing point without its changing to a solid. (10.8)
- Supercritical reaction (nuclear)** a reaction in which more than one neutron from each fission event causes another fission event. The process rapidly escalates to a violent explosion. (18.6)
- Superheating** the process of heating a liquid above its boiling point without its boiling. (10.8)
- Superoxide** a compound containing the O_2^- anion. (19.2)
- Surface tension** the resistance of a liquid to an increase in its surface area. (10.2)
- Surroundings** everything in the universe surrounding a thermodynamic system. (6.1)
- Syndiotactic chain** a polymer chain in which the substituent groups such as CH_3 are arranged on alternate sides of the chain. (22.5)
- Syngas** synthetic gas, a mixture of carbon monoxide and hydrogen, obtained by coal gasification. (6.6)
- System (thermodynamic)** that part of the universe on which attention is to be focused. (6.1)
- Systematic error** an error that always occurs in the same direction. (1.4)
- Tempering** a process in steel production that fine-tunes the proportions of carbon crystals and cementite by heating to intermediate temperatures followed by rapid cooling. (21.8)
- Termolecular step** a reaction involving the simultaneous collision of three molecules. (12.6)
- Tertiary structure (of a protein)** the overall shape of a protein, long and narrow or globular, maintained by different types of intramolecular interactions. (22.6)
- Theoretical yield** the maximum amount of a given product that can be formed when the limiting reactant is completely consumed. (3.10)
- Theory** a set of assumptions put forth to explain some aspect of the observed behavior of matter. (1.2)
- Thermal pollution** the oxygen-depleting effect on lakes and rivers of using water for industrial cooling and returning it to its natural source at a higher temperature. (11.3)
- Thermodynamic stability (nuclear)** the potential energy of a particular nucleus as compared to the sum of the potential energies of its component protons and neutrons. (18.1)
- Thermodynamics** the study of energy and its interconversions. (6.1)
- Thermoplastic polymer** a substance that when molded to a certain shape under appropriate conditions can later be remelted. (22.5)
- Thermoset polymer** a substance that when molded to a certain shape under pressure and high temperatures cannot be softened again or dissolved. (22.5)
- Third law of thermodynamics** the entropy of a perfect crystal at 0 K is zero. (16.5)
- Titration** a technique in which one solution is used to analyze another. (4.8)
- Torr** another name for millimeter of mercury (mm Hg). (5.1)
- Transfer RNA (tRNA)** a small RNA fragment that finds specific amino acids and attaches them to the protein chain as dictated by the codons in mRNA. (22.6)
- Transition metals** several series of elements in which inner orbitals (*d* or *f* orbitals) are being filled. (7.11; 19.1)
- Transuranium elements** the elements beyond uranium that are made artificially by particle bombardment. (18.3)
- Triple bond** a bond in which three pairs of electrons are shared by two atoms. (8.8)
- Triple point** the point on a phase diagram at which all three states of a substance are present. (10.9)
- Tyndall effect** the scattering of light by particles in a suspension. (11.8)
- Uncertainty (in measurement)** the characteristic that any measurement involves estimates and cannot be exactly reproduced. (1.4)
- Unimolecular step** a reaction step involving only one molecule. (12.6)
- Unit cell** the smallest repeating unit of a lattice. (10.3)
- Unit factor method** an equivalence statement between units used for converting from one unit to another. (1.6)
- Universal gas constant** the combined proportionality constant in the ideal gas law; $0.08206 L \cdot atm/K \cdot mol$ or $8.3145 J/K \cdot mol$. (5.3)
- Valence electrons** the electrons in the outermost principal quantum level of an atom. (7.11)
- Valence shell electron-pair repulsion (VSEPR) model** a model whose main postulate is that the structure around a given atom in a molecule is determined principally by minimizing electron-pair repulsions. (8.13)
- Van der Waals equation** a mathematical expression for describing the behavior of real gases. (5.8)
- Van't Hoff factor** the ratio of moles of particles in solution to moles of solute dissolved. (11.7)
- Vapor pressure** the pressure of the vapor over a liquid at equilibrium. (10.8)
- Vaporization (evaporation)** the change in state that occurs when a liquid evaporates to form a gas. (10.8)
- Viscosity** the resistance of a liquid to flow. (10.2)
- Volt** the unit of electrical potential defined as one joule of work per coulomb of charge transferred. (17.1)
- Voltmeter** an instrument that measures cell potential by drawing electric current through a known resistance. (17.1)
- Volumetric analysis** a process involving titration of one solution with another. (4.8)

Vulcanization a process in which sulfur is added to rubber and the mixture is heated, causing crosslinking of the polymer chains and thus adding strength to the rubber. (22.5)

Wave function a function of the coordinates of an electron's position in three-dimensional space that describes the properties of the electron. (7.5)

Wave mechanical model a model for the hydrogen atom in which the electron is assumed to behave as a standing wave. (7.5)

Wavelength the distance between two consecutive peaks or troughs in a wave. (7.1)

Weak acid an acid that dissociates only slightly in aqueous solution. (4.2; 14.2)

Weak base a base that reacts with water to produce hydroxide ions to only a slight extent in aqueous solution. (4.2; 14.6)

Weak electrolyte a material which, when dissolved in water, gives a solution that conducts only a small electric current. (4.2)

Weight the force exerted on an object by gravity. (1.3)

Work force acting over a distance. (6.1)

X-ray diffraction a technique for establishing the structure of crystalline solids by directing X rays of a single wavelength at a crystal and obtaining a diffraction pattern from which interatomic spaces can be determined. (10.3)

Zone of nuclear stability the area encompassing the stable nuclides on a plot of their positions as a function of the number of protons and the number of neutrons in the nucleus. (18.1)

Zone refining a metallurgical process for obtaining a highly pure metal that depends on continuously melting the impure material and recrystallizing the pure metal. (21.8)