GLOSSARY

A

absolute temperature — A temperature expressed in the Kelvin scale. The absolute temperature of a substance is a measure of the average kinetic energy of the molecules in the substance. (Section 7.2)

absorption — Absorption of a photon increases the energy of an atom or a molecule by the energy of the photon ($h\nu$). A photon can be absorbed only if its energy matches the energy difference between two energy levels in the atom or molecule. (Section 2.3)

acceptor orbital — The orbital on the oxidizing agent that receives the transferred electrons in a redox reaction. (Section 11.1)

acid dissociation constant — Equilibrium constant for the reaction $HA \rightarrow H^{1+} + A^{1-}$ in the Arrhenius definition, or $HA + H_2O \rightarrow H_3O^{1+} + A^{1-}$ in the Brønsted definition. (Section 12.6)

acid ionization constant — See acid dissociation constant. (Section 12.6)

acidic solutions — Solutions in which $[H_3O^{1+}] > [OH^{1-}]$. An acidic solution has a pH < 7.0 at 25 °C. (Section 12.9)

activation energy — The energy of the transition state relative to that of the reactants or products. It is the minimum energy that the reactants must have in order for a reaction to proceed. (Section 9.9)

active electrode — An electrode that is a participant in the half-reaction. For example, a copper electrode in a Cu^{2+} half-cell. (Section 11.3)

addition polymers — Polymers formed by addition reactions. (Section 13.6)

addition reaction — A reaction in which two reactants combine to form a single product. (Section 13.5)

adhesive forces — Forces between unlike molecules (compare with cohesive force). (Section 7.5)

alcohol — A compound with the general formula R–OH, where R is a generic group of atoms and OH is the hydroxyl group. (Section 13.4)

alkali metal An element that belongs to Group 1A. The common alkali metals are lithium, sodium, potassium, rubidium, and cesium. (Section 1.11)

alkaline earth metal An element that belongs to Group 2A. The common alkaline earth metals are beryllium, magnesium, calcium, strontium, and barium. (Section 1.11)

alkane A saturated hydrocarbon; i.e., a hydrocarbon that contains no multiple bonds. (Section 13.1)

alkene A hydrocarbon that contains carbon-carbon double bonds. (Section 13.1)

alkyl group An organic group formed by removing one hydrogen atom from an alkane. (Section 13.2)

amide An amine attached to a carbonyl. (Section 13.4)

amine An ammonia molecule in which one or more of the hydrogens have been replaced with R groups. (Section 13.4)

amino acid A compound that contains both amine and carboxylic acid functional groups. (Section 13.4)

amorphous solids Solids that have ordered arrangements of particles over short distances only. This is referred to as local order. (Section 8.1)

angstrom 10^{-10} m. The angstrom is commonly used for bond lengths because most bond lengths are between 1 and 2 Å. (Section 2.2)

anion A negatively charged species because it contains more electrons than protons. (Section 1.10)

anode Compartment or electrode at which oxidation occurs. (Section 11.3)

antiferromagnetic All electron spins are paired. (Section 14.6)

Arrhenius acid A substance that contains H atoms and produces H^{1+} ions in water. (Section 12.6)

Arrhenius base A substance that contains OH and produces OH^{1-} ions in water. (Section 12.6)

atom The smallest particle of an element that retains the properties of the element. (Section 1.3)

atomic mass The average relative mass of the atoms of an element based on the mass of carbon-12. (Section 1.5)

atomic mass unit A unit of mass that is 1/12 the mass of a single carbon-12 atom. (Section 1.5)

atomic number The number of protons in the nucleus. It is the number that identifies the atom. (Section 1.10)

atomic radius One-half the separation between two atoms that make contact in the unit cell of a metal atom. The atomic radius is also known as the metallic radius. (Section 8.2)

Avogadro's law Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules. (Section 1.4)

Avogadro's number 6.02×10^{23}, the number of items in a mole. (Section 1.5)

B

band gap The energy separation between the valence and conduction band. (Section 8.6)

band theory An extension of MO theory to metals. A very large number of atomic orbitals in a metal combine to form a very large number of molecular orbitals. The resulting molecular orbitals are so close in energy that they form an energy band. (Section 8.6)

barometer A device used to determine atmospheric (or barometric) pressure. (Section 7.1)

basic solutions Solutions in which $[H_3O^{1+}] < [OH^{1-}]$. A basic solutions has a pH > 7.0 at 25 °C. (Section 12.9)

binary compounds Compounds composed of only two elements. Al_2O_3 is a binary compound because it contains only Al and O. (Section 5.3)

blackbody radiation Light emitted by a solid as it is heated. (Section 2.2)

boiling point The temperature at which the vapor pressure equals the external pressure. If the external pressure is 1 atm, then the temperature is called the normal boiling point. (Section 7.6)

bond angle The angle formed by two bonds to the same atom. (Section 6.1)

bond dipole A measure of how polar the bond is. It is represented an arrow pointing from the positive end of the bond dipole (the less electronegative atom) toward the negative end of the bond dipole (the more electronegative atom). (Section 5.2)

bond energy The amount of energy required to break one mole of bonds *in the gas phase*. (Section 9.4)

bond length The distance between two bound nuclei. (Section 5.1)

bond order The number of shared pairs in a bond. As the bond order increases, the length of the bond decreases and its strength increases. In MO theory, it is determined as the number of bonding electrons − number of antibonding electrons in a bond. (Section 5.5)

bonding electrons The shared electrons in a covalent bond. (Section 5.1)

bonding pair A pair of electrons involved in a covalent bond. Bonding pairs are typically drawn as lines in the Lewis structure of the molecule. (Section 5.1)

Boyle's law The pressure-volume product of a fixed amount of gas at constant temperature is constant. $PV = k(n, T)$ (Section 7.1)

Brønsted acid A proton donor. (Section 12.2)

Brønsted base A proton acceptor. (Section 12.2)

branched chain A chain of atoms in which at least one atom is bound to three or more members of the chain. (Section 13.1)

bulk property A property of a material (such as a pure solid or liquid) as opposed to individual atoms or molecules. Bulk properties are often different than the atomic or molecular properties of the atoms or molecules making up the material. (Section 3.7)

C

carbonyl group A C=O group. (Section 13.4)

carboxyl group The combination of a carbonyl (C=O) and a hydroxyl group (O–H). Molecules with carboxyl groups are called carboxylic acids (RCOOH), and the deprotonated ions are called carboxylates ($RCOO^{1-}$). (Section 13.4)

carboxylic acid An acid in which the proton is on a carboxyl group (–COOH). (Section 13.4)

catalyst A substance that speeds up a reaction, but is unchanged by the process. (Section 9.10)

cathode Compartment or electrode at which reduction occurs. (Section 11.3)

cation A positively charged species because it contains fewer electrons than protons. (Section 1.10)

Charles's law The ratio of the volume of a fixed amount of gas to its temperature in kelvins at constant pressure is a constant. $V/T = k(n, P)$ (Section 7.1)

chemical property A property of the substance that requires the substance to change into another substance. Hydrogen and oxygen react to produce water is a chemical property of hydrogen. (Section 1.1)

chemistry That branch of science that deals with matter and the changes it undergoes. (Section 1.1)

cis A configuration in which two groups are on the same side of a bond or atom. (Section 13.3)

cohesive forces Forces between like molecules (compare with adhesive force). (Section 7.5)

collision frequency The number of collisions per unit volume per unit time, which normally has units of (moles of collisions)/(liter $\cdot$ s). (Section 9.10)

compound	A pure substance that consists of more than one element. (Section 1.4)
concentration	The amount of a substance divided by the volume in which it is contained. Concentration is normally used for a component of a mixture. (Section 7.1)
condensation	The process of converting a vapor into its liquid. (Section 7.6)
condensation polymers	Polymers formed by condensation reactions. (Section 13.6)
condensation reaction	A reaction in which two reactants combine to form two products (one of which is often a small molecule such as water or an alcohol). (Section 13.5)
conduction band	An unfilled band. Electrons in a conduction band are free to move throughout the metal due to the presence of unfilled orbitals. Thus, electrons can conduct electricity if they are in a conduction band. (Section 8.6)
conjugate acid-base pair	A Brønsted acid and base that differ by one proton only. (Section 12.3)
connectivity	The manner in which the atoms in a molecule are connected. (Section 13.1)
constitutional isomers	Compounds with the same formula but different connectivities. (Section 13.3)
continuous chain	A chain of atoms in which no atom is bound to more than two members of the chain. (Section 13.1)
continuous spectrum	A spectrum in which all wavelengths in the region are present. Thus, they merge into one another continuously. A rainbow is a continuous spectrum of visible light. (Section 2.1)
coordination number	The number of nearest neighbors around a particle in a crystal or the number of ligand atoms bound to the central metal in a coordination compound. (Section 8.4)
core electron	The tightly bound electrons that are unaffected by chemical reactions. Core electrons reside in filled sublevels and form a spherical shell of negative charge around the nucleus that affects the amount of nuclear charge that the outermost electrons experience. (Section 3.1)

corrosion The unwanted natural oxidation of a metal. (Section 11.7)

Coulomb's law Two charged particles experience a force that is proportional to the product of their charges and varies inversely with the dielectric of the medium and the square of the distance that separates them. (Section 1.8)

covalent bond Bond formed by sharing electrons. (Section 5.1)

critical point The point at the end of the liquid-vapor line in a phase diagram. Substances beyond the critical point are neither liquids nor gases; they are supercritical fluids. (Section 7.6)

critical pressure The pressure required to liquefy a gas at the critical temperature. (Section 7.6)

critical temperature The highest temperature at which a gas can be liquefied. (Section 7.6)

crystalline solids Solids with well defined and ordered repeat units of the particles making up the solid. The order exists throughout the crystal and is said to be long range. (Section 8.1)

D

degrees of freedom The basic set of motions (translations, rotations, and vibrations) that a molecule undergoes. The kinetic energy of a molecule is distributed amongst its degrees of freedom. A molecule with n atoms has $3n$ degrees of freedom. (Section 9.5)

delocalized Not confined to the region between two atoms. Applied to bonds and electrons, as in delocalized bond or delocalized electrons. (Section 6.5)

density The ratio of mass to volume. (Section 8.5)

deposition The process in which a vapor is converted into its solid. (Section 7.6)

detergent A substance that has both a hydrophobic region, which interacts well with grease and stains, and a hydrophilic region, which interacts well with water. (Section 10.4)

diamagnetism The tendency of certain atoms not to be attracted (or repelled slightly) by a magnetic field. It is an atomic property associated with atoms with no unpaired electrons. (Section 3.7)

diatomic molecules Molecules containing two and only two atoms. (Section 1.4)

dielectric constant A number that relates the ability of a medium to shield two charged particles from one another. A medium with a high dielectric constant shields the charges better than one with a low constant. (Section 1.8)

dipolar force An intermolecular force arising from the interaction of the opposite ends of permanent dipoles. (Section 7.3)

dipole Two poles. Bonds between atoms with different electronegativities have bond dipoles. Molecules in which the bond dipoles do not cancel have molecular dipoles. (Section 7.3)

dispersion force Forces between molecules that result from the interaction of temporary or induced dipoles. Dispersion forces increase approximately with molecular size. (Section 7.3)

dissociation energy The bond energy, the amount of energy required to break one mole of bonds in the gas phase. (Section 9.4)

dissolution The breaking apart of an ionic substance into its ions in solution. (Section 10.7)

donor orbital The orbital on the reducing agent that contains the electrons to be transferred in a redox reaction. (Section 11.1)

dynamic equilibrium An equilibrium attained when two competing processes occur at equal rates. Contrast to a static equilibrium where the competing processes stop. (Section 7.6)

E

effective nuclear charge The nuclear charge experienced by an electron. Z_{eff} for a valence electron is less than the full nuclear charge due to shielding by the other electrons. (Section 3.2)

electrochemistry The combination of electrical conduction through a circuit and electron transfer reactions. (Section 11.3)

electrode A metal immersed in a solution that provides a surface at which electrons can be transferred between an electrical circuit and a reactant in a redox reaction. Electrodes are active if they participate in the reaction and passive if they do not. (Section 11.3)

electrolysis A nonspontaneous redox reaction that is driven uphill in free energy by the application of an external electrical potential. (Section 11.8)

electrolyte A material that produces ions when dissolved in water. Electrolytes can be weak or strong depending upon the extent to which they produce ions. Substances that dissolve in water as molecules rather than ions are called nonelectrolytes. (Section 10.5)

electron A subatomic particle found outside the nucleus. It carries a -1 charge and has a mass of 5×10^{-4} amu. (Section 1.9)

electron configuration A listing of the occupied sublevels and the number of electrons that they contain. (Section 2.7)

electron density The probability of finding an electron in a particular region of space. The electron density is high in regions where the probability of finding an electron is high. (Section 2.4)

electronegativity A relative measure of the ability of an atom to attract bonding electrons to itself. Atoms with high electronegativities have unfilled orbitals that are low in energy. (Section 3.6)

electronic transition Changing the energy of an electron from one allowed state to another. (Section 2.3)

element A pure substance that cannot be broken down into a simpler substance by chemical means. (Section 1.4)

emission Emission of a photon decreases the energy of an atom or a molecule by the energy of the photon ($h\nu$). The energy of the photon equals the energy difference between two energy levels in the molecule or atom. (Section 2.3)

enantiomers Two molecules that are non-superimposable mirror images of one another. A molecule has an enantiomer if it has a stereocenter. (Section 13.3)

endothermic Absorbs heat. (Section 9.1)

energetics A combination of energy and kinetics. (Section 9.1)

energy band	A region of allowed energy in a metal in which there is no separation between adjacent energy levels. (Section 8.6)
energy level	An allowed amount of energy in a quantized system. (Section 2.3)
energy of interaction	The energy of two interacting particles relative to the energy of the two particles when they are not interacting. Energies of interaction in chemistry result from the electrostatic interactions between charged particles. (Section 1.8)
enthalpy of combustion	The heat released when one mole of a substance reacts with oxygen. (Section 9.3)
enthalpy of reaction	The heat absorbed or released by a reaction run at constant temperature and pressure. (Section 9.2)
entropy	The thermodynamic measure of the number of ways in which a system can distribute its energy. (Section 9.5)
enzyme	A biological compound (usually a protein) that acts as a catalyst. (Section 9.10)
equilibrium constant	The product of the equilibrium concentrations of the substances on the right side of a chemical equation divided by the equilibrium concentrations of the substances on the left side of a chemical equation. All concentrations are raised to the exponent equal to the substance's coefficient in the balanced equation. The concentrations of pure solids and liquids are considered to be unity, and the concentrations of gases are given as pressures in atmospheres. (Section 9.11)
ester	Compounds with the general formula RCOOR'. (Section 13.4)
esterification	A condensation reaction between a carboxylic acid and an alcohol to an ester and water. (Section 13.5)
evaporation	The process of converting a liquid to its vapor. (Section 7.6)
excited state	An allowed state that is not the lowest energy state. (Section 2.7)
exothermic	Gives off heat. (Section 9.1)

extensive reaction A reaction with a large equilibrium constant. If a reaction is extensive, the concentration of at least one of the reactants will get very small during the reaction. (Section 9.11)

F

factor label method A method that uses the labels (units) of numbers to determine the order and manner in which a series of numbers should be strung together to obtain an answer. (Section 1.5)

Fermi level The highest occupied energy level in a band. (Section 8.6)

ferrimagnet A magnetic material whose particles have opposing but unequal spins. (Section 14.6)

ferromagnet A magnetic material whose particles have aligned spins. (Section 14.6)

ferromagnetism Bulk magnetism in a material (such as iron) resulting from the alignment of the spins of adjacent atoms in the same direction. (Section 3.7)

first law of thermodynamics Energy is neither created nor destroyed in any process. (Section 9.1)

formal charge The charge an atom would have if the bonds were assumed to be covalent; i.e., if its bonding electrons were assigned equally between the atoms in each bond. (Section 5.8)

free energy of reaction The energy that is free to do work or the energy that must be supplied to make a nonspontaneous process proceed. $\Delta G = \Delta H - T\Delta S$ (Section 9.7)

frequency The number of oscillations per second that a wave undergoes. (Section 2.1)

functional group A group of connected atoms within a molecule that has a specific reactivity. (Section 13.4)

G

galvanic cell A spontaneous electrochemical cell. Galvanic cells convert chemical potential energy into electrical potential energy. (Section 11.3)

geometric isomers Stereoisomers that differ because two groups can be on the same side (cis isomer) or on the opposite side (trans isomer) of some structural feature. (Section 13.3)

ground state The lowest energy configuration. (Section 2.7)

group A vertical column in the periodic table. The elements in a group have similar properties. (Section 1.11)

H

half-reaction Half of a redox reaction that depicts only the electron gain or the electron loss by showing the electrons explicitly. Ox + ne^{1-} → Red is the general form of a reduction half-reaction. Half-reactions can also contain H_2O, and H^{1+} or OH^{1-} to balance oxygen and hydrogen atoms (Section 11.2)

halogen An element that belongs to Group 7A. The common halogens are fluorine, chlorine, bromine, and iodine. The elemental halogens are diatomic. (Section 1.11)

heat of fusion The heat required to melt a substance at its melting point. (Section 7.6)

heat of sublimation The amount of heat required to vaporize a solid. (Section 7.6)

heat of vaporization The amount of heat required to vaporize a liquid. (Section 7.6)

heterogeneous mixture A mixture whose composition varies as in a mixture of water and oil. (Section 10.1)

HOMO The highest occupied molecular orbital. (Section 6.5)

homogeneous mixture A mixture whose composition is the same throughout; i.e., one in which the concentration of each component is the same regardless of the volume that is sampled. Homogeneous mixtures are called solutions. (Section 10.1)

Hund's rule The number of electrons with identical spin is maximized when filling the orbitals of a sublevel. (Section 2.7)

hybrid orbital An orbital constructed by mathematical addition of two atomic orbitals. Hybrid orbitals are required to explain bonding in the orbital overlap model of bonding used in this course. (Section 6.4)

hybridization Mixing two or more atomic orbitals to get two or more hybrid orbitals. (Section 6.4)

hydration The process of surrounding a solute particle with water molecules. (Section 10.2)

hydrocarbon A compound that contains only carbon and hydrogen. (Section 13.1)

hydrogen bond Especially strong form of dipole-dipole interaction that occurs in compounds containing a hydrogen atom attached to N, O, or F. (Section 7.3)

hydrogenation The addition of hydrogen to a compound. (Section 13.1)

hydrophilic Water-loving. (Section 10.3)

hydrophobic Water-hating. (Section 10.3)

hydrophobic effect The tendency of water to exclude hydrophobic molecules by establishing an ice-like structure around them. (Section 10.3)

hypothesis A statement that is suggested to explain an observation. If a hypothesis proves successful in explaining many other experiments, it becomes a theory, but if it fails to explain a test, it is discarded or modified. (Section 1.1)

I

ideal gas law The relationship between the pressure (P), volume (V), temperature (T), and number of moles (n) of a gas. $PV = nRT$ (Section 7.1)

induced dipole A molecular dipole in one molecule caused by the asymmetric charge distribution in a neighboring molecule. (Section 7.3)

insulator A substance that does not conduct electricity at reasonable temperatures. Insulators are characterized by large band gaps. (Section 8.6)

intermolecular force A force that is between different molecules. Hydrogen bonding, dipole-dipole, and dispersion are intermolecular forces. (Section 7.3)

internuclear axis An imaginary line that connects to two bound atoms in a molecule. (Section 6.4)

intramolecular force — A force that is within a molecule. Chemical bonds are intramolecular forces. (Section 7.3)

ion — A charged species. (Section 1.10)

ion product — The reaction quotient for the reaction in which a solid dissolves into its ions in solution. It equals the product of the concentrations of the ions each raised to its coefficient in the balanced equation. $Q_{\text{ip}} = K_{\text{sp}}$ at equilibrium. (Section 12.9)

ion product constant of water — Equilibrium constant for the reaction $2\ H_2O \rightleftharpoons H_3O^{1+} + OH^{1-}$.

$K_{\text{w}} = [H_3O^{1+}][OH^{1-}]$, which has a value of 1.0×10^{-14} at 25 °C (Section 12.9)

ionic bond — Electrostatic force between oppositely charged ions. (Section 4.1)

ionization energy — The energy required to remove an electron from an atom or molecule. (Section 3.5)

isoelectronic — Having the same electron configuration. (Section 4.2)

isomers — Different molecules with the same formula. (Section 13.1)

isotope — Atoms with the same atomic number but different mass numbers; i.e., isotopes have the same number of protons but different numbers of neutrons. (Section 1.10)

K

kaolinite clays — Aluminosilicate sheets composed of a silicate and aluminate layers. They are the main component of china clay. (Section 8.8)

kelvin — The SI unit of temperature. K = °C + 273.15. (Section 7.1)

kinetic energy — Energy of motion $\left(KE = \frac{1}{2}mv^2\right)$. Anything in motion has the capacity to do work on another object by simply colliding with it. (Section 1.7)

kinetics — The study of reaction rates and mechanisms. (Section 9.9)

L

lattice The 3-D arrangement of the particles in a crystal. Each particle lies on a lattice site. (Section 8.1)

law A statement that summarizes many observations. (Section 1.2)

law of combining volumes Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules. (Section 1.4)

law of conservation of mass The total mass of reactants and products remains constant during a chemical reaction; i.e., mass is neither created nor destroyed in a chemical reaction. (Section 1.2)

law of definite proportions The elements of a compound are always present in definite proportions by mass. (Section 1.2)

law of multiple proportions The masses of one element that combine with a fixed mass of another element in different compounds of the same elements are in a ratio of small whole numbers. (Section 1.2)

Le Châtelier's principle A system at equilibrium will respond to a stress in such a way as to minimize the effect of the stress. (Section 9.12)

level An allowed energy designated by a quantum number. The level of an electron in an atom is designated by the n quantum number. (Section 2.5)

leveling effect The strengths of all acids stronger than hydronium ion are leveled to that of hydronium ion in water because the strong acids react extensively with water to produce hydronium ion. All strong bases are leveled to hydroxide ion in water because they all react extensively with water to produce hydroxide ion. (Section 12.4)

Lewis acid A substance with a low-lying, empty orbital that can be used to form a covalent bond to a Lewis base. (Section 12.1)

Lewis acid-base reaction The conversion of the lone pair on a Lewis base and the empty orbital on a Lewis acid into a covalent bond between the acid and the base. (Section 12.1)

Lewis base A substance with a lone pair that can be shared with a Lewis acid to form a covalent bond between the acid and the base. (Section 12.1)

Lewis structure A representation of a molecule that shows all of the valence electrons as dots. The dots are usually in pairs that represent bonding and nonbonding pairs. Bonding pairs are often represented by lines. (Section 5.4)

Lewis symbol A representation of an atom that shows the valence electrons as dots in four regions around the atom. (Section 5.4)

ligand A molecule or ion that is attached to a metal. Ligands are Lewis bases and metals are Lewis acids. (Section 14.1)

line spectrum A spectrum in which only certain wavelengths, which appear as lines, are present. Atomic spectra are line spectra. (Section 2.2)

liquid junction A device, which connects the anode and cathode of an electrochemical cell, that completes the electrical circuit by allowing ions to migrate between the two compartments. The liquid junction maintains the electrical neutrality of the two compartments while keeping the reactants separated. (Section 11.3)

load Any device in a galvanic cell that utilizes the free energy given off by the transferred electrons. (Section 11.3)

lone pair Pairs of nonbonding electrons. (Section 5.5)

LUMO The lowest unoccupied molecular orbital. (Section 6.5)

M

main group element A Group A element. (Section 1.11)

manometer A device used to determine the pressure of a gas. (Section 7.1)

mass number The number of protons plus the number of neutrons in the nucleus. (Section 1.10)

melting point The temperature at which the solid and liquid states are in equilibrium. (Section 7.6)

meniscus Curved shape of the top of a liquid. (Section 7.5)

metal A material that is shiny, malleable, and a good conductor of electricity. Elements that are metals lie on the left side of the periodic chart and represent about 80% of the elements. Metals react with nonmetals to form ionic compounds. (Section 1.11)

metallic bond A "sea of electrons" holds metal cations together in solid. (Section 8.6)

metallic radius One-half the separation between two atoms that make contact in the unit cell of a metal atom. The metallic radius is also known as the atomic radius. (Section 8.2)

metalloids Have properties intermediate between the metals and nonmetals. They are shiny but brittle. They are not good conductors of heat or electricity (they are semiconductors). Eight elements are metalloids. (Section 1.11)

micelle Spherical arrangement of detergent molecules in which the heads form a polar outer shell and the tails form a hydrophobic liquid center. (Section 10.4)

molar mass The mass of one mole of substance. The molar mass is equal to the atomic or molecular mass (weight) expressed in grams. (Section 1.5)

molarity Molarity is the number of moles of solute present in a liter of solution. (Section 7.1)

mole 6.02×10^{23} items. It is the number of molecules or atoms in a sample of a compound or element that has a mass equal to its molecular or atomic mass expressed in grams. (Section 1.5)

molecular dipole A measure of how polar a molecule is. It is represented by an arrow pointing from the center of positive charge toward the center of negative charge. It is equal to the product of the charge on the two poles and the distance between them. (Section 7.3)

molecular mass The average relative mass of the molecules of a compound based on the mass of carbon-12. (Section 1.5)

molecular orbital theory Bonding theory in which bonds can be formed from combinations of atomic orbitals of many atoms. This is different than the model emphasized in this course, which assumes that bonds are formed from the overlap of the orbitals of two adjacent atoms only. (Section 6.5)

molecule An independent particle that consists of two or more chemically bound atoms. (Section 1.3)

monomer A single unit building block that can be bound together to form larger molecules. Linking two monomers produces a dimer, linking three produces a trimer, and linking many produces a polymer. (Section 13.6)

N

net equation A chemical equation that shows only those substances that are changed during the reaction. (Section 10.8)

net ionic equation A chemical equation that shows only those ions that are involved in the reaction. (Section 10.8)

neutral solutions Solutions in which $[H_3O^{1+}] = [OH^{1-}]$. A neutral solution has a pH = 7.0 at 25 °C. (Section 12.9)

neutron A subatomic particle found in the nucleus. It carries no charge and has a mass of ∼1 amu. (Section 1.10)

noble gas An element that belongs to Group 8A. The common noble gases are helium, neon, argon, krypton, xenon, and radon. (Section 1.11)

nodal plane A plane of zero electron density in an orbital that lies between regions that do have electron density. p orbitals and π orbitals each contain a single nodal plane. (Section 2.6)

nonelectrolyte A substance whose aqueous solution does not conduct electricity. Electricity is not conducted because the electrolyte produces no ions in solution. (Section 10.5)

nonmetal Elements that are gases, liquids, or solids that are dull, brittle, and poor conductors of electricity. Nonmetals lie on the right side of the periodic chart. Nonmetals react with one another to form covalent compounds or with metals to form ionic compounds. (Section 1.11)

normal boiling point Temperature at which the vapor pressure of a liquid is 1 atm. (Section 7.6)

nucleotide A unit of a nucleic acid that consists of a phosphate, a sugar, and an N-containing base. (Section 13.6)

nucleus The very small center of the atom that contains all of the positive charge and virtually all of the mass of the atom. (Section 1.9)

nylon A polyamide produced in the reaction of a diamine and a diester. (Section 13.6)

O

octet rule Atoms strive to obtain an octet (eight) valence electrons in their molecules. (Section 5.5)

orbital A solution to the wave equation. It is most commonly used to refer to the region to which an electron is confined most of the time. In other words, it shows the electron density of the electron(s) that it contains. (Section 2.5)

oxidant Oxidizing agent. (Section 11.1)

oxidation The loss of electrons, which results in an increase in oxidation state. (Section 11.1)

oxidation state The charge an atom would have if the bonds were assumed to be ionic; i.e., if its bonding electrons were assigned to the more electronegative atom in each bond. (Section 4.4)

oxidizing agent A substance that promotes oxidation in other substances. The oxidizing agent is reduced in the process. (Section 11.1)

oxoacid Brønsted acids in which the proton is attached to an oxygen atom. (Section 12.5)

oxoanion An anion that consists of a central atom surrounded by oxygen atoms. The central atom is usually in a high oxidation state because it is surrounded by the very electronegative oxygen atoms. (Section 4.5)

P

packing efficiency The fraction of the volume of the unit cell that is occupied by particles. (Section 8.5)

paramagnetism The tendency of certain atoms to be attracted by a magnetic field. It is an atomic property that depends upon the number of unpaired electrons. (Section 3.7)

partial pressure The pressure exerted by one gas in a mixture of gases. The total pressure exerted by a mixture is the sum of the partial pressures of all of the components of the mixture. (Section 7.1)

pascal The SI unit of pressure. 1 Pa = 1 kg $\cdot$ m^{-1} $\cdot$ s^{-2} = 9.9 $\times$ 10^{-6} atm (Section 7.1)

passive electrode An electrode that does not participate in the half-reaction. For example, a platinum electrode in a half-cell. (Section 11.3)

Pauli exclusion principle No two electrons in an atom can have the same set of quantum numbers. (Section 2.7)

peptide An amide produced from the reaction of two amino acids. (Section 13.6)

percent ionic character A measure of the charge separation in a bond. Polar bonds have ionic character because there is charge separation. A bond is considered to be ionic if it is over 50% ionic. (Section 5.2)

period A horizontal row in the periodic table. The properties of the elements in a period vary gradually across the period. (Section 1.11)

periodic law When arranged in the order of their atomic numbers, the elements exhibit a periodicity in the chemical and physical properties. (Section 1.11)

periodic table An arrangement of the elements into rows (periods) and columns (groups) such that the elements in the same group have similar properties. (Section 1.11)

pH The negative base 10 logarithm of the hydronium ion concentration.

pH = $-\log [H_3O^{1+}]$ (Section 12.9)

phase diagram A diagram showing the temperatures and pressures at which the different phases of a substance are in equilibrium. (Section 7.6)

photon A quantum of electromagnetic radiation. (Section 2.2)

photosynthesis Process in which plants convert solar energy into carbohydrates. (Section 14.4)

physical property A property of a substance that is independent of other substances. Melting point, boiling point, color, and hardness are some physical properties. (Section 1.1)

pi bond Bond formed from the side-on interaction of two p orbitals. Pi bonds have nodal planes that contain the internuclear axis. (Section 6.4)

pK_a	The negative base 10 logarithm of the acid dissociation constant. $pK_a = -\log K_a$ (Section 12.9)
Planck's constant	The proportionality constant that relates the frequency of a photon to its energy. $h = 6.626 \times 10^{-34}$ J · s (Section 2.2)
polar	Molecules and bonds with dipoles are said to be polar. (Section 7.3)
polar covalent bond	Covalent bonds in which the bonding electrons are NOT shared equally. Thus, the bonds are between atoms of different electronegativities. (Section 5.2)
polar molecules	Molecules with an asymmetric charge distribution that results in non-coincident centers of negative and positive charge. (Section 7.3)
polyamide	A condensation polymer that contains many amide linkages. (Section 13.6)
polyene	An organic compound with many double bonds. (Section 13.1)
polymer	A large molecule consisting of many single unit building blocks called monomers. (Section 13.6)
polypeptide	A polyamide produced from the reaction of many amino acids. (Section 13.6)
polyunsaturated	Organic compounds with many multiple bonds. (Section 13.1)
potential energy	Energy due to position. In chemistry, potential energy arises from the interaction of charged particles, and the closer they are, the stronger they interact. (Section 1.7)
precipitate	A solid formed when two solutions are mixed, or the act of forming the solid. Thus, AgCl precipitates and is a precipitate when it does. (Section 10.8)
principal quantum number	Also called the n quantum number, it specifies the energy level of the electron. (Section 2.5)
protein	A large polypeptide. (Section 13.6)

proton A subatomic particle found in the nucleus. It carries a +1 charge and has a mass of ∼1 amu. (Section 1.10)

purely covalent bond Covalent bonds in which the bonding electrons are shared equally. Thus, the bonds are between atoms of nearly the same electronegativity. (Section 5.2)

Q

qualitative observations Observations that do not involve numbers. (Section 1.1)

quantitative observations Observations that involve numbers. (Section 1.1)

quantum Packet(s) of energy. (Section 2.2)

quantum numbers Numbers (usually integers) that designate the allowed states. In this course, we consider quantum numbers for electrons only, but all atomic and molecular states (e.g., vibrational, rotational, and nuclear) are described by quantum numbers. (Section 2.5)

R

rate constant The proportionality constant between the concentrations of the components (usually reactants) of a reaction and the rate of reaction. (Section 9.10)

rate law An expression that shows how the rate of a reaction is related to the concentrations of the components (usually reactants) in the reaction. (Section 9.10)

reaction coordinate The combination of intermolecular distances and molecular structural changes required to convert reactant molecules into product molecules. (Section 9.9)

reaction diagram A plot of the energy of reactants and products versus the reaction coordinate for the reaction. (Section 9.9)

redox couple The oxidized and reduced forms of the species involved in a half-reaction. (Section 11.1)

redox electrons The electrons that are transferred in a redox reaction. (Section 11.1)

redox reactions Electron transfer reactions. (Section 11.1)

reducing agent A substance that promotes reduction in other material. Reducing agents are oxidized by the process. (Section 11.1)

reductant Reducing agent. (Section 11.1)

reduction The gain of electrons, which results in a decrease in oxidation state. (Section 11.1)

residue One of the amino acids making up a protein. (Section 13.6)

resonance structure Lewis structures of a molecule that differ only in the placement of electrons. (Section 5.7)

respiration Process whereby animals extract energy from carbohydrates. (Section 14.4)

Rydberg equation An empirical relationship for the frequency of each line in a hydrogen spectrum in terms of the difference of the recipricals of two squared integers. (Section 2.2)

S

salt An ionic compound formed in an Arrhenius acid-base reaction. The anion of a salt is supplied by the acid, and the cation by the base. (Section 12.1)

salt bridge A liquid junction that consists of a saturated solution of a strong electrolyte, such as KCl. (Section 11.3)

saturated carbons Carbon atoms involved in four sigma bonds. (Section 13.1)

science That branch of knowledge that is gained by the application of the scientific method. (Section 1.1)

second law of thermodynamics The entropy of the universe increases in all spontaneous processes. (Section 9.6)

semiconductor A substance whose electrical conductivity increases with temperature. Semiconductors are characterized by small but nonzero band gaps. (Section 8.6)

shielding The amount by which the nuclear charge experienced by an electron is reduced by the negative charge of other electrons. Core electrons shield valence electrons much better than do other valence electrons because most of the electron density and charge of the core electrons lies between the valence electrons and the nucleus. (Section 3.2)

sigma bond Bond formed from the end-on interaction of two orbitals. Sigma bonds contain the internuclear axis. (Section 6.4)

smectite clays Also called swelling clays, they consist of a layer of aluminate octahedra sandwiched between two layers of silicate tetrahedra. (Section 8.8)

soaps Derived from fatty acids, soaps are similar to detergents except the polar head is a COO^{1-} (carboxylate) group. Their Ca^{2+} salts are water insoluble, and, since Ca^{2+} is a major source of water hardnesss, soaps do not function very well in hard water. (Section 10.4)

solubility The maximum amount of solute that will dissolve in a solute at a given temperature. (Section 10.2)

solubility product constant The equilibrium constant for the equilibrium between a solid and a solution of its ions. (Section 10.9)

solute A component of a solution that is not the solvent. (Section 10.1)

solution A homogeneous mixture. (Section 10.1)

solvation The process of surrounding a solute particle with solvent molecules. (Section 10.2)

solvent The substance responsible for the phase of a solution. If one of the components of a solution is a liquid, then it is ordinarily considered the solvent. (Section 10.1)

sp hybrid One of the two orbitals obtained by mixing one s and one p orbital on an atom. The two sp hybrids are separated by 180°. (Section 6.4)

sp^2 hybrid One of the three orbitals obtained by mixing one s and two p orbitals on an atom. The three sp^2 hybrids lie in plane and are separated by 120°. (Section 6.4)

sp^3 hybrid One of the four orbitals obtained by mixing one s and three p orbitals on an atom. The four sp^3 hybrids point toward the corners of a tetrahedron and are separated by 109°. (Section 6.4)

spectator ion Ions in solution that do not undergo reaction. (Section 10.8)

spectrum Radiant energy arranged in order of its frequency or wavelength. (Section 2.1)

spontaneous process A process that takes place without intervention. $\Delta S_{\text{univ}} > 0$ for all spontaneous processes, and $\Delta G < 0$ for spontaneous processes at constant temperature and pressure. (Section 9.5)

standard enthalpy of reaction Enthalpy change for a process when all reactants and products are in their standard states. (Section 9.2)

standard hydrogen electrode A half-cell containing 1 M H^{1+} and 1 atm H_2 that is used as the reference for standard reduction potentials. The standard reduction potential of the SHE is assigned a value of exactly 0 V. (Section 11.4)

standard reduction potential The cell potential obtained by connecting a SHE to the "−" or Lo terminal of a voltmeter and the couple whose standard reduction potential is to be measured to the "+" or Hi terminal. It is a measure of the relative free energy of the redox electron(s) in the couple. (Section 11.4)

standard state A reference state used to compare thermodynamic quantities. It is 1 atm pressure for a gas, a concentration of 1 M for a solute, and the pure substance for a solid or a liquid. (Section 9.2)

stereocenter A carbon atom that has four different groups attached to it. (Section 13.3)

stereoisomers Have the same connectivities, but differ in the spatial arrangement of their atoms. (Section 13.3)

stoichiometric factor The conversion factor in a stoichiometric calculation. It is the ratio of subscripts in a chemical formula or the coefficients in a balanced chemical equation of the desired and given substances. (Section 1.6)

stoichiometry The conversion from one chemical species into a chemically equivalent amount of another. The conversion is made through the use of chemical formulas or balanced chemical equations. (Section 1.6)

straight chain A chain of atoms in which no atom is bound to more than two members of the chain. (Section 13.1)

strong acid An acid that reacts extensively with water; i.e., one whose acid dissociation (ionization) constant is much greater than one. (Section 12.2)

strong base A base that reacts extensively with water. (Section 12.2)

sublevel Specified by the n and l quantum numbers, it dictates the energy of the electron and the size and shape of the orbital. (Section 2.5)

sublimation The process in which a solid is converted into its vapor. (Section 7.6)

supercritical fluid The phase of matter beyond the critical point. (Section 7.6)

surface tension Energy required to increase the surface area of a liquid by a fixed amount. (Section 7.5)

T

temperature A measure of the kinetic energy of the molecules in a system. (Section 7.2)

theory A statement that explains many observations. (Section 1.1)

thermal energy The kinetic energy of a molecule, ion, or atom. Thermal energy depends only upon the temperature. (Section 7.2)

thermochemical equation A chemical equation that includes a thermodynamic quantity, usually ΔH. (Section 9.2)

thermodynamics The study of energy and its transformations. (Section 9.1)

torr A unit of pressure. A pressure of 1 torr supports a column of mercury to a height of 1 mm. (Section 7.1)

trans A configuration in which two groups are on opposite sides of a bond or atom. (Section 13.3)

transition element An element (metal) in the d-block (B groups) of the periodic table. (Section 1.11)

transition metal A metal in the d-block (B groups) of the periodic table. (Section 1.11)

transition state The highest energy species through which the reactants and products must go in order to make the transition from one to the other. The transition state is formed in collisions between reactants or products, and, once formed, can break apart into either the reactants of the products. (Section 9.9)

triple point The conditions of temperature and pressure at which the solid, liquid, and vapor states of a substance are in equilibrium. (Section 7.6)

U

unit cell The simplest arrangement of particles that generates the entire lattice when repeated in all three dimensions. (Section 8.1)

unsaturated carbons Carbon atoms involved in less than four sigma bonds. (Section 13.1)

V

valence band Filled band containing the valence electrons of a metal. (Section 8.6)

valence electron Those outermost electrons that dictate the properties of the atom and are involved in chemical bonding. They reside in the outermost s sublevel and any unfilled sublevels. (Section 3.1)

van der Waals radius One-half of the distance between identical, nonbonded atoms in a crystal. Atoms that are closer than the sum of their van der Walls radii are assumed to be interacting. (Section 8.9)

vapor pressure The pressure of vapor in equilibrium with a liquid at a given temperature. (Section 7.6)

vaporization The process of converting a liquid to its vapor. (Section 7.6)

void space Unoccupied space in a unit cell. (Section 8.5)

volt SI unit of electrical potential. 1 V = 1 J/C (Section 11.3)

W

wave function — A function that contains all of the information about an electron in an atom. (Section 2.5)

wave-particle duality — A term used to indicate that photons (light) and very small particles, such as electrons, behave as both particles and waves. (Section 2.2)

wavelength — The distance between a point on a wave and the corresponding point on the next wave; i.e., the distance the wave travels during one cycle. (Section 2.1)

weak acid — An acid that does not react extensively with water; i.e., one with a dissociation constant that is much less than one. (Section 12.2)

weak base — A substance that reacts only slightly with water to produce hydroxide ions. (Section 12.2)

weak electrolyte — A substance whose aqueous solution conducts only a small current of electricity. Only a small current is conducted because only a small fraction of weak electrolyte molecules produce ions in water. (Section 12.2)