

## Glossary

**absolute zero (0 K)** | The lowest possible temperature that can be theoretically achieved; it corresponds to  $-273.15^{\circ}\text{C}$ .

**absorption spectrum** | A spectrum produced by the absorption of light by ground-state atoms.

**acid ionization constant ( $K_a$ )** | An equilibrium constant for the ionization (dissociation) of a weak acid (HA) with water,  $+ \rightleftharpoons +$  in which the concentration of water is treated as a constant: =

**acid rain** | Precipitation that is dramatically more acidic because of human activities.

**acid–base indicator** | A compound added in small amounts to an acid–base titration to signal the equivalence point by changing color.

**actinides** | Any of the 14 elements between (thorium) and (lawrencium).

**activation energy ( $E_a$ )** | The energy barrier or threshold that corresponds to the minimum amount of energy the particles in a reaction must have to react when they collide.

**activity (A)** | The decrease in the number of a radioisotope's nuclei per unit time:

**adduct** | The product of a reaction between a Lewis acid and a Lewis base with a coordinate covalent bond.

**aerosols** | A dispersion of solid or liquid particles in a gas.

**alcohol** | A class of organic compounds obtained by replacing one or more of the hydrogen atoms of a hydrocarbon with an  $-\text{OH}$  group.

**aliphatic hydrocarbons** | Alkanes, alkenes, alkynes, and cyclic hydrocarbons (hydrocarbons that are not aromatic).

**amalgams** | A solution (usually a solid solution) of a metal in liquid mercury.

**amine** | An organic compound that has the general formula  $\text{R}_n\text{N}$ , where R is an alkyl group. Amines, like ammonia, are bases.

**amorphous solid** | A solid with no particular structural order.

**amphiprotic** | Substances that can behave as either an acid or a base in a chemical reaction, depending on the nature of the other reactant(s).

**amphoteric** | When substances can behave as both an acid and a base.

**amplification mechanism** | A process by which elements that are present in trace amounts can exert large effects on the health of an organism.

**anions** | An ion that has fewer protons than electrons, resulting in a net negative charge.

**anisotropic** | An arrangement of molecules in which their properties depend on the direction they are measured.

**antibonding molecular orbital** | A molecular orbital that forms when atomic orbitals or orbital lobes of opposite sign interact to give decreased electron probability between the nuclei due to destructive reinforcement of the wave functions.

**aqueous solution** | A solution in which water is the solvent.

**aromatic hydrocarbons** | An unsaturated hydrocarbon consisting of a ring of six carbon atoms with alternating single and double bonds.

**Arrhenius equation** | An expression that summarizes the collision model of chemical kinetics:

**atmosphere (atm)** | Also referred to as standard atmospheric pressure, it is the atmospheric pressure required to support a column of mercury exactly 760 mm tall.

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**atomic mass unit (amu)** | One-twelfth of the mass of one atom of  $^{12}\text{C}$ .

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**atomic orbital** | A wave function with an allowed combination of  $l$ ,  $m$ , and quantum numbers.

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**atoms** | The fundamental, individual particles of which matter is composed.

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**aufbau principle** | The process used to build up the periodic table by adding protons one by one to the nucleus and adding the corresponding electrons to the lowest-energy orbital available without violating the Pauli exclusion principle.

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**average reaction rate** | The reaction rate calculated for a given time interval from the concentrations of either the reactant or one of the products at the beginning of the interval time and at the end of the interval

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**Avogadro's law** | A law that states that at constant temperature and pressure, the volume of a sample of gas is directly proportional to the number of moles of gas in the sample.

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**Avogadro's number** | The number of units (e.g., atoms, molecules, or formula units) in 1 mol:  $6.022 \times 10^{23}$ .

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**azimuthal quantum number ( $l$ )** | One of three quantum numbers that describes the shape of the region of space occupied by an electron.

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**band gap** | The difference in energy between the highest level of one energy band and the lowest level of the band above it, which represents a set of forbidden energies that do not correspond to any allowed combinations of atomic orbitals.

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**band theory** | A theory used to describe the bonding in metals and semiconductors.

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**bandwidth** | The difference in energy between the highest and lowest energy levels in an energy band.

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**barometer** | A device used to measure atmospheric pressure.

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**base** | A substance that produces one or more hydroxide ions and a cation when dissolved in aqueous solution, thereby forming a basic solution.

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**base ionization constant** | An equilibrium constant for the reaction of a weak base (B) with water, in which the concentration of water is treated as a constant. Abbreviation:  $K_b$ .

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**bases** | A substance that produces one or more hydroxide ions and a cation when dissolved in aqueous solution, thereby forming a basic solution.

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**bilayers** | A two-dimensional sheet consisting of a double layer of phospholipid molecules arranged tail to tail.

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**binary ionic compound** | An ionic compound that contains only two elements, one present as a cation and one as an anion.

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**biochemistry** | The application of chemistry to the study of biological processes.

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**blackbody radiation** | Electromagnetic radiation whose wavelength and color depends on the temperature of the object.

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**boiling point elevation ( $\Delta T_b$ )** | The difference between the boiling point of a solution and the boiling point of the pure solvent.

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**Boltzmann distributions** | A curve that shows the distribution of molecular speeds at a given temperature.

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**bomb calorimeter** | A device used to measure energy changes in chemical processes.

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**bond distance( $r_0$ )** | The optimal internuclear distance between two bonded atoms.

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**bond energy** | The enthalpy change that occurs when a given bond in a gaseous molecule is broken.

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**bond order** | The number of electron pairs that hold two atoms together.

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**bond order** | One-half the net number of bonding electrons in a molecule.

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**Born-Haber cycle** | A thermochemical cycle that describes the process in which an ionic solid is conceptually formed from its component elements in a stepwise manner.

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**Boyle's law** | A law that states that at constant temperature, the volume of a fixed amount of a gas is inversely proportional to its pressure.

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**Bragg equation** | The equation that describes the relationship between two x-ray beams diffracted from different planes of atoms:

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**buffer capacity** | The amount of strong acid or strong base that a buffer solution can absorb before the pH changes dramatically.

**Buffers** | Solutions that maintain a relatively constant pH when an acid or a base is added.

**Calorie** | A unit used to indicate the caloric content of food. It is equal to 1 kilocalorie (1 kcal).

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**calories (cal)** | A non-SI unit of energy: 1 cal = 4.184 J exactly.

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**Calorimetry** | A set of techniques used to measure enthalpy changes in chemical processes.

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**capillary action** | The tendency of a polar liquid to rise against gravity into a small-diameter glass tube.

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**carbon cycle** | The distribution and flow of carbon throughout the planet.

**carbon cycle** | The distribution and flow of carbon throughout the planet.

**carboxylic acids** | An organic compound that contains an -OH group covalently bonded to the carbon atom of a carbonyl group. The general formula of a carboxylic acid is . In water a carboxylic acid dissociates to produce an acidic solution.

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**catalysis** | The acceleration of a chemical reaction by a catalyst.

**catalysis** | The acceleration of a chemical reaction by a catalyst.

**catalysts** | A substance that participates in a reaction and causes it to occur more rapidly but that can be recovered unchanged at the end of the reaction and reused. Catalysts may also control which products are formed in a reaction.

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**cell** | A collection of molecules, capable of reproducing itself, that is surrounded by a phospholipid bilayer.

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**ceramic** | Any nonmetallic inorganic solid that is strong enough to be used in structural applications.

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**Ceramic-matrix composites** | A composite consisting of reinforcing fibers embedded in a ceramic matrix.

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**cesium chloride structure** | The unit cell for many ionic compounds with relatively large cations and a 1:1 cation:anion ratio.

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**chain reactions** | A reaction mechanism in which one or more elementary reactions that contain a highly reactive species repeat again and again during the reaction process.

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**chalcogens** | The elements in group 16 of the periodic table.

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**change in enthalpy ( $\Delta H$ )** | At constant pressure, the amount of heat transferred from the surroundings to the system or vice versa: .

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**Charles's law** | A law that states that at constant pressure, the volume of a fixed amount of gas is directly proportional to its absolute temperature (in kelvins).

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**chemical bonds** | An attractive interaction between atoms that holds them together in compounds.

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**chemical change** | A process in which the chemical composition of one or more substances is altered.

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**chemical energy** | One of the five forms of energy, chemical energy is stored within a chemical compound because of a particular arrangement of atoms. The other four forms of energy are radiant, thermal, nuclear, and electrical.

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**chemical equilibrium** | The point at which the forward and reverse reaction rates become the same so that the net composition of the system no longer changes with time.

**Chemical properties** | The characteristic ability of a substance to react to form new substances.

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**chemical reactions** | A process in which a substance is converted to one or more other substances with different compositions and properties.

**Chemistry** | The study of matter and the changes that material substances undergo.

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**cholesteric phase** | One of three different ways that most liquid crystals can orient themselves. The molecules are arranged in planes (similar to the smectic phase), but each layer is rotated by a certain amount with respect to those above and below it, giving it a helical structure.

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**Clausius-Clapeyron equation** | A linear relationship that expresses the nonlinear relationship between the vapor pressure of a liquid and temperature: In where is pressure, is the heat of vaporization, is the universal gas constant, is the absolute temperature, and C is a constant. The Clausius-Clapeyron equation can be used to calculate the heat of vaporization of a liquid from its measured vapor pressure at two or more temperatures.

**Clausius–Clapeyron equation** | A linear relationship that expresses the nonlinear relationship between the vapor pressure of a liquid and temperature:  $\ln$  where  $p$  is pressure,  $\Delta H_{\text{vap}}$  is the heat of vaporization,  $R$  is the universal gas constant,  $T$  is the absolute temperature, and  $C$  is a constant. The Clausius–Clapeyron equation can be used to calculate the heat of vaporization of a liquid from its measured vapor pressure at two or more temperatures.

**Coal** | A complex solid material derived primarily from plants that died and were buried hundreds of millions of years ago and were subsequently subjected to high temperatures and pressures. It is used as a fuel.

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**coefficient** | A number greater than 1 preceding a formula in a balanced chemical equation and indicating the number of atoms, molecules, or formula units of a reactant or a product.

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**colligative properties** | A property of a solution that depends primarily on the *number* of solute particles rather than the *kind* of solute particles.

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**colloid** | A heterogeneous mixture of particles with diameters of about 2–500 nm that are distributed throughout a second phase and do not separate from the dispersing phase on standing.

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**combustion** | The burning of a material in an oxygen atmosphere.

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**combustion reaction** | An oxidation–reduction reaction in which the oxidant is .

**combustion reaction** | An oxidation–reduction reaction in which the oxidant is .

**common ion effect** | The shift in equilibrium that results when a strong electrolyte containing one ion in common with a reaction system that is at equilibrium is added to the system.

**complete ionic equation** | A chemical equation that shows which ions and molecules are hydrated and which are present in other forms and phases.

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**Composite materials** | A material that consists of at least two distinct phases: the matrix (which constitutes the bulk of the material) and fibers or granules that are embedded within the matrix.

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**concentration** | The quantity of solute that is dissolved in a particular quantity of solvent or solution.

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**condensation** | The physical process by which atoms or molecules in the vapor phase enter the liquid phase.

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**conduction band** | The band of empty molecular orbitals in a semiconductor.

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**conjugate acid–base pair** | An acid and a base that differ by only one hydrogen ion.

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**conjugate acid–base pairs** | An acid and a base that differ by only one hydrogen ion. All acid–base reactions involve two conjugate acid–base pairs, the Brønsted–Lowry acid and the base it forms after donating its proton, and the Brønsted–Lowry base and the acid it forms after accepting a proton.

**conjugate acid–base pairs** | An acid and a base that differ by only one hydrogen ion. All acid–base reactions involve two conjugate acid–base pairs, the Brønsted–Lowry acid and the base it forms after donating its proton, and the Brønsted–Lowry base and the acid it forms after accepting a proton.

**constant-pressure calorimeter** | A device used to measure enthalpy changes in chemical processes at constant pressure.

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**Cooper pairs** | Pairs of electrons that migrate through a superconducting material as a unit.

**Cooper pairs** | Pairs of electrons that migrate through a superconducting material as a unit.

**coordinate covalent bond** | A covalent bond in which both electrons come from the same atom.

**coordinate covalent bond** | A covalent bond in which both electrons come from the same atom.

**coordination number** | The number of nearest neighbors in a solid structure.

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**covalent atomic radius ( $r_{\text{cov}}$ )** | Half the distance between the nuclei of two like atoms joined by a covalent bond in the same molecule.

**covalent atomic radius ( $r_{\text{cov}}$ )** | Half the distance between the nuclei of two like atoms joined by a covalent bond in the same molecule.

**covalent bond** | The electrostatic attraction between the positively charged nuclei of the bonded atoms and the negatively charged electrons they share.

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**Covalent solids** | A solid that consists of two- or three-dimensional networks of atoms held together by covalent bonds.

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**critical point** | The combination of the critical temperature and the critical pressure of a substance.

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**crown ethers** | Cyclic polyether with four or more oxygen atoms separated by two or three carbon atoms. All crown ethers have a central cavity that can accommodate a metal ion coordinated to the ring of oxygen atoms.

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**cryogenic liquids** | An ultracold liquid formed from the liquefaction of gases.

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**Cryptands** | Consisting of three chains connected by two nitrogen atoms, cryptands have a central cavity that can encapsulate a metal ion coordinated to the oxygen and nitrogen atoms.

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**Crystallization** | A physical process used to separate homogeneous mixtures (solutions) into their component substances. Crystallization separates mixtures based on differences in their solubilities.

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**cubic close-packed (ccp) structure** | One of two variants of the close-packed arrangement—the most efficient way to pack spheres in a lattice—in which the atomic positions alter from layer to layer in an ABCABC... pattern.

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**cyclic hydrocarbon** | A hydrocarbon in which the ends of the carbon chain are connected to form a ring of covalently bonded carbon atoms.

**cyclic hydrocarbon** | A hydrocarbon in which the ends of the carbon chain are connected to form a ring of covalently bonded carbon atoms.

**Dalton's law of partial pressures** | A law that states that the total pressure exerted by a mixture of gases is the sum of the partial pressures of component gases.

**Dalton's law of partial pressures** | A law that states that the total pressure exerted by a mixture of gases is the sum of the partial pressures of component gases.

**defects** | Errors in an idealized crystal lattice.

**defects** | Errors in an idealized crystal lattice.

**Deformation** | A distortion that occurs when a dislocation moves through a crystal.

**Deformation** | A distortion that occurs when a dislocation moves through a crystal.

**degenerate** | Having the same energy.

**degenerate** | Having the same energy.



**density ( $d$ )** | An intensive property of matter, density is the mass per unit volume (usually expressed in  $\text{g}/\text{cm}^3$ ). At a given temperature, the density of a substance is a constant.

**density ( $d$ )** | An intensive property of matter, density is the mass per unit volume (usually expressed in  $\text{g}/\text{cm}^3$ ). At a given temperature, the density of a substance is a constant.

**dialysis** | A process that uses a semipermeable membrane with pores large enough to allow small solute molecules and solvent molecules to pass through but not large solute molecules.

**dialysis** | A process that uses a semipermeable membrane with pores large enough to allow small solute molecules and solvent molecules to pass through but not large solute molecules.

**dielectric constant ( $\epsilon$ )** | A constant that expresses the ability of a bulk substance to decrease the electrostatic forces between two charged particles.

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**dipole moment** | The product of the partial charge on the bonded atoms and the distance between the partial charges; , where is measured in coulombs (C) and in meters (m).

**dipole moment** | The product of the partial charge on the bonded atoms and the distance between the partial charges; , where is measured in coulombs (C) and in meters (m).

**dipole-dipole interactions** | A kind of intermolecular interaction (force) that results between molecules with net dipole moments.

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**Distillation** | A physical process used to separate homogeneous mixtures (solutions) into their component substances. Distillation makes use of differences in the volatilities of the component substances.

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**edge dislocation** | A crystal defect that results from the insertion of an extra plane of atoms into part of the crystal lattice.

**edge dislocation** | A crystal defect that results from the insertion of an extra plane of atoms into part of the crystal lattice.

**effusion** | The escape of a gas through a small (usually microscopic) opening into an evacuated space.

**effusion** | The escape of a gas through a small (usually microscopic) opening into an evacuated space.

**electrical insulators** | A material that conducts electricity poorly because its valence bands are full.

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**electron affinity(EA)** | The energy change that occurs when an electron is added to a gaseous atom:

**electron affinity(EA)** | The energy change that occurs when an electron is added to a gaseous atom:

**electron configuration** | The arrangement of an element's electrons in its atomic orbitals.

**electron configuration** | The arrangement of an element's electrons in its atomic orbitals.

**electron density** | Electron distributions that are represented as standing waves.

**electron density** | Electron distributions that are represented as standing waves.

**electron sea** | Valence electrons that are delocalized throughout a metallic solid.

**electron sea** | Valence electrons that are delocalized throughout a metallic solid.

**electron shielding** | The effect by which electrons closer to the nucleus neutralize a portion of the positive charge of the nucleus and thereby decrease the attractive interaction between the nucleus and an electron farther away.

**electron shielding** | The effect by which electrons closer to the nucleus neutralize a portion of the positive charge of the nucleus and thereby decrease the attractive interaction between the nucleus and an electron farther away.

**electron spin** | The magnetic moment that results when an electron spins. Electrons have two possible orientations (spin up and spin down), which are described by a fourth quantum number ( $m_s$ ).

**electron spin** | The magnetic moment that results when an electron spins. Electrons have two possible orientations (spin up and spin down), which are described by a fourth quantum number ( $m_s$ ).

**Electron-deficient molecules** | A compound that has less than an octet of electrons around one atom.

**Electron-deficient molecules** | A compound that has less than an octet of electrons around one atom.

**electronegativity** | The relative ability of an atom to attract electrons to itself in a chemical compound.

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**elementary reaction** | Each of the complex series of reactions that take place in a stepwise fashion to convert reactants to products.

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**Emulsions** | A dispersion of one liquid phase in another liquid with which it is immiscible.

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**endothermic** | A process in which heat is transferred to a system from its surroundings.

**endothermic** | A process in which heat is transferred to a system from its surroundings.

**endpoint** | The point in a titration at which an indicator changes color.

**endpoint** | The point in a titration at which an indicator changes color.

**energy-level diagram** | A schematic drawing that compares the energies of the molecular orbitals (bonding, antibonding, and nonbonding) with the energies of the parent atomic orbitals.

**energy-level diagram** | A schematic drawing that compares the energies of the molecular orbitals (bonding, antibonding, and nonbonding) with the energies of the parent atomic orbitals.

**enthalpy ( $H$ )** | The sum of a system's internal energy and the product of its pressure and volume :

**enthalpy ( $H$ )** | The sum of a system's internal energy and the product of its pressure and volume :

**Enthalpy of formation ( $\Delta H_f$ )** | The enthalpy change for the formation of 1 mol of a compound from its component elements.

**Enthalpy of formation ( $\Delta H_f$ )** | The enthalpy change for the formation of 1 mol of a compound from its component elements.

**enthalpy of reaction ( $\Delta H_{rxn}$ )** | The change in enthalpy that occurs during a chemical reaction.

**enthalpy of reaction ( $\Delta H_{rxn}$ )** | The change in enthalpy that occurs during a chemical reaction.

**enthalpy of sublimation ( $\Delta H_{sub}$ )** | The enthalpy change that accompanies the conversion of a solid directly to a gas.

**enthalpy of sublimation ( $\Delta H_{sub}$ )** | The enthalpy change that accompanies the conversion of a solid directly to a gas.

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**entropy(S)** | The degree of disorder in a thermodynamic system. The greater the number of possible microstates for a system, the higher the entropy.

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**enzyme** | A catalyst that occurs naturally in living organisms and catalyzes biological reactions.

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**Enzyme inhibitors** | Substances that decrease the reaction rate of an enzyme-catalyzed reaction by binding to a specific portion of the enzyme, thus slowing or preventing a reaction from occurring.

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**enzymes** | Catalysts that occur naturally in living organisms and that catalyze biological reactions.

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**equilibrium** | The point at which the rates of the forward and reverse reactions become the same, so that the net composition of the system no longer changes with time.

**equilibrium** | The point at which the rates of the forward and reverse reactions become the same, so that the net composition of the system no longer changes with time.

**equilibrium constant ( $K$ )** | The ratio of the rate constants for the forward reaction and the reverse reaction; that is, It is also the equilibrium constant calculated from solution concentrations: for the general reaction in which each component is in solution.

**equilibrium constant ( $K$ )** | The ratio of the rate constants for the forward reaction and the reverse reaction; that is, It is also the equilibrium constant calculated from solution concentrations: for the general reaction in which each component is in solution.

**equilibrium constant expression** | For a balanced chemical equation, the ratio is for the general reaction

**equilibrium constant expression** | For a balanced chemical equation, the ratio is for the general reaction

**equilibrium vapor pressure** | The pressure exerted by a vapor in dynamic equilibrium with its liquid.

**equilibrium vapor pressure** | The pressure exerted by a vapor in dynamic equilibrium with its liquid.

**equivalence point** | The point in a titration where a stoichiometric amount (i.e., the amount required to react completely with the unknown) of the titrant has been added.

**equivalence point** | The point in a titration where a stoichiometric amount (i.e., the amount required to react completely with the unknown) of the titrant has been added.

**equivalence point** | The point in a titration where a stoichiometric amount of the titrant has been added.

**essential elements** | Any of the 19 elements that are absolutely required in the human diet for survival. An additional seven elements are thought to be essential for humans.

**essential elements** | Any of the 19 elements that are absolutely required in the human diet for survival. An additional seven elements are thought to be essential for humans.

**Essential trace elements** | Elements that are required for the growth of most organisms.

**Essential trace elements** | Elements that are required for the growth of most organisms.

**evaporation (or vaporization)** | The physical process by which atoms or molecules in the liquid phase enter the gas or vapor phase.

**evaporation (or vaporization)** | The physical process by which atoms or molecules in the liquid phase enter the gas or vapor phase.

**exact numbers** | An integer obtained either by counting objects or from definitions (e.g., 1 in. = 2.54 cm). Exact numbers have infinitely many significant figures.

**exact numbers** | An integer obtained either by counting objects or from definitions (e.g., 1 in. = 2.54 cm). Exact numbers have infinitely many significant figures.

**excited state** | Any arrangement of electrons that is higher in energy than the ground state.

**excited state** | Any arrangement of electrons that is higher in energy than the ground state.

**exothermic** | A process in which heat is transferred from a system to its surroundings.

**exothermic** | A process in which heat is transferred from a system to its surroundings.

**expanded-valence molecules** | A compound with more than an octet of electrons around an atom.

**expanded-valence molecules** | A compound with more than an octet of electrons around an atom.

**f block** | The elements in the periodic table in which the  $(n - 2)f$  orbitals are being filled.

**f block** | The elements in the periodic table in which the  $(n - 2)f$  orbitals are being filled.

**face-centered cubic (fcc)** | A cubic unit cell with eight component atoms, molecules, or ions located at the corners of a cube plus an identical component in the center of each face of the cube.

**face-centered cubic (fcc)** | A cubic unit cell with eight component atoms, molecules, or ions located at the corners of a cube plus an identical component in the center of each face of the cube.

**fibers** | A particle of a synthetic polymer that is more than 100 times longer than it is wide.

**fibers** | A particle of a synthetic polymer that is more than 100 times longer than it is wide.

**first-order reaction** | A reaction whose rate is directly proportional to the concentration of one reactant.

**first-order reaction** | A reaction whose rate is directly proportional to the concentration of one reactant.

**formal charge** | The difference between the number of valence electrons in a free atom and the number of electrons assigned to it in a particular Lewis electron structure.

**formal charge** | The difference between the number of valence electrons in a free atom and the number of electrons assigned to it in a particular Lewis electron structure.

**formula mass** | The sum of the atomic masses of all the elements in the empirical formula, each multiplied by its subscript.

**formula mass** | The sum of the atomic masses of all the elements in the empirical formula, each multiplied by its subscript.

**formula unit** | The absolute grouping of atoms or ions represented by the empirical formula.

**formula unit** | The absolute grouping of atoms or ions represented by the empirical formula.

**fractional crystallization** | The separation of compounds based on their relative solubilities in a given solvent.

**fractional crystallization** | The separation of compounds based on their relative solubilities in a given solvent.

**freezing point depression ( $\Delta T_f$ )** | The difference between the freezing point of a pure solvent and the freezing point of the solution.

**freezing point depression ( $\Delta T_f$ )** | The difference between the freezing point of a pure solvent and the freezing point of the solution.

**Frenkel defect** | A defect in an ionic lattice that occurs when one of the ions is in the wrong position.

**Frenkel defect** | A defect in an ionic lattice that occurs when one of the ions is in the wrong position.

**frequency factor** | A constant in the Arrhenius equation, it converts concentrations to collisions per second.

**frequency factor** | A constant in the Arrhenius equation, it converts concentrations to collisions per second.

**fundamental** | The lowest-energy standing wave.

**fundamental** | The lowest-energy standing wave.

**fusion (or melting)** | The conversion of a solid to a liquid.

**fusion (or melting)** | The conversion of a solid to a liquid.

**gas constant** | A proportionality constant that is used in the ideal gas law.

**gas constant** | A proportionality constant that is used in the ideal gas law.

**glass** | An amorphous, translucent solid. A glass is a solid that has been cooled too quickly to form ordered crystals.

**glass** | An amorphous, translucent solid. A glass is a solid that has been cooled too quickly to form ordered crystals.

**Graham's law** | A law that states that the rate of effusion of a gaseous substance is inversely proportional to the square root of its molar mass.

**Graham's law** | A law that states that the rate of effusion of a gaseous substance is inversely proportional to the square root of its molar mass.

**grain boundary** | The place where two grains in a solid intersect.

**grain boundary** | The place where two grains in a solid intersect.

**greenhouse effect** | The phenomenon in which substances absorb thermal energy radiated by Earth, thus trapping thermal energy in the atmosphere.

**greenhouse effect** | The phenomenon in which substances absorb thermal energy radiated by Earth, thus trapping thermal energy in the atmosphere.

**greenhouse gases** | A substance that absorbs thermal energy radiated by Earth, thus trapping thermal energy in the atmosphere.

**greenhouse gases** | A substance that absorbs thermal energy radiated by Earth, thus trapping thermal energy in the atmosphere.

**group-transfer reactions** | A reaction in which a recognizable functional group is transferred from one molecule to another.

**group-transfer reactions** | A reaction in which a recognizable functional group is transferred from one molecule to another.

**half-life** | The period of time it takes for the concentration of a reactant to decrease to one-half its initial value.

**half-life** | The period of time it takes for the concentration of a reactant to decrease to one-half its initial value.

**hardness** | The resistance of ionic materials to scratching or abrasion.

**hardness** | The resistance of ionic materials to scratching or abrasion.

**heat ( $q$ )** | Thermal energy that can be transformed from an object at one temperature to an object at another temperature.

**heat ( $q$ )** | Thermal energy that can be transformed from an object at one temperature to an object at another temperature.

**heat capacity ( $C$ )** | The amount of energy needed to raise the temperature of an object 1°C. The units of heat capacity are joules per degree Celsius

**heat capacity ( $C$ )** | The amount of energy needed to raise the temperature of an object 1°C. The units of heat capacity are joules per degree Celsius

**Heisenberg uncertainty principle** | A principle stating that the uncertainty in the position of a particle multiplied by the uncertainty in its momentum is greater than or equal to Planck's constant divided by  $4\pi$ :

**Heisenberg uncertainty principle** | A principle stating that the uncertainty in the position of a particle multiplied by the uncertainty in its momentum is greater than or equal to Planck's constant divided by  $4\pi$ :

**Henderson-Hasselbalch equation** | A rearranged version of the equilibrium constant expression that provides a direct way to calculate the pH of a buffer solution:  $\text{pH} = +\log([\text{base}]/[\text{acid}])$ .

**Henry's law** | An equation that quantifies the relationship between the pressure and the solubility of a gas:

**Henry's law** | An equation that quantifies the relationship between the pressure and the solubility of a gas:

**Hess's law** | The enthalpy change for an overall reaction is the sum of the values for the individual reactions.

**Hess's law** | The enthalpy change for an overall reaction is the sum of the values for the individual reactions.

**heterogeneous** | A mixture in which a material is not completely uniform throughout.

**heterogeneous** | A mixture in which a material is not completely uniform throughout.

**heterogeneous catalysis** | A catalytic reaction in which the catalyst is in a different phase from the reactants.

**heterogeneous catalysis** | A catalytic reaction in which the catalyst is in a different phase from the reactants.

**heterogeneous catalyst** | A catalyst that is in a different physical state than the reactants.

**heterogeneous catalyst** | A catalyst that is in a different physical state than the reactants.

**heterogeneous equilibrium** | An equilibrium in which the reactants of an equilibrium reaction, the products, or both are in more than one phase.

**heterogeneous equilibrium** | An equilibrium in which the reactants of an equilibrium reaction, the products, or both are in more than one phase.

**heteronuclear diatomic molecules** | A molecule that consists of two atoms of different elements.

**heteronuclear diatomic molecules** | A molecule that consists of two atoms of different elements.

**high-temperature superconductors** | A material that becomes a superconductor at temperatures greater than 30 K.

**high-temperature superconductors** | A material that becomes a superconductor at temperatures greater than 30 K.

**homogeneous** | A mixture in which all portions of a material are in the same state, have no visible boundaries, and are uniform throughout.

**homogeneous** | A mixture in which all portions of a material are in the same state, have no visible boundaries, and are uniform throughout.

**homogeneous catalysis** | A catalytic reaction in which the catalyst is uniformly dispersed throughout the reactant mixture to form a solution.

**homogeneous catalysis** | A catalytic reaction in which the catalyst is uniformly dispersed throughout the reactant mixture to form a solution.

**homonuclear diatomic molecule** | A molecule that consists of two atoms of the same element.

**homonuclear diatomic molecule** | A molecule that consists of two atoms of the same element.

**Hund's rule** | A rule stating that the lowest-energy electron configuration for an atom is the one that has the maximum number of electrons with parallel spins in degenerate orbitals.

**Hund's rule** | A rule stating that the lowest-energy electron configuration for an atom is the one that has the maximum number of electrons with parallel spins in degenerate orbitals.

**hybrid atomic orbitals** | New atomic orbitals formed from the process of hybridization.

**hybrid atomic orbitals** | New atomic orbitals formed from the process of hybridization.

**hydrated ions** | Individual cations and anions that are each surrounded by their own shell of water molecules.

**hydrated ions** | Individual cations and anions that are each surrounded by their own shell of water molecules.

**hydration** | The process of surrounding solute particles with water molecules.

**hydration** | The process of surrounding solute particles with water molecules.

**hydrogen bonds** | An unusually strong dipole-dipole interaction (intermolecular force) that results when hydrogen is bonded to very electronegative elements, such as O, N, and F.

**hydrogen bonds** | An unusually strong dipole-dipole interaction (intermolecular force) that results when hydrogen is bonded to very electronegative elements, such as O, N, and F.

**hydrolysis reactions** | A chemical reaction in which a salt reacts with water to yield an acidic or a basic solution.

**hydronium ion** | The ion, represented as

**hydronium ion** | The ion, represented as

**hydrophobic** | A substance that repels water. Hydrophobic substances do not interact favorably with water.

**hydrophobic** | A substance that repels water. Hydrophobic substances do not interact favorably with water.

**hypothesis** | A tentative explanation for scientific observations that puts the system being studied into a form that can be tested.

**hypothesis** | A tentative explanation for scientific observations that puts the system being studied into a form that can be tested.

**ideal gas** | A hypothetical gaseous substance whose behavior is independent of attractive and repulsive forces.

**ideal gas** | A hypothetical gaseous substance whose behavior is independent of attractive and repulsive forces.

**ideal gas law** | A law relating pressure, temperature, volume, and the amount of an ideal gas.

**ideal gas law** | A law relating pressure, temperature, volume, and the amount of an ideal gas.

**ideal solution** | A solution that obeys Raoult's law.

**ideal solution** | A solution that obeys Raoult's law.

**indicators** | An intensely colored organic molecule whose color changes dramatically depending on the pH of the solution.

**indicators** | An intensely colored organic molecule whose color changes dramatically depending on the pH of the solution.

**induced dipole** | A short-lived dipole moment that is created in atoms and nonpolar molecules adjacent to atoms or molecules with an instantaneous dipole moment.

**induced dipole** | A short-lived dipole moment that is created in atoms and nonpolar molecules adjacent to atoms or molecules with an instantaneous dipole moment.

**inert metals** | The metals at the bottom of the activity series, which have the least tendency to be oxidized.

**inert metals** | The metals at the bottom of the activity series, which have the least tendency to be oxidized.

**inorganic compounds** | An ionic or covalent compound that consists primarily of elements other than carbon and hydrogen.

**inorganic compounds** | An ionic or covalent compound that consists primarily of elements other than carbon and hydrogen.

**instantaneous rate** | The reaction rate of a chemical reaction at any given point in time.

**instantaneous rate** | The reaction rate of a chemical reaction at any given point in time.

**integrated rate law** | A rate law that expresses the reaction rate in terms of the initial concentration and the measured concentration of one or more reactants ([R]) after a given amount of time

**integrated rate law** | A rate law that expresses the reaction rate in terms of the initial concentration and the measured concentration of one or more reactants ([R]) after a given amount of time

**Intensive properties** | A physical property that does not depend on the amount of the substance and physical state at a given temperature and pressure.

**Intensive properties** | A physical property that does not depend on the amount of the substance and physical state at a given temperature and pressure.

**intermediate** | A species in a reaction mechanism that does not appear in the balanced chemical equation for the overall reaction.

**intermediate** | A species in a reaction mechanism that does not appear in the balanced chemical equation for the overall reaction.

**intermetallic compounds** | An alloy that consists of certain metals that combine in only specific proportions and whose properties are frequently quite different from those of their constituent elements.

**intermetallic compounds** | An alloy that consists of certain metals that combine in only specific proportions and whose properties are frequently quite different from those of their constituent elements.

**interstitial alloy** | An alloy formed by inserting smaller atoms into holes in the metal lattice.

**interstitial alloy** | An alloy formed by inserting smaller atoms into holes in the metal lattice.

**interstitial impurity** | A point defect that results when an impurity atom occupies an octahedral hole or a tetrahedral hole in the lattice between atoms.

**interstitial impurity** | A point defect that results when an impurity atom occupies an octahedral hole or a tetrahedral hole in the lattice between atoms.

**ion pairs** | A cation and anion that are in intimate contact in solution rather than separated by solvent and that migrates in solution as a single unit.

**ion pairs** | A cation and anion that are in intimate contact in solution rather than separated by solvent and that migrates in solution as a single unit.

**ion pumps** | A complex assembly of proteins that selectively transports ions across cell membranes toward the side with the higher concentration.

**ion pumps** | A complex assembly of proteins that selectively transports ions across cell membranes toward the side with the higher concentration.

**ion-product constant of liquid water ( $K_w$ )** | An equilibrium constant for the autoionization of water,  $\rightleftharpoons +$  in which the concentration of water is treated as a constant:  $=$

**ion-product constant of liquid water ( $K_w$ )** | An equilibrium constant for the autoionization of water,  $\rightleftharpoons +$  in which the concentration of water is treated as a constant:  $=$



**ionic bonding** | A type of chemical bonding in which positively and negatively charged ions are held together by electrostatic forces.

**ionic bonding** | A type of chemical bonding in which positively and negatively charged ions are held together by electrostatic forces.

**ionic liquids** | Ionic substances that are liquids at room temperature and pressure and that consist of small, symmetrical anions combined with larger, symmetrical organic cations that prevent the formation of a highly organized structure.

**ionic liquids** | Ionic substances that are liquids at room temperature and pressure and that consist of small, symmetrical anions combined with larger, symmetrical organic cations that prevent the formation of a highly organized structure.

**ionic radius** | The radius of a cation or anion.

**ionic radius** | The radius of a cation or anion.

**ionic solid** | A solid that consists of positively and negatively charged ions held together by electrostatic forces.

**ionic solid** | A solid that consists of positively and negatively charged ions held together by electrostatic forces.

**ionization energy(I)** | The minimum amount of energy needed to remove an electron from the gaseous atom in its ground state:

**ionization energy(I)** | The minimum amount of energy needed to remove an electron from the gaseous atom in its ground state:

**ions** | A charged particle produced when one or more electrons is removed from or added to an atom or molecule.

**ions** | A charged particle produced when one or more electrons is removed from or added to an atom or molecule.

**isoelectronic series** | A group of ions or atoms and ions that have the same number of electrons and thus the same ground-state electron configuration.

**isoelectronic series** | A group of ions or atoms and ions that have the same number of electrons and thus the same ground-state electron configuration.

**isolated system** | A system that can exchange neither energy nor matter with its surroundings.

**isolated system** | A system that can exchange neither energy nor matter with its surroundings.

**joule (J)** | The SI unit of energy:

**joule (J)** | The SI unit of energy:

**ketones** | A class of organic compounds with the general form  $RC(O)R'$ , in which the carbon atom of the carbonyl group is bonded to two alkyl groups (c.f. aldehyde). The alkyl groups may be the same or different.

**ketones** | A class of organic compounds with the general form  $RC(O)R'$ , in which the carbon atom of the carbonyl group is bonded to two alkyl groups (c.f. aldehyde). The alkyl groups may be the same or different.

**kinetic energy (KE)** | Energy due to the motion of an object: where is the mass of the object and is its velocity.

**kinetic energy (KE)** | Energy due to the motion of an object: where is the mass of the object and is its velocity.

**kinetic molecular theory of gases** | A theory that describes, on the molecular level, why ideal gases behave the way they do.

**kinetic molecular theory of gases** | A theory that describes, on the molecular level, why ideal gases behave the way they do.

**$K_p$**  | An equilibrium constant expressed as the ratio of the partial pressures of the products and reactants, each raised to its coefficient in the chemical equation.

**$K_p$**  | An equilibrium constant expressed as the ratio of the partial pressures of the products and reactants, each raised to its coefficient in the chemical equation.

**law of conservation of energy** | The total amount of energy in the universe remains constant. Energy can be neither created nor destroyed, but it can be converted from one form to another.

**law of conservation of energy** | The total amount of energy in the universe remains constant. Energy can be neither created nor destroyed, but it can be converted from one form to another.

**law of conservation of mass** | In any chemical reaction, the mass of the substances that react equals the mass of the products that are formed.

**law of conservation of mass** | In any chemical reaction, the mass of the substances that react equals the mass of the products that are formed.

**law of conservation of orbitals** | A law that states that the number of molecular orbitals produced is the same as the number of atomic orbitals used to create them.

**law of conservation of orbitals** | A law that states that the number of molecular orbitals produced is the same as the number of atomic orbitals used to create them.

**law of definite proportions** | A chemical substance always contains the same proportions of elements by mass.

**law of definite proportions** | A chemical substance always contains the same proportions of elements by mass.

**law of mass action** | For the general balanced chemical equation the equilibrium constant expression is

**law of mass action** | For the general balanced chemical equation the equilibrium constant expression is

**law of multiple proportions** | When two elements form a series of compounds, the ratios of the masses of the second element that are present per gram of the first element can almost always be expressed as the ratios of integers. (The same law holds for the mass ratios of compounds forming a series that contains more than two elements.)

**law of multiple proportions** | When two elements form a series of compounds, the ratios of the masses of the second element that are present per gram of the first element can almost always be expressed as the ratios of integers. (The same law holds for the mass ratios of compounds forming a series that contains more than two elements.)

**Le Châtelier's principle** | If a stress is applied to a system at equilibrium, the composition of the system will change to relieve the applied stress.

**Le Châtelier's principle** | If a stress is applied to a system at equilibrium, the composition of the system will change to relieve the applied stress.

**leveling effect** | The phenomenon that makes the strongest acid that can exist in water. Any species that is a stronger acid than is leveled to the strength of in aqueous solution.

**Lewis acid** | Any species that can accept a pair of electrons.

**Lewis acid** | Any species that can accept a pair of electrons.

**Lewis electron dot symbols** | A system that can be used to predict the number of bonds formed by most elements in their compounds.

**Lewis electron dot symbols** | A system that can be used to predict the number of bonds formed by most elements in their compounds.

**limiting reactant** | The reactant that restricts the amount of product obtained in a chemical reaction.

**limiting reactant** | The reactant that restricts the amount of product obtained in a chemical reaction.

**line spectrum** | A spectrum in which light of only a certain wavelength is emitted or absorbed, rather than a continuous range of wavelengths.

**line spectrum** | A spectrum in which light of only a certain wavelength is emitted or absorbed, rather than a continuous range of wavelengths.

**linear combinations of atomic orbitals (LCAOs)** | Molecular orbitals created from the sum and the difference of two wave functions (atomic orbitals).

**linear combinations of atomic orbitals (LCAOs)** | Molecular orbitals created from the sum and the difference of two wave functions (atomic orbitals).

**Liquefaction** | The condensation of gases into a liquid form.

**Liquefaction** | The condensation of gases into a liquid form.

**liquid crystals** | A substance that exhibits phases that have properties intermediate between those of a crystalline solid and a normal liquid and possess long-range molecular order but still flow.

**liquid crystals** | A substance that exhibits phases that have properties intermediate between those of a crystalline solid and a normal liquid and possess long-range molecular order but still flow.

**London dispersion forces** | A kind of intermolecular interaction (force) that results from temporary fluctuations in the electron distribution within atoms and nonpolar molecules.

**London dispersion forces** | A kind of intermolecular interaction (force) that results from temporary fluctuations in the electron distribution within atoms and nonpolar molecules.

**lustrous** | Having a shiny appearance. Metals are lustrous, whereas nonmetals are not.

**lustrous** | Having a shiny appearance. Metals are lustrous, whereas nonmetals are not.

**macrominerals** | Any of the six essential elements (Na, Mg, K, Ca, Cl, and P) that provide essential ions in body fluids and form the major structural components of the body.

**macrominerals** | Any of the six essential elements (Na, Mg, K, Ca, Cl, and P) that provide essential ions in body fluids and form the major structural components of the body.

**magnetic quantum number ( $m_l$ )** | One of three quantum numbers that describes the orientation of the region of space occupied by an electron with respect to an applied magnetic field.

**magnetic quantum number ( $m_l$ )** | One of three quantum numbers that describes the orientation of the region of space occupied by an electron with respect to an applied magnetic field.

**manometers** | A device used to measure the pressures of samples of gases contained in an apparatus.

**manometers** | A device used to measure the pressures of samples of gases contained in an apparatus.

**mass number (A)** | The number of protons and neutrons in the nucleus of an atom of an element.

**mass number (A)** | The number of protons and neutrons in the nucleus of an atom of an element.

**matter** | Anything that occupies space and has mass.

**matter** | Anything that occupies space and has mass.

**mean free path** | The average distance traveled by a molecule between collisions.

**mean free path** | The average distance traveled by a molecule between collisions.

**mechanical work** | The energy required to move an object a distance when opposed by a force :

**mechanical work** | The energy required to move an object a distance when opposed by a force :

**Meissner effect** | The phenomenon in which a superconductor completely expels a magnetic field from its interior.

**Meissner effect** | The phenomenon in which a superconductor completely expels a magnetic field from its interior.

**melting point** | The temperature at which the individual ions in a lattice or the individual molecules in a covalent compound have enough kinetic energy to overcome the attractive forces that hold them together in the solid.

**melting point** | The temperature at which the individual ions in a lattice or the individual molecules in a covalent compound have enough kinetic energy to overcome the attractive forces that hold them together in the solid.

**meniscus** | The upper surface of the liquid in a tube.

**meniscus** | The upper surface of the liquid in a tube.

**Metal-matrix composites** | A composite that consists of reinforcing fibers embedded in a metal or a metal alloy matrix.

**Metal-matrix composites** | A composite that consists of reinforcing fibers embedded in a metal or a metal alloy matrix.

**metallic solids** | A solid that consists of metal atoms held together by metallic bonds.

**metallic solids** | A solid that consists of metal atoms held together by metallic bonds.

**micelles** | A spherical or cylindrical aggregate of detergents or soaps in water that minimizes contact between the hydrophobic tails of the detergents or soaps and water.

**micelles** | A spherical or cylindrical aggregate of detergents or soaps in water that minimizes contact between the hydrophobic tails of the detergents or soaps and water.

**midpoint** | The point in an acid–base titration at which exactly enough acid (or base) has been added to neutralize one-half of the base (or the acid) originally present:

**miscible** | Capable of forming a single homogeneous phase, regardless of the proportions with which the substances are mixed.

**miscible** | Capable of forming a single homogeneous phase, regardless of the proportions with which the substances are mixed.

**molality (m)** | The number of moles of solute present in exactly 1 kg of solvent.

**molality (m)** | The number of moles of solute present in exactly 1 kg of solvent.

**molar mass** | The mass in grams of 1 mol of a substance.

**molar mass** | The mass in grams of 1 mol of a substance.

**molar volume** | The molar mass of an element divided by its density.

**molar volume** | The molar mass of an element divided by its density.

**molarity (M)** | A common unit of concentration that is the number of moles of solute present in exactly 1 L of solution

**molarity (M)** | A common unit of concentration that is the number of moles of solute present in exactly 1 L of solution

**mole (mol)** | The quantity of a substance that contains the same number of units (e.g., atoms or molecules) as the number of carbon atoms in exactly 12 g of isotopically pure carbon-12.

**mole (mol)** | The quantity of a substance that contains the same number of units (e.g., atoms or molecules) as the number of carbon atoms in exactly 12 g of isotopically pure carbon-12.

**mole fraction (X)** | The ratio of the number of moles of any component of a mixture to the total number of moles of all species present in the mixture.

**mole fraction (X)** | The ratio of the number of moles of any component of a mixture to the total number of moles of all species present in the mixture.

**mole ratio** | The ratio of the number of moles of one substance to the number of moles of another, as depicted by a balanced chemical equation.

**mole ratio** | The ratio of the number of moles of one substance to the number of moles of another, as depicted by a balanced chemical equation.

**molecular formula** | A representation of a covalent compound that consists of the atomic symbol for each component element (in a prescribed order) accompanied by a subscript indicating the number of atoms of that element in the molecule. The subscript is written only if the number is greater than 1.

**molecular formula** | A representation of a covalent compound that consists of the atomic symbol for each component element (in a prescribed order) accompanied by a subscript indicating the number of atoms of that element in the molecule. The subscript is written only if the number is greater than 1.

**molecular geometry** | The arrangement of the bonded atoms in a molecule or a polyatomic ion in space.

**molecular geometry** | The arrangement of the bonded atoms in a molecule or a polyatomic ion in space.

**molecular mass** | The sum of the average masses of the atoms in one molecule of a substance, each multiplied by its subscript.

**molecular mass** | The sum of the average masses of the atoms in one molecule of a substance, each multiplied by its subscript.

**molecular orbital theory** | A delocalized bonding model in which molecular orbitals are created from the linear combination of atomic orbitals (LCAOs).

**molecular orbital theory** | A delocalized bonding model in which molecular orbitals are created from the linear combination of atomic orbitals (LCAOs).

**Molecular solids** | A solid that consists of molecules held together by relatively weak forces, such as dipole-dipole interactions, hydrogen bonds, and London dispersion forces.

**Molecular solids** | A solid that consists of molecules held together by relatively weak forces, such as dipole-dipole interactions, hydrogen bonds, and London dispersion forces.

**molecularity** | The number of molecules that collide during any step in a reaction mechanism.

**molecularity** | The number of molecules that collide during any step in a reaction mechanism.

**molten salt** | A salt that has been heated to its melting point.

**molten salt** | A salt that has been heated to its melting point.

**monatomic** | A species containing a single atom.

**monatomic** | A species containing a single atom.

**monatomic ions** | An ion with only a single atom.

**monatomic ions** | An ion with only a single atom.

**n-type semiconductor** | A semiconductor that has been doped with an impurity that has more valence electrons than the atoms of the host lattice.

**n-type semiconductor** | A semiconductor that has been doped with an impurity that has more valence electrons than the atoms of the host lattice.

**nanotubes** | One of at least four allotropes of carbon that are cylinders of carbon atoms and are intermediate in structure between graphite and the fullerenes.

**nanotubes** | One of at least four allotropes of carbon that are cylinders of carbon atoms and are intermediate in structure between graphite and the fullerenes.

**net ionic equation** | A chemical equation that shows only those species that participate in the chemical reaction.

**net ionic equation** | A chemical equation that shows only those species that participate in the chemical reaction.

**neutral solution** | A solution in which the total positive charge from all the cations is matched by an identical total negative charge from all the anions.

**neutral solution** | A solution in which the total positive charge from all the cations is matched by an identical total negative charge from all the anions.

**neutrons** | A subatomic particle with no charge that resides in the nucleus of almost all atoms.

**neutrons** | A subatomic particle with no charge that resides in the nucleus of almost all atoms.

**noble gases** | Any element in group 18 of the periodic table. All are unreactive monatomic gases at room temperature and pressure.

**noble gases** | Any element in group 18 of the periodic table. All are unreactive monatomic gases at room temperature and pressure.

**nodes** | The point where the amplitude of a wave is zero.

**nodes** | The point where the amplitude of a wave is zero.

**nonbonding molecular orbitals** | A molecular orbital that forms when atomic orbitals or orbital lobes interact only very weakly, creating essentially no change in the electron probability density between the nuclei.

**nonbonding molecular orbitals** | A molecular orbital that forms when atomic orbitals or orbital lobes interact only very weakly, creating essentially no change in the electron probability density between the nuclei.

**nonstoichiometric compounds** | A solid that has intrinsically variable stoichiometries without affecting the fundamental structure of the crystal.



**nonstoichiometric compounds** | A solid that has intrinsically variable stoichiometries without affecting the fundamental structure of the crystal.

**nonvolatile liquids** | A liquid with a relatively low vapor pressure.

**nonvolatile liquids** | A liquid with a relatively low vapor pressure.

**normal boiling point** | The temperature at which a substance boils at a pressure of 1 atm.

**normal boiling point** | The temperature at which a substance boils at a pressure of 1 atm.

**nucleus** | The central core of an atom where protons and any neutrons reside.

**nucleus** | The central core of an atom where protons and any neutrons reside.

**octane rating** | A measure of a fuel's ability to burn in a combustion engine without knocking or ping (indications of premature combustion). The higher the octane rating, the higher quality the fuel.

**octane rating** | A measure of a fuel's ability to burn in a combustion engine without knocking or ping (indications of premature combustion). The higher the octane rating, the higher quality the fuel.

**octaves** | A group of seven elements, corresponding to the horizontal rows in the main group elements (not counting the noble gases, which were unknown at the time).

**octaves** | A group of seven elements, corresponding to the horizontal rows in the main group elements (not counting the noble gases, which were unknown at the time).

**octet rule** | The tendency for atoms to lose, gain, or share electrons to reach a total of eight valence electrons.

**octet rule** | The tendency for atoms to lose, gain, or share electrons to reach a total of eight valence electrons.

**orbital energies** | A particular energy associated with a given set of quantum numbers.

**orbital energies** | A particular energy associated with a given set of quantum numbers.

**osmosis** | The net flow of solvent through a semipermeable membrane.

**osmosis** | The net flow of solvent through a semipermeable membrane.

**osmotic pressure (II)** | The pressure difference between the two sides of a semipermeable membrane that separates a pure solvent from a solution prepared from the same solvent.

**osmotic pressure (II)** | The pressure difference between the two sides of a semipermeable membrane that separates a pure solvent from a solution prepared from the same solvent.

**overall chemical equation** | A chemical equation that shows all the reactants and products as undissociated, electrically neutral compounds.

**overall chemical equation** | A chemical equation that shows all the reactants and products as undissociated, electrically neutral compounds.

**overlapping bands** | Molecular orbitals derived from two or more different kinds of valence electrons that have similar energies.

**overlapping bands** | Molecular orbitals derived from two or more different kinds of valence electrons that have similar energies.

**overtones** | The vibration of a standing wave that is higher in energy than the fundamental vibration.

**overtones** | The vibration of a standing wave that is higher in energy than the fundamental vibration.

**oxidation** | The loss of one or more electrons in a chemical reaction. The substance that loses electrons is said to be oxidized.

**oxidation** | The loss of one or more electrons in a chemical reaction. The substance that loses electrons is said to be oxidized.

**oxidation state** | The charge that each atom in a compound would have if all its bonding electrons were transferred to the atom with the greater attraction for electrons.

**oxidation state** | The charge that each atom in a compound would have if all its bonding electrons were transferred to the atom with the greater attraction for electrons.

**oxidation state method** | A procedure for balancing oxidation-reduction (redox) reactions in which the overall reaction is conceptually separated into two parts: an oxidation and a reduction.

**oxidation state method** | A procedure for balancing oxidation-reduction (redox) reactions in which the overall reaction is conceptually separated into two parts: an oxidation and a reduction.

**oxidation-reduction reactions** | A chemical reaction that exhibits a change in the oxidation states of one or more elements in the reactants that has the general form oxidant + reductant → reduced oxidant + oxidized reductant.

**oxidation-reduction reactions** | A chemical reaction that exhibits a change in the oxidation states of one or more elements in the reactants that has the general form oxidant + reductant → reduced oxidant + oxidized reductant.

**oxoacids** | An acid in which the dissociable ion is attached to an oxygen atom of a polyatomic anion.

**oxoacids** | An acid in which the dissociable ion is attached to an oxygen atom of a polyatomic anion.

**Ozone** | An unstable form of oxygen that consists of three oxygen atoms bonded together (O<sub>3</sub>). A layer of ozone in the stratosphere helps protect the plants and animals on earth from harmful ultraviolet radiation. Ozone is responsible for the pungent smell we associate with lightning discharges and electric motors. It is also toxic.

**Ozone** | An unstable form of oxygen that consists of three oxygen atoms bonded together (O<sub>3</sub>). A layer of ozone in the stratosphere helps protect the plants and animals on earth from harmful ultraviolet radiation. Ozone is responsible for the pungent smell we associate with lightning discharges and electric motors. It is also toxic.

**ozone layer** | A concentration of ozone in the stratosphere (about 10<sup>15</sup> ozone molecules per liter) that acts as a protective screen, absorbing ultraviolet light that would otherwise reach the surface of the earth, where it would harm plants and animals.

**ozone layer** | A concentration of ozone in the stratosphere (about 10<sup>15</sup> ozone molecules per liter) that acts as a protective screen, absorbing ultraviolet light that would otherwise reach the surface of the earth, where it would harm plants and animals.

**p-type semiconductor** | A semiconductor that has been doped with an impurity that has fewer valence electrons than the atoms of the host lattice.

**p-type semiconductor** | A semiconductor that has been doped with an impurity that has fewer valence electrons than the atoms of the host lattice.

**partial pressure** | The pressure a gas in a mixture would exert if it were the only one present (at the same temperature and volume).

**partial pressure** | The pressure a gas in a mixture would exert if it were the only one present (at the same temperature and volume).

**parts per billion (ppb)** | Micrograms of solute per kilogram of solvent.

**parts per billion (ppb)** | Micrograms of solute per kilogram of solvent.

**parts per thousand (ppt)** | Grams of solute per kilogram of solvent, primarily used in the health sciences.

**parts per thousand (ppt)** | Grams of solute per kilogram of solvent, primarily used in the health sciences.

**pascal (Pa)** | The SI unit for pressure. The pascal is newtons per square meter.

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**Pauli exclusion principle** | A principle stating that no two electrons in an atom can have the same value of all four quantum numbers.

**Pauli exclusion principle** | A principle stating that no two electrons in an atom can have the same value of all four quantum numbers.

**percent composition** | The percentage of each element present in a pure substance. With few exceptions, the percent composition of a chemical compound is constant (see law of definite proportions).

**percent composition** | The percentage of each element present in a pure substance. With few exceptions, the percent composition of a chemical compound is constant (see law of definite proportions).

**percent yield** | The ratio of the actual yield of a reaction to the theoretical yield multiplied by 100 to give a percentage.

**percent yield** | The ratio of the actual yield of a reaction to the theoretical yield multiplied by 100 to give a percentage.

**periodic table** | A chart of the chemical elements arranged in rows of increasing atomic number so that the elements in each column (group) have similar chemical properties.

**periodic table** | A chart of the chemical elements arranged in rows of increasing atomic number so that the elements in each column (group) have similar chemical properties.

**perovskite structure** | A structure that consists of a bcc array of two metal ions, with one set (M) located at the corners of the cube, and the other set (M') in the centers of the cube.

**perovskite structure** | A structure that consists of a bcc array of two metal ions, with one set (M) located at the corners of the cube, and the other set (M') in the centers of the cube.

**pH** | The negative base-10 logarithm of the hydrogen ion concentration:

**pH** | The negative base-10 logarithm of the hydrogen ion concentration:

**pH scale** | A logarithmic scale used to express the hydrogen ion concentration of a solution, making it possible to describe acidity or basicity quantitatively.

**pH scale** | A logarithmic scale used to express the hydrogen ion concentration of a solution, making it possible to describe acidity or basicity quantitatively.

**phase changes** | A change of state that occurs when any of the three forms of matter (solids, liquids, and gases) is converted to either of the other two.

**phase changes** | A change of state that occurs when any of the three forms of matter (solids, liquids, and gases) is converted to either of the other two.

**phase diagram** | A graphic summary of the physical state of a substance as a function of temperature and pressure in a closed system.

**phase diagram** | A graphic summary of the physical state of a substance as a function of temperature and pressure in a closed system.

**photoelectric effect** | A phenomenon in which electrons are ejected from the surface of a metal that has been exposed to light.

**photoelectric effect** | A phenomenon in which electrons are ejected from the surface of a metal that has been exposed to light.

**photons** | A quantum of radiant energy, each of which possesses a particular energy given by

**photons** | A quantum of radiant energy, each of which possesses a particular energy given by

**physical change** | A change of state that does not affect the chemical composition of a substance.

**physical change** | A change of state that does not affect the chemical composition of a substance.

**pi star ( $\pi^*$ ) orbital** | An antibonding molecular orbital formed from the difference of the side-to-side interactions of two or more parallel atomic orbitals, creating a nodal plane perpendicular to the internuclear axis.

**pi star ( $\pi^*$ ) orbital** | An antibonding molecular orbital formed from the difference of the side-to-side interactions of two or more parallel atomic orbitals, creating a nodal plane perpendicular to the internuclear axis.

**pinning** | A process that increases the mechanical strength of a material by introducing multiple defects into a material so that the presence of one defect prevents the motion of another.

**pinning** | A process that increases the mechanical strength of a material by introducing multiple defects into a material so that the presence of one defect prevents the motion of another.

**Plastic** | The property of a material that allows it to be molded into almost any shape.

**Plastic** | The property of a material that allows it to be molded into almost any shape.

**pnictogens** | The elements in group 15 of the periodic table.

**pnictogens** | The elements in group 15 of the periodic table.

**polar bond** | A chemical bond in which there is an unequal distribution of charge between the bonding atoms.

**polar bond** | A chemical bond in which there is an unequal distribution of charge between the bonding atoms.

**polar covalent bonds** | A covalent bond in which the electrons are shared unequally between the bonded atoms.

**polar covalent bonds** | A covalent bond in which the electrons are shared unequally between the bonded atoms.

**polarizability** | The ease of deformation of the electron distribution in an atom or molecule.

**polarizability** | The ease of deformation of the electron distribution in an atom or molecule.

**polyatomic** | Molecules that contain more than two atoms.

**polyatomic** | Molecules that contain more than two atoms.

**Polyatomic ions** | A group of two or more atoms that has a net electrical charge.

**Polyatomic ions** | A group of two or more atoms that has a net electrical charge.

**polymer-matrix composite** | A composite that consists of reinforcing fibers embedded in a polymer matrix.

**polymer-matrix composite** | A composite that consists of reinforcing fibers embedded in a polymer matrix.

**precipitate** | The insoluble product that forms in a precipitation reaction.

**precipitate** | The insoluble product that forms in a precipitation reaction.

**precise** | Multiple measurements give nearly identical values.

**precise** | Multiple measurements give nearly identical values.

**pressure( $P$ )** | The amount of force exerted on a given area of surface:

**pressure( $P$ )** | The amount of force exerted on a given area of surface:

**principal quantum number ( $n$ )** | One of three quantum numbers that tells the average relative distance of an electron from the nucleus.

**principal quantum number ( $n$ )** | One of three quantum numbers that tells the average relative distance of an electron from the nucleus.

**principal shell** | All the wave functions that have the same value of because those electrons have similar average distances from the nucleus.

**principal shell** | All the wave functions that have the same value of because those electrons have similar average distances from the nucleus.

**product(s)** | The final compound(s) produced in a chemical reaction.

**product(s)** | The final compound(s) produced in a chemical reaction.

**promotion** | The excitation of an electron from a filled atomic orbital to an empty or valence orbital.

**promotion** | The excitation of an electron from a filled atomic orbital to an empty or valence orbital.

**pseudo noble gas configurations** | The and similar electron configurations that are particularly stable and are often encountered in the heavier -block elements.

**pseudo noble gas configurations** | The and similar electron configurations that are particularly stable and are often encountered in the heavier -block elements.

**pyrolysis** | A high-temperature decomposition reaction that can be used to form fibers of synthetic polymers.

**pyrolysis** | A high-temperature decomposition reaction that can be used to form fibers of synthetic polymers.

**quantum** | The smallest possible unit of energy. Energy can be gained or lost only in integral multiples of a quantum.

**quantum** | The smallest possible unit of energy. Energy can be gained or lost only in integral multiples of a quantum.

**quantum mechanics** | A theory developed by Erwin Schrödinger that describes the energies and spatial distributions of electrons in atoms and molecules.

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**R** | The abbreviation used for alkyl groups and aryl groups in general formulas and structures.

**R** | The abbreviation used for alkyl groups and aryl groups in general formulas and structures.

**radicals** | Species that have one or more unpaired valence electrons.

**radicals** | Species that have one or more unpaired valence electrons.

**radioactivity** | The spontaneous emission of energy rays (radiation) by matter.

**radioactivity** | The spontaneous emission of energy rays (radiation) by matter.

**Raoult's law** | An equation that quantifies the relationship between solution composition and vapor pressure:

**Raoult's law** | An equation that quantifies the relationship between solution composition and vapor pressure:

**rate constant** | A proportionality constant whose value is characteristic of the reaction and the reaction conditions and whose numerical value does not change as the reaction progresses under a given set of conditions.

**rate constant** | A proportionality constant whose value is characteristic of the reaction and the reaction conditions and whose numerical value does not change as the reaction progresses under a given set of conditions.

**rate laws** | Mathematical expressions that describe the relationships between reactant rates and reactant concentrations in a chemical reaction.

**rate laws** | Mathematical expressions that describe the relationships between reactant rates and reactant concentrations in a chemical reaction.

**rate-determining step** | The slowest step in a reaction mechanism.

**rate-determining step** | The slowest step in a reaction mechanism.

**reaction mechanisms** | The sequence of events that occur at the molecular level during a reaction.

**reaction mechanisms** | The sequence of events that occur at the molecular level during a reaction.

**reaction order** | Numbers that indicate the degree to which the reaction rate depends on the concentration of each reactant.

**reaction order** | Numbers that indicate the degree to which the reaction rate depends on the concentration of each reactant.

**reaction quotient ( $Q$ )** | A quantity derived from a set of values measured at any time during the reaction of any mixture of reactants and products, regardless of whether the system is at equilibrium: for the general balanced chemical equation

**reaction quotient ( $Q$ )** | A quantity derived from a set of values measured at any time during the reaction of any mixture of reactants and products, regardless of whether the system is at equilibrium: for the general balanced chemical equation

**reaction quotient ( $Q_p$ )** | A quantity derived from a set of values measured at any time during the reaction of any mixture of reactants and products in the gas phase, regardless of whether the system is at equilibrium: for the general balanced chemical equation

**reaction quotient ( $Q_p$ )** | A quantity derived from a set of values measured at any time during the reaction of any mixture of reactants and products in the gas phase, regardless of whether the system is at equilibrium: for the general balanced chemical equation

**reaction rates** | The changes in concentrations of reactants and products with time.

**reaction rates** | The changes in concentrations of reactants and products with time.

**reductants (or reducing agents)** | A compound that is capable of donating electrons; thus it is oxidized.

**reductants (or reducing agents)** | A compound that is capable of donating electrons; thus it is oxidized.

**reduction** | The gain of one or more electrons in a chemical reaction. The substance that gains electrons is said to be reduced.

**reduction** | The gain of one or more electrons in a chemical reaction. The substance that gains electrons is said to be reduced.

**reforming** | The second process used in petroleum refining, which is the chemical conversion of straight-chain alkanes to either branched-chain alkanes or mixtures of aromatic hydrocarbons.

**reforming** | The second process used in petroleum refining, which is the chemical conversion of straight-chain alkanes to either branched-chain alkanes or mixtures of aromatic hydrocarbons.

**resonance structures** | A Lewis electron structure that has different arrangements of electrons around atoms whose positions do not change.

**resonance structures** | A Lewis electron structure that has different arrangements of electrons around atoms whose positions do not change.

**reverse osmosis** | A process that uses the application of an external pressure greater than the osmotic pressure of a solution to reverse the flow of solvent through the semipermeable membrane.

**reverse osmosis** | A process that uses the application of an external pressure greater than the osmotic pressure of a solution to reverse the flow of solvent through the semipermeable membrane.

**root mean square (rms) speed( $v_{rms}$ )** | The speed of a gas particle that has average kinetic energy.

**root mean square (rms) speed( $v_{rms}$ )** | The speed of a gas particle that has average kinetic energy.

**salt** | The general term for any ionic substance that does not have as the anion or as the cation.

**salt** | The general term for any ionic substance that does not have as the anion or as the cation.

**saturated** | A solution with the maximum possible amount of a solute under a given set of conditions.

**saturated** | A solution with the maximum possible amount of a solute under a given set of conditions.

**Schottky defects** | A coupled pair of vacancies—one cation and one anion—that maintains the electrical neutrality of an ionic solid.

**Schottky defects** | A coupled pair of vacancies—one cation and one anion—that maintains the electrical neutrality of an ionic solid.

**scientific method** | The procedure that scientists use to search for answers to questions and solutions to problems.

**scientific method** | The procedure that scientists use to search for answers to questions and solutions to problems.

**scientific notation** | A system that expresses numbers in the form  $N \times 10^n$ , where  $N$  is greater than or equal to 1 and less than 10 ( $1 \leq N < 10$ ) and  $n$  is an integer that can be either positive or negative ( $10^0 = 1$ ). The purpose of scientific notation is to simplify the manipulation of numbers with large or small magnitudes.

**scientific notation** | A system that expresses numbers in the form  $N \times 10^n$ , where  $N$  is greater than or equal to 1 and less than 10 ( $1 \leq N < 10$ ) and  $n$  is an integer that can be either positive or negative ( $10^0 = 1$ ). The purpose of scientific notation is to simplify the manipulation of numbers with large or small magnitudes.

**second-order reaction** | A reaction whose rate is proportional to the square of the concentration of the reactant (for a reaction with the general form  $2A \rightarrow$  products) or is proportional to the product of the concentrations of two reactants (for a reaction with the general form  $A + B \rightarrow$  products).

**second-order reaction** | A reaction whose rate is proportional to the square of the concentration of the reactant (for a reaction with the general form  $2A \rightarrow$  products) or is proportional to the product of the concentrations of two reactants (for a reaction with the general form  $A + B \rightarrow$  products).

**seed crystal** | A solid sample of a substance that can be added to a supercooled liquid or a supersaturated solution to help induce crystallization.

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**seed crystal** | A solid sample of a substance that can be added to a supercooled liquid or a supersaturated solution to help induce crystallization.

**seed crystal** | A solid sample of a substance that can be added to a supercooled liquid or a supersaturated solution to help induce crystallization.

**semiconductors** | A substance such as Si and Ge that has a conductivity between that of metals and insulators.

**semiconductors** | A substance such as Si and Ge that has a conductivity between that of metals and insulators.

**semimetals** | Any element that lies adjacent to the zigzag line in the periodic table that runs from boron to astatine. Semimetals (also called metalloids) exhibit properties intermediate between those of metals and nonmetals.

**semimetals** | Any element that lies adjacent to the zigzag line in the periodic table that runs from boron to astatine. Semimetals (also called metalloids) exhibit properties intermediate between those of metals and nonmetals.

**sigma ( $\sigma$ ) orbital** | A bonding molecular orbital in which the electron density along the internuclear axis and between the nuclei has cylindrical symmetry.

**sigma ( $\sigma$ ) orbital** | A bonding molecular orbital in which the electron density along the internuclear axis and between the nuclei has cylindrical symmetry.

**sigma star ( $\sigma^*$ ) orbital** | An antibonding molecular orbital in which there is a region of zero electron probability (a nodal plane) perpendicular to the internuclear axis.

**sigma star ( $\sigma^*$ ) orbital** | An antibonding molecular orbital in which there is a region of zero electron probability (a nodal plane) perpendicular to the internuclear axis.

**significant figures** | Numbers that describe the value without exaggerating the degree to which it is known to be accurate.

**significant figures** | Numbers that describe the value without exaggerating the degree to which it is known to be accurate.

**single-displacement reactions** | A chemical reaction in which an ion in solution is displaced through oxidation of a metal.

**single-displacement reactions** | A chemical reaction in which an ion in solution is displaced through oxidation of a metal.

**sintering** | A process that fuses the grains of a ceramic into a dense, strong material. Sintering is used to produce high-strength ceramics.

**sintering** | A process that fuses the grains of a ceramic into a dense, strong material. Sintering is used to produce high-strength ceramics.

**sodium chloride structure** | The solid structure that results when the octahedral holes of an fcc lattice of anions are filled with cations.

**sodium chloride structure** | The solid structure that results when the octahedral holes of an fcc lattice of anions are filled with cations.

**sol-gel process** | A process used to manufacture ceramics by producing fine powders of ceramic oxides with uniformly sized particles.

**sol-gel process** | A process used to manufacture ceramics by producing fine powders of ceramic oxides with uniformly sized particles.

**solid electrolytes** | A solid material with a very high electrical conductivity.

**solid electrolytes** | A solid material with a very high electrical conductivity.

**solubility** | A measure of the how much of a solid substance remains dissolved in a given amount of a specified liquid at a specified temperature and pressure.

**solubility** | A measure of the how much of a solid substance remains dissolved in a given amount of a specified liquid at a specified temperature and pressure.

**solutions** | A homogeneous mixture of two or more substances in which the substances present in lesser amounts (the solutes) are dispersed uniformly throughout the substance present in greater amount (the solvent).

**sp hybrid orbital** | The two equivalent hybrid orbitals that result when one orbital and one orbital are combined (hybridized). The two hybrid orbitals are oriented at  $180^\circ$  from each other. They are equivalent in energy, and their energy is between the energy values associated with pure and pure orbitals.

**sp hybrid orbital** | The two equivalent hybrid orbitals that result when one orbital and one orbital are combined (hybridized). The two hybrid orbitals are oriented at  $180^\circ$  from each other. They are equivalent in energy, and their energy is between the energy values associated with pure and pure orbitals.

**sp<sup>2</sup> hybrid atomic orbitals** | The three equivalent hybrid orbitals that result when one orbital and two orbitals are combined (hybridized). The three hybrid orbitals are oriented in a plane at  $120^\circ$  from each other. They are equivalent in energy, and their energy is between the energy values associated with pure and pure orbitals.



**$sp^2$  hybrid atomic orbitals** | The three equivalent hybrid orbitals that result when one orbital and two orbitals are combined (hybridized). The three hybrid orbitals are oriented in a plane at  $120^\circ$  from each other. They are equivalent in energy, and their energy is between the energy values associated with pure and pure orbitals.

**$sp^3$  hybrid atomic orbitals** | The four equivalent hybrid orbitals that result when one orbital and three orbitals are combined (hybridized). The four hybrid orbitals point at the vertices of a tetrahedron, so they are oriented at  $109.5^\circ$  from each other. They are equivalent in energy, and their energy is between the energy values associated with pure and pure orbitals.

**$sp^3$  hybrid atomic orbitals** | The four equivalent hybrid orbitals that result when one orbital and three orbitals are combined (hybridized). The four hybrid orbitals point at the vertices of a tetrahedron, so they are oriented at  $109.5^\circ$  from each other. They are equivalent in energy, and their energy is between the energy values associated with pure and pure orbitals.

**$sp^3d$  hybrid orbitals** | The five hybrid orbitals that result when one three and one orbitals are combined (hybridized).

**$sp^3d$  hybrid orbitals** | The five hybrid orbitals that result when one three and one orbitals are combined (hybridized).

**$sp^3d^2$  hybrid orbitals** | The six equivalent hybrid orbitals that result when one , three , and two orbitals are combined (hybridized).

**$sp^3d^2$  hybrid orbitals** | The six equivalent hybrid orbitals that result when one , three , and two orbitals are combined (hybridized).

**specific heat ( $C_s$ )** | The amount of energy needed to increase the temperature of 1 g of a substance by  $1^\circ\text{C}$ . The units of are

**specific heat ( $C_s$ )** | The amount of energy needed to increase the temperature of 1 g of a substance by  $1^\circ\text{C}$ . The units of are

**specific heat ( $C_s$ )** | The number of joules required to raise the temperature of 1 g of a substance by  $1^\circ\text{C}$ .

**specific heat ( $C_s$ )** | The number of joules required to raise the temperature of 1 g of a substance by  $1^\circ\text{C}$ .

**speed ( $v$ )** | The distance traveled by a wave per unit time.

**speed ( $v$ )** | The distance traveled by a wave per unit time.

**speed of light ( $c$ )** | The speed with which all forms of electromagnetic radiation travel in a vacuum.

**speed of light ( $c$ )** | The speed with which all forms of electromagnetic radiation travel in a vacuum.

**standard enthalpies of formation ( $\Delta H_f^\circ$ )** | The enthalpy change for the formation of 1 mol of a compound from its component elements when the component elements are each in their standard states. The standard enthalpy of formation of any element in its most stable form is zero by definition.

**standard enthalpies of formation ( $\Delta H_f^\circ$ )** | The enthalpy change for the formation of 1 mol of a compound from its component elements when the component elements are each in their standard states. The standard enthalpy of formation of any element in its most stable form is zero by definition.

**standard enthalpy of reaction ( $\Delta H_r^\circ$ )** | The enthalpy change that occurs when a reaction is carried out with all reactants and products in their standard state.

**standard enthalpy of reaction ( $\Delta H_r^\circ$ )** | The enthalpy change that occurs when a reaction is carried out with all reactants and products in their standard state.

**standard molar volume** | The volume of 1 mol of an ideal gas at STP ( $0^\circ\text{C}$  and 1 atm pressure), which is 22.41 L.

**standard molar volume** | The volume of 1 mol of an ideal gas at STP ( $0^\circ\text{C}$  and 1 atm pressure), which is 22.41 L.

**standard solution** | A solution whose concentration is precisely known.

**standard solution** | A solution whose concentration is precisely known.

**standard temperature and pressure (STP)** | The conditions  $0^\circ\text{C}$  (273.15 K) and 1 atm pressure for a gas.

**standard temperature and pressure (STP)** | The conditions  $0^\circ\text{C}$  (273.15 K) and 1 atm pressure for a gas.

**state function** | A property of a system whose magnitude depends on only the present state of the system, not its previous history.

**state function** | A property of a system whose magnitude depends on only the present state of the system, not its previous history.

**steric factor ( $p$ )** | The fraction of orientations of particles that result in a chemical reaction.

**steric factor ( $p$ )** | The fraction of orientations of particles that result in a chemical reaction.

**stock solution** | A commercially prepared solution of known concentration.

**stock solution** | A commercially prepared solution of known concentration.

**stoichiometric quantity** | The amount of product or reactant specified by the coefficients in a balanced chemical equation.

**stoichiometric quantity** | The amount of product or reactant specified by the coefficients in a balanced chemical equation.

**strong electrolytes** | An electrolyte that dissociates completely into ions when dissolved in water, thus producing an aqueous solution that conducts electricity very well.

**strong electrolytes** | An electrolyte that dissociates completely into ions when dissolved in water, thus producing an aqueous solution that conducts electricity very well.

**structural formulas** | A representation of a molecule that shows which atoms are bonded to one another and, in some cases, the approximate arrangement of atoms in space.

**structural formulas** | A representation of a molecule that shows which atoms are bonded to one another and, in some cases, the approximate arrangement of atoms in space.

**subshell** | A group of wave functions that have the same values of and

**subshell** | A group of wave functions that have the same values of and

**substitutional impurity** | A point defect that results when an impurity atom occupies a normal lattice site.

**substitutional impurity** | A point defect that results when an impurity atom occupies a normal lattice site.

**substrate** | The reactant in an enzyme-catalyzed reaction.

**substrate** | The reactant in an enzyme-catalyzed reaction.

**Superalloys** | A high-strength alloy based on cobalt, nickel, and iron, often of complex composition, that is used in applications that require mechanical strength, high surface stability, and resistance to high temperatures.

**Superalloys** | A high-strength alloy based on cobalt, nickel, and iron, often of complex composition, that is used in applications that require mechanical strength, high surface stability, and resistance to high temperatures.

**supercritical fluid** | The single, dense fluid phase that exists above the critical temperature of a substance.

**supercritical fluid** | The single, dense fluid phase that exists above the critical temperature of a substance.

**superheated liquid** | An unstable liquid at a temperature and pressure at which it should be a gas.

**superheated liquid** | An unstable liquid at a temperature and pressure at which it should be a gas.

**surface tension** | The energy required to increase the surface area of a liquid by a certain amount. Surface tension is measured in units of energy per area (e.g., ).

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**surfactants** | Substances (surface-active agents), such as soaps and detergents, that disrupt the attractive intermolecular interactions between molecules of a polar liquid, thereby reducing the surface tension of the liquid.

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**surroundings** | All the universe that is not the system; that is, system + surroundings = universe.

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**Système internationale d'unités (or SI)** | A system of units based on metric units that requires measurements to be expressed in decimal form. There are seven base units in the SI system.

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**tetrahedral holes** | One of two kinds of holes in a face-centered cubic array of atoms or ions (the other is an octahedral hole). Tetrahedral holes are located between an atom at a corner and the three atoms at the centers of the adjacent faces of the face-centered cubic unit cell. An atom or ion in a tetrahedral hole has a coordination number of 4.

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**theoretical yield** | The maximum amount of product that can be formed from the reactants in a chemical reaction, which theoretically is the amount of product that would be obtained if the reaction occurred perfectly and the method of purifying the product were 100% efficient.

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**theory** | A statement that attempts to explain why nature behaves the way it does.

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**thermochemistry** | A branch of chemistry that describes the energy changes that occur during chemical reactions.

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**thermodynamic control** | The altering of reaction conditions so that a single desired product or set of products is present in significant quantities at equilibrium.

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**titration curve** | A plot of the pH of the solution being titrated versus the amount of acid or base (of known concentration) added.

**transition elements** | Any element in groups 3–12 in the periodic table. All of the transition elements are metals.

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**transition state** | Also called the activated complex, the arrangement of atoms that first forms when molecules are able to overcome the activation energy and react.

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**transmutation** | The process of converting one element to another.

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**triads** | A set of three elements that have similar properties.

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**triple bond** | A chemical bond formed when two atoms share three pairs of electrons.

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**triple point** | The point in a phase diagram where the solid/liquid, liquid/gas, and solid/gas lines intersect; it represents the only combination of temperature and pressure at which all three phases are in equilibrium and can therefore exist simultaneously.

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**triprotic acid** | A compound that can donate three protons per molecule in separate steps.

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**troposphere** | The lowest layer of the atmosphere, the troposphere extends from earth's surface to an altitude of about 11–13 km (7–8 miles). The temperature of the troposphere decreases steadily with increasing altitude.

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**Tyndall effect** | The phenomenon of scattering a beam of visible light.

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**ultraviolet light** | High-energy radiation that cannot be detected by the human eye but can cause a wide variety of chemical reactions that are harmful to organisms.

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**unit cell** | The smallest repeating unit of a crystal lattice.

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**vacancy** | A point defect that consists of a single atom missing from a site in a crystal.

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**valence bond theory** | A localized bonding model that assumes that the strength of a covalent bond is proportional to the amount of overlap between atomic orbitals and that an atom can use different combinations of atomic orbitals (hybrids) to maximize the overlap between bonded atoms.

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**valence electrons** | Electrons in the outermost shell of an atom.

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**valence-shell electron-pair repulsion (VSEPR) model** | A model used to predict the shapes of many molecules and polyatomic ions, based on the idea that the lowest-energy arrangement for a compound is the one in which its electron pairs (bonding and nonbonding) are as far apart as possible.

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**van der Waals atomic radius( $r_{vdw}$ )** | Half the internuclear distance between two nonbonded atoms in the solid.

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**van der Waals equation** | A modification of the ideal gas law designed to describe the behavior of real gases by explicitly including the effects of molecular volume and intermolecular forces.

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**van der Waals forces** | The intermolecular forces known as dipole–dipole interactions and London dispersion forces.

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**van't Hoff factor( $i$ )** | The ratio of the apparent number of particles in solution to the number predicted by the stoichiometry of the salt.

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**vapor pressure** | The pressure created over a liquid by the molecules of a liquid substance that have enough kinetic energy to escape to the vapor phase.

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**Viscosity ( $\eta$ )** | The resistance of a liquid to flow.

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**volume** | The amount of space occupied by a sample of matter.

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**waters of hydration** | The loosely bound water molecules in hydrate compounds. These waters of hydration can often be removed by simply heating the compound.

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**wave** | A periodic oscillation that transmits energy through space.

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**wave function ( $\Psi$ )** | A mathematical function that relates the location of an electron at a given point in space to the amplitude of its wave, which corresponds to its energy.

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**wave–particle duality** | A principle that matter and energy have properties typical of both waves and particles.

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**weak bases** | A base in which only a fraction of the molecules react with water to produce and the corresponding cation.

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**weak electrolytes** | A compound that produces relatively few ions when dissolved in water, thus producing an aqueous solution that conducts electricity poorly.

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**weight** | A force caused by the gravitational attraction that operates on an object. The weight of an object depends on its location (c.f. mass).

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**Work hardening** | The practice of introducing a dense network of dislocations throughout a solid, making it very tough and hard.

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**x-ray diffraction** | An technique used to obtain information about the structures of crystalline substances by using x-rays.

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**zeroth-order reaction** | A reaction whose rate is independent of concentration.

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**zinc blende structure** | The solid structure that results when half of the tetrahedral holes in an fcc lattice of anions are filled with cations with a 1:1 cation:anion ratio and a coordination number of 4.

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