

# GLOSSARY/INDEX

## A

Abbreviated electron configuration, of multi-electron atoms 151–154

**Absolute zero** Zero kelvins (0 K), the lowest possible temperature, equivalent to  $-273.15^{\circ}\text{C}$ . It is the point beyond which motion can no longer be decreased. 18

**Accuracy** How closely a measured value approaches the true value of the property. 20

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**Acidic solution** A solution with a significant concentration of hydronium ions,  $\text{H}_3\text{O}^+$ . 248, 340

Acid rain 255

pH and 346

Acrylamide 597

Activated complex 587

**Activation energy** The minimum energy necessary for reactants to reach the activated complex and proceed to products. 588

**Active site** A specific section of the protein structure of an enzyme in which the substrate fits and reacts. 666

**Actual yield** The amount of product that is actually obtained in a chemical reaction. 428

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Addition, rounding off for 45–46

**Addition polymer** A polymer that contains all of the atoms of the original reactant in its structure. This category includes polyethylene, polypropylene, and poly(vinyl chloride). 669–670

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internal combustion engine and 468

Air bags 502

Air pollution

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volatile organic solvents and 490

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**Alcohol** Compounds that contain a hydrocarbon group with one or more  $-\text{OH}$  groups attached. 196, 639. *See also* Methanol, Ethanol, and 2-propanol

hydrogen bonds and 531

**Aldehyde** A compound that has a hydrogen atom or a hydrocarbon group connected to a  $-\text{CHO}$  group. 641

Aldol, molecular structure of 645

Alka-Seltzer 502

**Alkali metals** Group 1 (or 1A) on the periodic table; *See also* Lithium, Sodium, Potassium, and Cesium 85

ion charges of 182–183

**Alkaline earth metals** Group 2 (or 2A) on the periodic table; *See also* Beryllium, Magnesium, and Calcium 85

ion charges of 183

**Alkane** A hydrocarbon (a compound composed of carbon and hydrogen) in which all of the carbon-carbon bonds are single bonds. 637

**Alkene** A hydrocarbon that has one or more carbon-carbon double bonds. 638

**Alkyne** A hydrocarbon that has one or more carbon-carbon triple bonds. 638

**Alpha emission** The process of releasing an alpha particle by atoms that have too many protons to be stable. 696

nuclear equations for 699–701

Alpha helix 656–657

**Alpha particle** The emission from radioactive nuclides that is composed of two protons and two neutrons in the form of a helium nucleus. 696

effects on body 706–707

penetration of the body 707

Alternate Synthetic Pathways Award 597

**Alum.** *See* Aluminum sulfate

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Aluminum bromide, production and use 399

Aluminum chloride 243

Aluminum fluoride, production and use 447

Aluminum hydroxide, dissolving in acid 352

Aluminum oxide 306

Aluminum sulfate

old books and 355

production and use 456

water purification 420

- Americium-241 and smoke detectors 711
- Amide** A compound with the general formula RCONR, in which each R represents hydrogen atoms or hydrocarbon groups. 644  
in digestion 665  
as peptide bond 656
- Amine** A compound with the general formula R<sub>3</sub>N, in which R represents a hydrogen atom or a hydrocarbon group (and at least one R group being a hydrocarbon group). 643–644
- Amino acid** The monomer that forms the protein polymers. They contain an amine functional group and a carboxylic acid group separated by a carbon. 654–655  
in origin of life 616–618  
protein formation and 656  
in silk 666
- 1-Aminobutane 643
- Aminopeptidase 664
- Ammonia 341–342  
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- Ammonium nitrate, in cold packs 322
- Ammonium perchlorate, space shuttle and 409
- Ammonium phosphate, fertilizers and 377
- Ammonium sulfide, use 243
- Amount of substance, base unit of 10
- Amphere, as unit of measure 11
- Amphetamine 558
- Amphoteric substance** A substance that can act as either a Bronsted-Lowry acid or a Bronsted-Lowry base, depending on the circumstances. 359
- Amylase 664
- Amylopectin 652–653
- Amylose 652–653
- Analogy, to electron behavior 132
- Anastas, Paul T. 5
- Anderson, Carl 155
- Androstanedione 662, 663
- Aniline, production and use 445, 448
- Animal fat 561
- Anion** An ion formed from an atom that has gained one or more electrons and thus has become negatively charged. 91  
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in classifying types of compounds 180  
in ionic bond formation 177–178  
monatomic 183  
naming 236–237, 239–241  
polyatomic 185–187  
structure of ionic compounds 185  
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- Anode** The electrode at which oxidation occurs in a voltaic cell. It is the source of electrons and is the negative electrode. 389
- Antacid 300, 482
- Anti-electron (positron) 155
- Antimatter 155
- Antioxidant, aging and 376
- Antiparticle 155
- Application, in scientific method 8–9
- Aquamarine 294
- Aqueous solution** A solution in which water is the solvent. 309
- Arene** (or aromatic compound) A compound that contains the benzene ring. 638–639
- Arginine (Arg, R), structure of 655
- Argon  
in air 486  
in incandescent light bulbs 472  
in neon lights 485
- Aromatic.** See Arene A compound that contains the benzene ring.
- Aromatic compounds** Compounds that contain the benzene ring.. See Arene
- Arrhenius, Svante August 248
- Arrhenius acid** According to the Arrhenius theory, any substance that generates hydronium ions, H<sub>3</sub>O<sup>+</sup>, when added to water. 248–255, 340–347. See also Acid  
binary acid 250  
compared to Brønsted/Lowry acids 356–360  
defined 248, 340  
names and formulas for 256–258  
organic (or carbon-based) acid 250  
oxyacids 250  
reactions with bases 348–355
- Arrhenius base** A substance that produces hydroxide ions, OH<sup>−</sup>, when added to water. 342–346. See also Base  
compared to Brønsted/Lowry bases 356–360  
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- Arsenic (As)  
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- Asparagine (Asn, N), structure of 655
- Aspartame 681, 687
- Aspartic acid (Asp, D)  
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- Asphalt, London forces in 532–533
- Asymmetry, in polar molecules 528, 529
- Atmosphere (atm), as unit of pressure 461
- Atmospheric pressure 461  
boiling-point temperature and 521–522
- Atom** The smallest part of the element that retains the chemical characteristics of the element itself. 88–90  
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in chemical reactions 300–302  
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orbital diagram 142  
oxidation numbers of 377–384  
protons, neutrons, and electrons 89  
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size of 89  
size of nucleus 89  
structure of 88–92
- Atomic mass** The weighted average of the masses of the naturally occurring isotopes of an element.  
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relative 102
- Atomic mass unit (u or amu)** One-twelfth the mass of an atom of carbon-12. Carbon-12 is the isotope of carbon that contains 6 protons,

- 6 neutrons, and 6 electrons. 89, 101–102
- Atomic number** The number of protons in an atom's nucleus. It establishes the element's identity. 93  
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- Atomic orbitals  
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*2p* 139  
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- Attraction. *See also* Gravitational attraction; Electrostatic attraction; Strong force; Particle-particle attractions  
between gas particles 460  
between liquid particles 510  
intermolecular 523–533  
particle-particle attraction 523–538
- Aurum 83
- Automobile Exhaust 173
- Average, weighted 100
- Avogadro's Law** Volume and the number of gas particles are directly proportional if the temperature and pressure are constant. 467
- Avogadro's number** The number of atoms in 12 g of carbon-12. To four significant figures, it is  $6.022 \times 10^{23}$ . 102–103
- B**
- Bacon, Roger 33
- Bacteria 400  
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- Baking powder 175
- Balance, electronic 23, 46
- Balanced chemical equation  
coefficient 301  
coefficients to conversion factors 415–416  
in equation stoichiometry 414–421
- Balancing chemical equations 302–307  
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- Ball-and-stick model** A representation of a molecule that uses balls for atoms and sticks for covalent bonds. 96  
of acetic acid molecule 250  
for acetylene 214  
for boron trifluoride 213  
for ethane 213  
for organic molecules 636  
of methane 211  
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- Band of stability** On a graph of the numbers of neutrons versus protons in the nuclei of atoms, the portion that represents stable nuclides. 695
- Barium ion, solubility of compounds with 317
- Barium sulfate 319
- Barnes, Randy 663
- Base 341–345 *See also* Arrhenius base  
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- Base units** The seven units from which all other units in the SI system of measurement are derived. 10–11  
table of 11
- Basic solution** A solution with a significant concentration of hydroxide ions,  $\text{OH}^-$ . 341
- Battery** A device that has two or more voltaic cells connected together. The term is also used to describe any device that converts chemical energy into electrical energy using redox reactions. 388–393. *See also* Voltaic cell  
defined 388, 389  
dry cell 390–391  
nickel-cadmium batteries 392  
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zinc-air 393
- Beef fat 560–561
- Bends, the 572
- Benitoite 294
- Bent geometry** The molecular geometry formed around an atom with two bond groups and two lone pairs or two bond groups and one lone pair. 212
- Benzene 276
- Berkelium (Bk) 701
- Beryllium (Be)  
electron configuration and orbital diagram 144  
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- Beta emission** The conversion of a neutron to a proton, which stays in the nucleus, and an electron, called a beta particle in this context, which is ejected from the atom. 696  
nuclear equations for 699–701
- Beta particle** A high-velocity electron released from radioactive nuclides that have too many neutrons. 696  
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penetration of the body 707
- Beta sheet 656
- Big Bang 718
- Binary acid** Substances that have the general formula of  $\text{HX}(aq)$ , where X is one of the first four halogens:  $\text{HF}(aq)$ ,  $\text{HCl}(aq)$ ,  $\text{HBr}(aq)$ , and  $\text{HI}(aq)$ . 250  
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- Binary covalent compound** A compound that consists of two nonmetallic elements.  
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- Binary ionic compound** An ionic compound whose formula contains one symbol for a metal and one symbol for a nonmetal. 239
- Binding energy** The amount of energy released when a nucleus is formed. 713
- Biocatalyst 597
- Biochemistry** The chemistry of biological systems. 650–663
- Biomolecule 650–663  
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- Blake, William 119

- Bleach** dangerous combination with acid 356  
pH of 347
- Blocks**, in periodic table 146–147
- Blood** pH of 347
- Blue litmus paper**, detecting acids with 348
- Boiling** The conversion of liquid to vapor anywhere in the liquid rather than just at the top surface. 518–522  
defined 520  
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- Boiling-point temperature** The temperature at which a liquid boils. It is also the temperature at which the equilibrium vapor pressure of the liquid becomes equal to the external pressure acting on the liquid. 520  
effect of external pressure 520–522  
strengths of attractions and 522
- Bond**. *See* Chemical bond
- Bond angle** The angle formed by straight lines (representing bonds) connecting the nuclei of three adjacent atoms. 210
- Bond dipole** A polar covalent bond, which has an atom with a partial positive charge and an atom with a partial negative charge. 525
- Bond polarity**, predicting 524–528
- Books**, preserving 355
- Boron (B)** brain cancer treatment and 717  
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covalent bonding pattern 195  
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- Boron trifluoride** 194
- Bovine pancreatic trypsin inhibitor (BPTI)** 656–658
- Boyle's Law** The pressure of a gas is inversely proportional to the volume it occupies if the number of gas particles and the temperature are constant. 462–463
- Brain**, intoxicating liquids and 214
- Brain cancer**, treatment for 717
- Brandes, Jay A.** 617
- Breathing** 469
- Bristlecone pines** and carbon-14 dating 710
- Bromide ion**, solubility of compounds with 317
- Bromine (Br)** structure 97  
use 546
- Bromomethane**, and threshold limit value, or TLV 498
- Brønsted-Lowry acid** A substance that donates protons, H<sup>+</sup>, in a Bronsted-Lowry acid-base reaction. *See* Acid, Brønsted-Lowry
- Brønsted-Lowry acid-base reaction** A chemical reaction in which a proton, H<sup>+</sup>, is transferred. *See* Acid-base reaction, Brønsted-Lowry
- Brønsted-Lowry base** A substance that accepts protons, H<sup>+</sup>, in a Bronsted-Lowry acid-base reaction. *See* Base, Brønsted-Lowry
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- Calcium dihydrogen phosphate**, production and use 453
- Calcium hydrogen sulfite**, production and use 407
- Calcium nitrate** 243, 312–313
- Calcium phosphide** (or photophor), empirical formula for 273
- Calorie (with an uppercase C), Cal** The dietary calorie. In fact, a Calorie is a kilocalorie or 4184 joules. 127
- calorie (with a lowercase c), cal** A common energy unit. Equivalent to 4.184 joules. 127
- Cancer**, boron fusion and 717
- Capsaicin** 559
- Carbohydrate** Sugar, starch, and cellulose. Also called saccharides. 650–653
- Carbon (C)** 90  
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- Carbon-13** 709
- Carbon-14**, radioactive decay of 709
- Carbon-14 dating** The process of determining the age of an artifact that contains material from formerly living plants or animals by analyzing the ratio of carbon-14 to carbon-12 in the object. 709–710
- Carbonate ion** 343  
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- Carbon monoxide** catalytic converters and 385 covalent bond formation 193 in hydrogen gas production 598 incomplete combustion and 385 Lewis structure of 193 as pollutant 385 in synthesis gas 598
- Carbon tetrachloride**, use and production 502
- Carboxylic acid** A compound that have a hydrogen atom or a hydrocarbon group connected to a -COOH (or -CO<sub>2</sub>H) group. 250, 353, 640 in acid-base reactions 353 forming name of 257
- Carboxypeptidase**, in digestion 664
- Carnegie Institution** 617
- Carothers, W. H.** 667
- Catalyst** A substance that speeds a chemical reaction without being permanently altered itself. 594–597, 597 automobile catalytic converter 385 equilibrium and 614–615 green chemistry and 597 homogeneous and heterogeneous 596–597 in producing hydrogen gas 598
- Catalytic converter** 385, 596–597
- Cathode** The electrode at which reduction occurs in a voltaic cell. It is the positive electrode. 389
- Cation** An ion formed from an atom that has lost one or more electrons and thus has become positively charged. 91 formation of 181, 182–183 monatomic naming 236 roles in body 185 names 240 produced by ionizing radiation 706
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- Celsius scale** 18–19 Celsius to Fahrenheit conversion 58–60 Celsius to Kelvin conversion 58–60
- Cesium (Cs)**, electron configuration of 152
- Cesium-137** 706
- Cesium chloride**, crystal structure of 186–187
- Chain-growth (or addition) polymers** A polymer that contains all of the atoms of the original reactant in its structure. This category includes polyethylene, polypropylene, and poly(vinyl chloride). 669
- Chain reaction** A process in which one of the products of a reaction initiates another identical reaction. 715
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- Charge** in atoms 89 in chemical bonds 178, 524–527 in HCl molecules 176 in hydrogen bonds 529 of ions 182–185 in London forces 532 in molecules 528–529 in water molecules 212, 307
- Charge cloud**, for electrons 90, 136–139
- Charles' Law** The pressure of a gas is inversely proportional to the volume it occupies if the number of gas particles and the temperature are constant. 465
- Chemical bond** An attraction between atoms or ions in chemical compounds. Covalent bonds and ionic bonds are examples. 175–179. *See also* Ionic bond; Covalent bond angles between 210–212 energy and 123–124 ionic bond 177–179 nonpolar covalent 176 polar covalent 176 predicting bond type 179–181, 524–525 summary 178
- Chemical change**. *See* Chemical reaction
- Chemical compound**. *See* Compound
- Chemical Elements**. *See* Element
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- Chemical equilibrium**. *See* Equilibrium
- Chemical formula** A concise written description of the components of a chemical compound. It identifies the elements in the compound by their symbols and indicates the relative number of atoms of each element with subscripts. 172–173. *See also* Chemical nomenclature for acids 256–258 for binary covalent compounds 246 in chemical equations 301 conversion factors from 267–270 for monatomic ions 236 of polyatomic ions 238 of polymers 667–670
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- Chemical reaction** The conversion of one or more pure substances into one or more different pure substances. 300 acid-base 348–357 chemical equations for 300–302 collision theory for 586 combination 382 combustion 383–385 completion 252 converting to names 259–260 decomposition 383 double-displacement 312 endothermic 322–323 energy and 321–323 equilibrium constants for 602–607 exothermic 321–322 general process, collision theory 586–592, 634–640, 650–656, 664–670, 666–672, 692–698 neutralization 348–355 oxidation-reduction 372–375 precipitation 312–318. *See also* Precipitation reaction predicting extent of 602–605 rate 592–596 concentration effect 593–594 temperature effect 592–593 reversible 251, 597–598 reversible reaction and equilibrium 597–601

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- Chemistry** The structure and behavior of matter. 4. *See also* Organic chemistry; Biochemistry  
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- Clinton, Bill 5
- Coal, acid rain and 255
- Cobalt-60  
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food irradiation and 711  
gamma ray emission and 698
- Coefficients** The numbers in front of chemical formulas in a balanced chemical equation. 301
- Coffee  
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- Cold-start emissions, catalytic converters and 385
- Cold packs 322
- Collision theory** A model for the process of chemical change. 586–592, 634–640, 650–656, 664–672, 692–698  
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- Combination (or synthesis) reaction** The joining of two or more elements or compounds into one product. 382
- Combinatorial chemistry 649
- Combined gas law equation 476
- Combustion analysis, empirical and molecular formulas from 278
- Combustion reaction** Rapid oxidation accompanied by heat and usually light. 383–384  
incomplete 385  
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- Complete (or molecular) equation** A chemical equation that includes uncharged formulas for all of the reactants and products. The formulas include the spectator ions, if any. 316
- Complete combustion 383–384
- Complete electron configuration 148–150
- Complete ionic equation** A chemical equation that describes the actual form for each substance in solution. For example, ionic compounds that are dissolved in water are described as separate ions. 315
- Completion reaction 252
- Compound** A substance that contains two or more elements, the atoms of these elements always combining in the same whole-number ratio. 172  
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binary ionic 239  
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ionic 180  
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molecular 180  
as pure substance 172–175
- Computer-based tools that accompany this text 7
- Concentration** The number of particles per unit volume. For gases, it is usually described in terms of moles of gas particles per liter of container. Substances in solution are described with molarity (moles of solute per liter of solution). 593  
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equilibrium constants and 602–605  
rate of reaction and 593–594
- Condensation** The change from vapor to liquid. 510  
dynamic equilibrium between evaporation and 513–515  
rate of 513
- Condensation (or step-growth) polymer** A polymer formed in a reaction that releases small molecules, such as water. This category includes nylon and polyester. 667
- Condensation reaction** A chemical reaction in which two substances combine to form a larger molecule with the release of a small molecule, such as water. 656
- Condensed formula 635
- Confirmation, in scientific method 9
- Conjugate acid** The molecule or ion that forms when one H<sup>+</sup> ion is added to a molecule or ion. 357
- Conjugate acid-base pair** Two molecules or ions that differ by one H<sup>+</sup> ion. 357–358
- Conjugate base** The molecule or ion that forms when one H<sup>+</sup> ion is removed from a molecule or ion. 358
- Conservation of Energy, Law of 122
- Control rods** Rods containing substances such as cadmium or boron (which are efficient neutron absorbers), used to regulate the rate of nuclear fission in a power plant and

- to stop the fission process if necessary. 716
- Conversion factor** A ratio that describes the relationship between two units. 34–36  
 atomic mass as 104  
 density as 49  
 English-metric 38  
 in equation stoichiometry 418  
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- Corliss, Jack 617
- Corundum 290
- Counting by weighing 100–102
- Covalent bond** A link between atoms that results from their sharing two electrons. 96  
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- Covalent bonding patterns 195–196
- Creatine 663
- Critical temperature 490
- Cronenberg, David 7
- Crude oil 532–533
- Crystals** Solid particles whose component atoms, ions, or molecules are arranged in an organized, repeating pattern. 314
- Cubic centimeter 15
- Cubic meter 12
- Cyanide ion, determining Lewis structure 203–204
- Cycle, in electromagnetic radiation 130
- Cyclopropane 689
- Cysteine (Cys, C)  
 disulfide bonds between 658  
 structure of 655
- D**
- d block, on periodic table 146–147
- Dacron, as polyester 669
- Dalton's Law of Partial Pressures** The total pressure of a mixture of gases is equal to the sum of the partial pressures of each gas. 485–489, 523–527, 597–601
- Dead Sea Scrolls 710
- Decaffeination 491
- Decimal place  
 calculators and 40  
 measurements and 39  
 rounding for addition and subtraction and 45
- Decomposition reaction** The conversion of one compound into two or more simpler substances. 383
- Denature** To change the tertiary structure of a protein, causing it to lose its natural function. 665
- Density, mass** Mass divided by volume. 47–51  
 calculating for gases 474  
 of common substances 48  
 definition 47  
 determination of 50–51  
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- Designing Safer Chemicals Award 5
- Detergent 563  
 cleaning with 562–563  
 pH and 347
- Deuterium 92–93  
 in heavy water 59
- DEZ treatment 355
- Diamond 89  
 atoms in 90, 103  
 London forces in 534–535
- Diatomic** Composed of paired atoms. The diatomic elements are H<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>, F<sub>2</sub>, Cl<sub>2</sub>, Br<sub>2</sub>, and I<sub>2</sub>. 97
- Dichlorine monoxide, production and use 411
- Dichloromethane, in decaffeinating coffee 491
- Dietary calorie, Cal Equivalent to 4.184 kJ 127
- Dietary Supplement and Health Act of 1994 663
- Diethyl ether, structure of 641
- Diethyl zinc (DEZ), in book preservation 355
- Difference in electronegativity, in predicting bond type and polarity 524–525
- Digestion** The process of converting large molecules into small molecules that can move into the blood stream to be carried throughout the body. 664–666
- Digestive enzymes 664–666
- Digital readouts 23
- Dihydrogen phosphate, as amphoteric 359
- Dimensional analysis. *See* Unit analysis
- Dimethyl ether, Lewis structure for 206
- Dipole** A molecule that contains an asymmetrical distribution of positive and negative charges.  
 bond 525  
 induced 532–533  
 instantaneous 532–533
- Dipole-dipole attraction** The intermolecular attraction between the partial negative end of one polar molecule and the partial positive end of another polar molecule. 523  
 hydrogen bonds and 530  
 London forces and 532
- Diprotic acid** An acid that can donate two hydrogen ions per molecule in a reaction. 250
- Dirac, Paul Adrien 155
- Direct-contact method 491
- Disaccharide** Sugar molecule composed of two monosaccharide units. 652  
 digestion products 664
- Dispersion forces. *See* London forces
- Disproof, in scientific method 9
- Disruption of equilibrium 610–616  
 catalysts and 614–615  
 concentrations and 610–613  
 Le Chatelier's Principle 614–616
- Distance, between particles of gases 460
- Distillation, of salt water 81
- Disulfide bond** A covalent bond between two sulfur atoms on cysteine amino acids in a protein structure. 658
- Division, rounding off for 40
- DNA (deoxyribonucleic acid)  
 aging and 376  
 hydrogen bonding in 530
- Dolomite rock, hard water and 320
- Dopamine, Parkinson's disease and 8
- Double-displacement reaction** A chemical reaction that has the form: AB + CD to AD + CB 312  
 acid-base 352  
 precipitation 312–315
- Double-exchange reaction. *See* Double-displacement reaction
- Double-replacement reaction. *See* Double-displacement reaction
- Double bond** A link between atoms that results from the sharing of four electrons. It can be viewed as two 2-electron covalent bonds. 192
- Drug design 649
- Dry cell battery, chemistry of 390–391

Dry ice 552

**Dynamic equilibrium** A system that has two equal and opposing rates of change, from state A to state B and from state B to state A. There are constant changes between state A and state B but no net change in the amount of components in either state. *See Equilibrium*

## E

E.I. Du Pont de Nemours and Company 667

Earth, elemental composition of 719

Electric cars, zinc-air batteries in 393

Electric current, base unit of 11

Electric field, in electromagnetic radiation 130

Electric power plant, using nuclear fission 714–717

**Electrode** A electrical conductor placed in the half-cells of a voltaic cell. 389

**Electrolysis** The process by which a redox reaction is pushed in the non-spontaneous direction or the process of applying an external voltage to a voltaic cell, causing electrons to move from what would normally be the cell's cathode toward its anode. 391

**Electrolyte** The portion of a voltaic cell that allows ions to flow. 390

**Electron** A negatively charged particle found outside the nucleus of an atom. 90, 132–136

in atoms 90–92

in batteries 388

as beta decay 696–697

in chemical bonds 176, 187–193

constructing Lewis structures and 198

electronegativity and 524

in ions 90–92

in isotopes 92–93

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in metallic elements 98

in multi-electron atoms 142

octets of 189

in oxidation-reduction reactions 372–375

particle interpretation of the wave character 136

as standing wave 134

valence 188

waveform of 134

**Electron-dot symbol** A representation of an atom that consists of its

elemental symbol surrounded by dots representing its valence electrons. 189

**Electron capture** In radioactive nuclides that have too few neutrons, the combination of an electron with a proton to form a neutron, which stays in the nucleus. 697

nuclear equations for 699–701

Electron cloud 90, 136

**Electron configuration** A description of the complete distribution of an element's electrons in atomic orbitals. 142, 144–145

abbreviated 151–154

Study Sheet 149, 198

**Electronegativity** A measure of the electron attracting ability of an atom in a chemical bond. 524–527

Study Sheet 526

**Electron group geometry** A description of the arrangement of all the electron groups around a central atom in a molecule or polyatomic ion, including the lone pairs. 212

Electron sharing, in chemical bonds 176

Electron spin 142, 144

Electron transfer, in chemical bond formation 177–178

**Electron volt (eV)** An energy unit equivalent to  $1.6 \times 10^{-19}$  joules. It is often used to describe the energy associated with nuclear changes. 713

Electroplating 391

**Electrostatic force (or electromagnetic force)** The force between electrically charged particles. 694

**Element** A substance that cannot be chemically converted into simpler substances; a substance in which all of the atoms have the same number of protons and therefore the same chemical characteristics. 80–99

atomic mass of 104

compound versus 172–173

diatomic 97

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structure of 88–99

symbols for 83

table of percent abundances in Earth's crust, waters, and atmosphere 719

Element 111, creation of 94

Element 114, creation of 94

Emerald 294

**Empirical formula** A chemical formula that includes positive integers that describe the simplest ratio of the atoms of each element in a compound. 271 calculating 271–275

converting to molecular formula 275–278

Study Sheet 273

Enamel 354

**Endergonic changes** Changes that absorb energy 123

energy diagram 590–591

**Endothermic change** A change that leads a system to absorb heat energy from the surroundings. 323

**Energy** The capacity to do work.

activation 588–590

chemical bonds and 123–124

chemical changes and 321–323

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*See* Green Chemistry

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**Enzyme** A naturally occurring catalyst.

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digestive 664–666

metallic cations in 185

why specific 666

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Epinephrine 558

Equation. *See* Chemical equation,

Nuclear equation; Ideal gas equation

**Equation stoichiometry** Calculations

that make use of the quantitative relationships between the substances in a chemical reaction to convert the amount of one substance in the chemical reaction to the amount of a different substance in the reaction 417–421

ideal gases and 478–485

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Study Sheet 437

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homogeneous 600

Le Chatelier's Principle and 614–

616

reversible reactions and 597–609

saturated solution and 568–569

ski shop analogy for 601

**Equilibrium constant** A value that de-

scribes the extent to which reversible

reactions proceed toward products be-

fore reaching equilibrium. 602–605

calculating values for 603–604

extent of reaction and 605

with heterogeneous equilibria

606–608

table of 604

temperature and 608–609

writing expressions for 602–603

**Equilibrium constant expression** An

expression showing the ratio of the

concentrations of products to the

concentrations of reactants for a reversible

reaction at equilibrium. 602

**Equilibrium vapor pressure** The par-

tial pressure of vapor above a liquid in a closed system with a dynamic equilibrium between the rate of evapora-

tion and the rate of condensation.

515–516

in bubble formation 519–520

temperature and 516

**Ester** A compound with two hydrocar-

bon groups surrounding an oxygen

atom. 642–643

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olestra as 660–661

Estradiol, structure of 662

Ethanamide 644

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Ethene. *See* Ethylene

**Ether** A compound with two hydrocar-

bon groups surrounding an oxygen

atom. 641

Ethyl alcohol. *See* Ethanol

Ethyl butanoate 643

Ethylene (or ethene) 192

polyethylene formation and 669

Ethylene glycol 639

in polyester formation 668

Ethylene oxide, use and production 503

Ethyne. *See* Acetylene

**Evaporation** The conversion of a liquid

to a gas. 79, 511–512

cooling and 512

rate of. *See* Rate of evaporation

Exact numbers, significant figures and

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Examples, in this book 6

**Excited state** The condition of an atom

that has at least one of its electrons in orbitals that do not represent the lowest possible potential energy. 138

Exercises, in this book 6

**Exergonic changes** Changes that

release energy. 124

energy diagram 590

Exhaust 173

Exhaust systems, catalytic converters and

385

**Exothermic change** A change that leads to heat energy being released from the system to the surroundings. 322

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8–9

External kinetic energy 128

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fblock, of elements 147

Fahrenheit scale 18–19

Fahrenheit to Celsius conversion  
58–59

**Family** All the elements in a given col-

umn on the periodic table; also called  
group. 85

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Fingerprints 517

Fire extinguishers, sodium carbonate in  
343

Fireworks

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light emitted from 139

**Fission** Nuclear reaction that yields en-

ergy by splitting larger atoms to form  
more stable, smaller atoms. 714–715

Flame retardant, phosphates in 238

Flashtubes 499

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94

Fluorapatite, tooth decay and 354

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**Formaldehyde** 628, 641  
  determining Lewis structure 202–203  
  in herbicide formation 597  
  production and use 401, 629  
**Formic acid**, molecular structure of 640  
**Formula mass** The weighted average of the masses of the naturally occurring formula units of the substance. It is the sum of the atomic masses of the atoms in a formula unit. 265–266  
  calculations 266  
**Formula unit** A group represented by a substance's chemical formula, that is, a group containing the kinds and numbers of atoms or ions listed in the chemical formula. 264  
**Fortrel®** (registered trademark) 669  
**Fractional charge**, in chemical bonds 176  
**France**, zinc-air batteries in 393  
**Free radicals** Particles with unpaired electrons. 706  
**Fructose** 650–651  
**Functional group** A small section of an organic molecule that to a large extent determines the chemical and physical characteristics of the molecule. 638  
**Furnace method** 414  
**Fusion** Nuclear reaction that yields energy by combining smaller atoms to make larger, more stable ones. 714, 718
- G**
- Galactose 650–651  
**Galapagos Islands**, global warming experiments at 431  
**Galileo Galilei** 9  
**Gallium-67**, radioactive decay of 700  
**Galvanizing nails** 306  
**Gamma aminobutyric acid**, gamma aminobutyric acid, or GABA 645  
  intoxicating liquids and 214  
**Gamma ray** A stream of high-energy photons. 131, 698  
  antimatter and 155  
  harmful effects of 706–707  
  penetration of the body 707  
  in radioactive decay 698  
**Gas** The state in which a substance can easily change shape and volume. 76, 79–80.  
  Avogadro's Law 467  
  in book preservation 355  
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**Gas pressure.** *See also Gas*  
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  Dalton's Law of partial pressures 485–489  
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  in gas stoichiometry 478–485  
  in ideal gas equation 470  
  internal combustion engine and 468  
  number of gas particles and 466  
  standard 479  
  temperature and 464  
  volume and 462–463  
**Gas stoichiometry** 478–485  
**Gastric juice** 482  
  pH and 347  
**Gay-Lussac's Law** The pressure of a gas is inversely proportional to the volume it occupies if the number of gas particles and the temperature are constant. 464  
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**Geometry** 209–213. *See Molecular shape*  
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 Making Chemicals from Safer Reactants 276  
 Sea-Nine antifoulant and 5  
 spray paint and 490  
 Greenhouse gases 430, 573  
 Greenspan, Alan 90  
**Ground state** The condition of an atom whose electrons are in the orbitals that give it the lowest possible potential energy. 138  
**Group** All the elements in a given column on the periodic table; also called family. 85  
 Guitar strings, like electrons 132–134
- H**
- Half-life** The time it takes for one-half of a sample to disappear. 702–704  
**Half-reaction** Separate oxidation or reduction reaction equation in which electrons are shown as a reactant or product. 374  
**Halogen**  
 covalent bond formation 194  
 ion formation 182  
 London forces in 532–533  
 in periodic table 85  
 Hard water, soaps and detergents in 563  
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**Heat** The energy that is transferred from a region of higher temperature to a region of lower temperature as a consequence of the collisions of particles. 129
- in chemical equations 302  
 in endothermic reactions 323–324, 590–591  
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**Heavy water**, freezing point of 59  
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**Helium**  
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*See also Alpha particles*  
**Hematite** 294  
**Hemoglobin** 385  
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**Heptane**, octane rating and 637  
**Heterogeneous catalyst** A catalyst that is in the same phase as the reactants (so that all substances are gases or all are in solution). 596  
**Heterogeneous equilibrium** An equilibrium in which the reactants and products are not all in the same phase (gas, liquid, solid, or aqueous). 606–607  
**Hexane**, solubility in 554–557  
**1-Hexanol** 636  
**3-Hexanol**, molecular structure of 636  
**High-density polyethylene (HDPE)** 669  
**Histidine**, structure of 655  
**Homogeneous catalyst** A catalyst that is in the same phase as the reactants (so that all substances are gases or all are in solution). 596  
**Homogeneous equilibrium** An equilibrium system in which all of the components are in the same phase (gas, liquid, solid, or aqueous). 600  
**Hormone** 661  
**Huber, Claudia** 617  
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**Hydride ion** 236  
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**Hydrobromic acid**, forming name of 256  
**Hydrocarbon** Compounds that contain only carbon and hydrogen. 191, 533  
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 oxidation number of 378  
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 structure 96  
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**Hydrogenation** A process by which hydrogen is added to an unsaturated triglyceride to convert double bonds to single bonds. This can be done by combining the unsaturated triglyceride with hydrogen gas and a platinum catalyst. 659  
**Hydrogen atom**, electron wavesforms in 134–141  
**Hydrogen bond** The intermolecular attraction between a nitrogen, oxygen, or fluorine atom of one molecule and a hydrogen atom bonded to a nitrogen, oxygen, or fluorine atom in another molecule. 529–531

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**Hydrogen carbonate ion**  
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**Hydrogen fluoride**  
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**Hydrogen halides**, as polar molecules 529

**Hydrogen peroxide**  
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**Hydrogen sulfate ion** 356  
as cleaning agent 356  
as weak acid 254, 340

**Hydrogen sulfide**  
threshold limit value, or TLV 498  
**Hydrolysis** A chemical reaction in which larger molecules are broken down into smaller molecules by a reaction with water in which a water molecule is split in two, each part joining a different product molecule. 665

**Hydronium ion**  $\text{H}_3\text{O}^+$  248–249, 340–341  
in acid-base reactions 348–353  
acids and 248–254  
pH and 346–348

**Hydrophilic** (“water loving”) A polar molecule or ion (or a portion of a molecule or polyatomic ion) that is attracted to water. 558

**Hydrophobic** (“water fearing”) A nonpolar molecule (or a portion of a molecule or polyatomic ion) that is not expected to mix with water. 558

Hydrothermal vent 617–618

**Hydroxide ion**  
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solubility of compounds with 317

**Hydroxides** Compounds that contain hydroxide ions. 341

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3-Hydroxybutanal 645

17-Hydroxyprogesterone, molecular structure of 662

**Hypochlorite ion**

in bleach 356

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**Hypothesis**, in scientific method 8–9

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**Ideal Gas** A gas for which the ideal gas model is a good description. 461  
calculations involving 470–478  
equation stoichiometry and 478–483

**Ideal gas constant (R)** 470

**Ideal Gas Equation** 470–475

combined gas law equation and 476  
equation stoichiometry and 480–485

**Ideal gas model** The model for gases that assumes (1) the particles are point-masses (they have mass but no volume) and (2) there are no attractive or repulsive forces between the particles. 461

Incandescent light bulbs 472

**Induced dipole** 532

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Infrared (IR) radiation 131

**Inner transition metals** The 28 elements at the bottom of the periodic table. 86

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Instantaneous dipole 532

**Intermolecular attraction** Attraction between molecules. 529–533  
dipole-dipole attraction 523  
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**Iodine-125**

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**iodine-131** 706–707

**Iodine pentafluoride**, production and use 407, 451

**Ion** Any charged particle, whether positively or negatively charged. 90–92

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cation 91. *See also Cation*

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monatomic cation. *See Cation*, monatomic

polyatomic. *See Polyatomic ion*

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symbols for 91

**Ionic bond** The attraction between a cation and an anion. 177–179  
in ionic compounds 180

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**Ionic compound** A compound that consists of ions held together by ionic bonds. 180, 236–250

as bases 343

binary 239, 242, 372–374

formula mass of 265–266

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solubility of 317

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as strong and weak bases 343

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**Ionizing radiation** Alpha particles, beta particles, and gamma photons, which are all able to strip electrons from atoms as they move through matter, leaving ions in their wake. 706

**Iridium (Ir)**, in catalytic converter 385

**Iridium-192**, checking pipe joints and 711

**Iron (Fe)**

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**Iron-59** 712  
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**Isobutene**, use 638  
**Isoleucine (Ile, I)**, molecular structure of 654  
**Isomers** Compounds that have the same molecular formula but different molecular structures. 206  
 Lewis structures of 206–207  
 of organic compounds 634  
**Isooctane** 637  
**Isopropyl alcohol**. *See* 2-propanol  
**Isotopes** Atoms that have the same number of protons but different numbers of neutrons. They have the same atomic number but different mass numbers. 92–94  
 atomic numbers of 93  
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**Jesus of Nazareth** 710  
**Jewelry**, elements in 83  
**Joule, J** The accepted SI unit for energy. 127

**K**

**Kaposi's sarcoma** 649  
**Kelvin**, a temperature unit 19  
**Kelvin scale** 11, 18–19  
 gas temperature and 461  
 temperature conversions for 58–60  
**Kerosene**, London forces and 532  
**Ketone** A compound that have a hydrogen atom or a hydrocarbon group connected to a -CHO group. 642  
**Kettering**, Charles F. 132  
**Khirbat Qumrân** 710  
**Kilo (k)** prefix 13  
**Kilocalorie (kcal, Cal)** 127  
**Kilogram (kg)** 11

**Kilojoule (kJ)** 128  
**Kilometer (km)** 13  
**Kilopascal (kPa)** 461  
**Kinetic energy, KE** The capacity to do work resulting from the motion of an object. 121  
 chemical reactions and 321–322  
 in formation of water 321  
 internal and external 129  
 mass and 121  
 of reactant molecules 587–588  
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**Krypton**, light bulbs and 475  
**Krypton-81** 693, 710

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**Lactase**, in digestion 664  
**Lactic acid**, in cosmetic lotion 368  
**Lactose**, or milk sugar 652  
**Laskowski**, Edweard R. 663  
**Latent fingerprints** 517  
**Law of Conservation of Energy**  
 Energy can be neither created nor destroyed, but it can be transferred from one system to another and changed from one form to another. 122  
**Lawrence Laboratory** 701  
**L-dopa** 8  
**Lead(II) ion**, solubility of compounds with 317  
**Lead (Pb)**  
 in creating elements 110 94  
 density of 47  
 gasoline and 408  
**lead-206**, in radioactive decay series 705  
**Lead-acid batteries**, chemistry of 393  
**Lebowitz**, Fran 33

**Le Chatelier's principle** If a system at equilibrium is altered in a way that disrupts the equilibrium, the system will shift so as to counter the change. 614–616  
**Leclanché cell** 390–391  
**Length** 14–15  
 range of 15  
**Leucine (Leu, L)**, structure of 654  
**Levi, Primo** 3  
**Levodopa**, in Parkinson's disease 8  
**Levodopa**, in Parkinson's disease 8  
**Lewis structure** A representation of a molecule that consists of the

elemental symbol for each atom in the molecule, lines to show covalent bonds, and pairs of dots to indicate lone pairs. 190–194, 195–205

general steps for drawing 200, 460  
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**Life**

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**Light bulbs**

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"Like dissolves like" guideline, for solubility 554–557

**Lime** 409

**Limestone** 354, 592  
 acid rain and 255  
 increasing permeability of 249

**Limestone caverns** 368

**Limiting reactant** The reactant that runs out first and limits the amount of product that can form. 422–427  
 global warming and 430–431  
 how chosen 422–423  
 Study Sheet 426

**Linear geometry** The geometric arrangement that keeps two electron groups as far apart as possible. It leads to angles of 180° between the groups. 213

**Linear molecules** 213, 215

**Line drawing** 558, 635

**Ling Po** 7

**Liquid** The state in which a substance has a constant volume at a constant temperature but can change its shape. 76, 78

boiling 518–520

dissolving gases in 570

dissolving solids in 564–569

dynamic equilibrium between vapors and 571

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**Liquid-liquid solutions** 311

**Liquid elements** 87

**Liter** 12

**Lithium (Li)**

from Big Bang 718

electron configuration and orbital diagram 144

formation of 718

- Lithium-7, in treating brain cancer 717  
 Lithium batteries 393  
 Lithium hydroxide, uses 341  
 Litmus, detecting acids and bases with 348  
**London forces** The attractions produced between molecules by instantaneous and induced dipoles. 532–533  
 molecular size and 532  
**Lone pair** Two electrons that are not involved in the covalent bonds between atoms but are important for explaining the arrangement of atoms in molecules. They are represented by pairs of dots in Lewis structures. 189  
 Low-density polyethylene (LDPE) 669  
 Lucretius 345  
 Luminous intensity, base unit for 11  
 Luminous tubes 477  
 Lungs, gases in 469  
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 Lye soap 562  
**Lysine (Lys, K)**  
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- M**
- “Mickey Finn” sedative 206  
 Magic numbers and nuclear stability 94, 713  
 Magnesium (Mg), meals ready to eat (MREs) and 549  
 Magnesium chloride, production and use 411  
 Magnesium oxide 241  
 Magnetic field, in electromagnetic radiation 130  
 Magnetic resonance imaging (MRI) 708  
**Main-group element** The elements in groups 1, 2, and 13 through 18 (the “A” groups) on the periodic table; also called representative elements. 86  
**Malleable** Capable of being extended or shaped by the blows of a hammer. 85  
 Maltase, in digestion 664  
 Maltose, molecular structure of 652  
 Manganese (Mn)  
 in dry cell batteries 390–391  
 how made 292  
 Manganese(II) oxide, naming 240  
 Manganese(II) phosphate  
 production and use 406  
 uses 368  
 Manganese dioxide, in dry cell batteries 390–391  
 Marble, acid rain and 255  
 Margarine 659  
 Martin, John 430–431  
**Mass** The amount of matter in an object. Mass can also be defined as the property of matter that leads to gravitational attractions between objects and therefore gives rise to weight. 16–17  
 base unit of 11  
 density and 47–49  
 of elements and compounds 267–271  
 English-metric unit conversions of 55  
 kinetic energy and 121  
 measuring 16–17  
 percentage by 52–53  
 range of 17  
 weight and 16–17  
 weighted average 100  
**Mass density** Mass divided by volume (usually called density). 47–51  
 as conversion factor 49–51  
**Mass number** The sum of the number of protons and neutrons in an atom’s nucleus. 93  
 binding energy versus 714  
 in nuclear equations 699  
 in nuclides 692  
 Mass percentage 52  
 Matches, chemicals in 305  
**Matter** Anything that has mass and takes up space. 16  
 chemistry and 4  
 classification of 172–175  
 existence of 155  
 origin of 718  
 as solid, liquid, or gas 76–80  
 Mayo Clinic 663  
 Meals ready to eat (MRE) 549  
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 Meitner, Lise 82  
 Meniscus, in measurement 21  
 Menstrual cycles, hormones in 662  
 Menthol 560  
**Metal-nonmetal compounds**  
 bonds in 525  
 formulas and names of 239  
**Metallic bond** The attraction between the positive metal cations that form the fundamental structure of a solid metal and the negative charge from the mobile sea of electrons that surround the cations. 534  
 Metallic elements 86  
 attractive forces in 534–535  
 ion charges of 182–184  
**Metalloids or semimetals** The elements that have some but not all of the characteristics of metals. 86  
 bonding patterns of 199  
 in periodic table 86  
**Metals** The elements that (1) have a metallic luster, (2) conduct heat and electric currents well, and (3) are malleable. 85, 98–99  
 electrolysis to purify 391  
 forming cations 181  
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 Meter 10, 11  
 Methamphetamine, molecular structure of 558–559  
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 Methanoic acid 640  
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 Methionine (Met, M), structure of 655  
 Methyl alcohol 196. *See also* Methanol  
 Methyl bromide  
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 Methylene chloride, in decaffeinating coffee 491  
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- MeV (million electron volts) 713
- micro (mu) prefix 13
- Microwaves 131
- Mifepristone 681
- Milk, pH of 347
- milli (m) prefix 13
- Millimeter of mercury (mmHg), as unit of pressure 461
- Miscible** Can be mixed in any proportion without any limit to solubility. 552
- Mixture** A sample of matter that contains two or more pure substances and has variable composition. 173  
of gases 485
- Model** A simplified approximation of reality. *See also* Scientific model  
calculating 433  
collision theory as 586–592  
of gases 79  
ideal gas 461  
of liquids 78  
of metallic elements 98  
of solids 76–77  
strengths and weaknesses of 187  
valence-bond 188–193
- Moderator** A substance in a nuclear reactor that slows neutrons as they pass through it. 716
- Molarity** (abbreviated M) Moles of solute per liter of solution. 433–438  
equation stoichiometry and 434–438
- Molar mass** The mass in grams of one mole of substance. 104–107  
from atomic mass 104  
calculations using atomic mass 105  
calculations using ionic formula mass 266  
calculations using molecular mass 263  
in equation stoichiometry 416–420  
in ideal gas equation 471  
from ionic formula mass 265  
from molecular mass 262–263
- Molar volume at STP 479
- Mole** (mol) The amount of substance that contains the same number of particles as there are atoms in 12 g of carbon-12. 11, 102–103  
in equation stoichiometry 478–485  
in ideal gas equation 479
- Molecular compound** A compound composed of molecules. In such compounds, all of the bonds between atoms are covalent bonds. 180  
attractive forces in 535  
in oxidation-reduction reactions 375  
water solubility of 555
- Molecular dipole** A molecule with an asymmetrical distribution of positive and negative charge. 523
- Molecular equation. *See* Complete equation
- Molecular formula** The chemical formula that describes the actual numbers of atoms of each element in a molecule of a compound. 271  
from empirical formula 275–278  
empirical formulas versus 271  
Study Sheet 277
- Molecular geometry** The description of the arrangement of all the atoms around a central atom in a molecule or polyatomic ion. This description does not consider lone pairs. 209–216. *See also* Geometry
- Molecular mass** The weighted average of the masses of the naturally occurring molecules of a molecular substance. It is the sum of the atomic masses of the atoms in a molecule. 262–263  
calculating 263  
in calculating molecular formulas 275–276
- Molecular models 96
- Molecular polarity, predicting 528
- Molecular Shape 209–211  
ball-and-stick model 210  
geometric sketch 210  
space-filling model 210
- Molecular size, London forces and 532–533
- Molecule** An uncharged collection of atoms held together with covalent bonds. 96  
diatomic 97  
as formula unit 264  
of hydrogen 96  
in molar mass 262  
shapes of 209–216
- Momentum, of particles in evaporation 511
- Monatomic anions** Negatively charged particles, such as  $\text{Cl}^-$ ,  $\text{O}^{2-}$ , and  $\text{N}^{3-}$ , that contain single atoms with a negative charge. 182. *See also* Anion, monatomic
- charges 182  
naming 236
- Monatomic cation** Positively charged particles, such as  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Al}^{3+}$ , that contain single atoms with a positive charge. 183. *See also* Cation, monatomic  
formation 182–183  
naming 236  
roles in body 185
- Monatomic ion, charges 184
- Monoethanolamine 613
- Monomer** The repeating unit in a polymer. 652  
in addition polymers 669  
in polysaccharides 652–653  
in proteins 654
- Monoprotic acid** An acid that donates one hydrogen ion per molecule in a reaction. 250, 340
- Monosaccharide** Sugar molecule with one saccharide unit. 650
- Monosodium glutamate (MSG), taste and 345
- Monsanto Company 597
- Moss Landing Marine Laboratories 430
- Mount Everest, atmospheric pressure at the top 521
- MTBE 641
- Multiplication  
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- Mylar, as polyester 669
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- Nano (n) prefix 13
- Natrium 83
- Natural gas 187
- Nature, elements found in 82
- Neon (Ne)  
electron configuration and orbital diagram 145  
luminous tubes and 477  
in neon lights 477, 489
- Nerve cells  
intoxicating liquids and 214  
taste and 345
- Net ionic equation** A chemical equation for which the spectator ions have

- been eliminated, leaving only the substances actively involved in the reaction. 316
- Net rate of solution 565–567
- Neutralization reaction** A chemical reaction between an acid and a base. *See Acid-base reaction*
- Neutron** An uncharged particle found in the nucleus of an atom. 89  
in nuclear fission 714–715  
as nuclear glue 694  
nuclear stability and 694–695
- Newton (N), a unit of force 16
- NiCd batteries. *See Nickel-Cadmium batteries*
- Nickel (Ni), in the creation of elements 110 and 111 94
- Nickel-60, gamma ray emission by 698
- Nickel-cadmium battery, chemistry of 392
- Nicotine 293
- Nippoldt, Todd B. 663
- Nitrate ion  
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- Nitric acid  
acid rain and 255  
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- Nitride ion, forming name of 236
- Nitril hydratase 597
- Nitrogen (N)  
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- Nitrogen molecules, velocities of 460
- Nitrogen monoxide 596  
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- oxidation-reduction and 375
- Nitrogen narcosis 572
- Nitrogen oxides  
in automobile exhaust 127
- Nitroglycerine, in decomposition reactions 383
- Nitrosyl chloride, production and use 631
- Nitrosyl fluoride, molecular geometry 216
- Nitrous oxide, formation of 304
- Noble gases, structure 95
- Node** The locations in a waveform where the intensity of the wave is always zero. 133
- Nomenclature. *See Chemical nomenclature*
- Nonmetals** The elements that do not have the characteristics of metals. Some of the nonmetals are gases at room temperature and pressure, some are solids, and one is a liquid. Various colors and textures occur among the nonmetals. 85  
forming anions 181
- Nonpolar covalent bond** A covalent bond in which the difference in electron-attracting ability of two atoms in a bond is negligible (or zero), so the atoms in the bond have no significant charges. 176  
predicting existence of 524–527
- Nonpolar molecular substance, solubility and 554–555
- Normal boiling-point temperature** The temperature at which the equilibrium vapor pressure of the liquid equals one atmosphere. 521
- Notation, for nuclides 692–693
- Nuclear chemistry** The study of the properties and behavior of atomic nuclei. 691
- Nuclear decay series** A series of radioactive decays that lead from a large unstable nuclide, such as uranium-238, to a stable nuclide, such as lead-206. 705
- Nuclear energy 713–718
- Nuclear equation** The shorthand notation that describes nuclear reactions. It shows changes in the participating nuclides' atomic numbers (the number of protons) and mass numbers (the sum of the numbers of protons and neutrons). 698–702
- Nuclear fission 714–715
- Nuclear fusion 718
- Nuclear power plant 716–717
- Nuclear reaction** A process that results in a change in an atomic nucleus (as opposed to a chemical reaction, which involves the loss, gain, or sharing of electrons). 698–702
- Nuclear reactors 714–717
- Nuclear stability 694–695, 713–714
- Nucleon number** The sum of the numbers of protons and neutrons (nucleons) in the nucleus of an atom. It is also called the mass number. 692
- Nucleons** The particles that reside in the nucleus of atoms (protons and neutrons). 692
- Nucleus** The extremely small, positively charged core of the atom. 89  
of atom 89  
creation of new elements and 94  
electrons around 134–140  
of helium atoms 95  
mass number and 93  
stability of 694
- Nuclide** A particular type of nucleus that is characterized by a specific atomic number ( $Z$ ) and nucleon number ( $A$ ). 692  
band of stability of 695  
in nuclear equations 698–702  
radioactive 703  
symbol 692–693  
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- Nutrients, for phytoplankton 430
- Nylon 667  
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- Oil industry 354
- Olestra 660–661, 718–719
- Oligopeptide 656
- Open-chain forms, of monosaccharides 650–651
- Orange juice, pH of 347
- Orbital diagram** A drawing that uses lines or squares to show the distribution of electrons in orbitals and arrows to show the relative spin of each

- electron. 142, 144–145  
Study Sheet 149, 198
- Orbitals** *See* Atomic orbitals
- Organic acid** Carbon-based acids. 250
- Organic chemistry** The branch of chemistry that involves the study of carbon-based compounds. 191, 634–648
- Organic compound** 634–648
- alcohol 639
  - aldehyde 641
  - alkane 637
  - alkene 638
  - alkyne 638
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  - amine 643–644
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  - carboxylic acid 640
  - condensed formula 635
  - ester 642–643
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  - ketone 642
  - line drawing 558, 635
  - table of types 646–647
- Organophosphorus compounds** 293
- Oxalic acid** 640
- uses 235
- Oxidation** Any chemical change in which at least one element loses electrons, either completely or partially. 372–373, 375
- Oxidation-reduction reaction** The chemical reactions in which there is a complete or partial transfer of electrons, resulting in oxidation and reduction. These reactions are also called redox reactions. 372–375
- within batteries 388–393
  - half-reaction 374
  - oxidation 372
  - oxidation numbers (or states) 377–382
  - reduction 373
  - uses of 371
- Oxidation number (or state)** A tool for keeping track of the flow of electrons in redox reactions. 377–382
- assignment of oxidation numbers 378
  - Study Sheet 378
- Oxidation state.** *See* Oxidation number
- Oxidizing agent** A substance that gains electrons, making it possible for another substance to lose electrons and be oxidized. 374
- aging and 376
- defined 374
- oxidation numbers and 377–382
- Oxoacid.** *See* Oxyacid
- Oxyacid (oxoacid)** Molecular substances that have the general formula  $H_aX_bO_c$ . In other words, they contain hydrogen, oxygen, and one other element represented by X; the a, b, and c represent subscripts. 250
- names for 257
  - as polar molecule 529
- Oxygen (O)**
- in combustion reactions 383–385
  - covalent bond formation 193–194
  - diatomic molecules of 97
  - electron configuration and orbital diagram 145
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  - in formation of water 300–301
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- Paint spraying,** preventing air pollution 490
- Palladium,** in catalytic converter 385
- Pancreatic amylase,** in digestion 664
- Pancreatic lipase,** in digestion 664
- Paper,** saving acidic 355
- Parkinson's disease** 7–8
- positron emission tomography and 155
  - scientific method and 7–8
- Partial charge**
- in chemical bonds 176, 524–527
  - in hydrogen bonds 529
  - in London forces 532–533
- Partial electron transfer in oxidation-reduction reactions** 375
- Partially hydrogenated triglycerides** 659–660
- Partial pressure** The portion of the total pressure that one gas in a mixture of gases contributes. Assuming ideal gas character, the partial pressure of any gas in a mixture is the pressure that the gas would yield if it were alone in the container. 485
- effect on gas solubility 571
- equilibrium vapor pressure as 515–516
- Particle-particle attractions** 523, 597
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- Particle nature of matter** 76–80
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- Particles**
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  - in gases 79
  - in liquids 78
  - radiant energy as 130–131
  - in solids 76–77
  - space occupied 79
- Pascal (Pa), pressure unit** 461
- Pearl ash,** empirical formula for 274
- Pentane**
- hexane solubility of 554
  - in solution 311
  - water solubility of 554
- Pepper,** spiciness of 559
- Pepsin,** in digestion 664
- Peptide** A substance that contains two or more amino acids linked together by peptide bonds. 656
- how form 616–618
- Peptide bond** An amide functional group that forms when the carboxylic acid group on one amino acid reacts with the amine group of another amino acid. 656
- Percentage** 52–53
- as conversion factor 52
  - by mass, definition 52
  - by volume 52
- Percentage calculations** 52–53, 57
- in calculating empirical formulas 274
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- Percent yield** The actual yield divided by the theoretical yield times 100. 428–430
- why less than 100% 428–429
- Periodic table of the elements** 84–88
- electronegativity and 524
  - group number 85
  - group or family 85
  - hydrogen, position on periodic table 87

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 representative (or main-group) elements, transition metals, and inner transition metals 86
- Periods** The horizontal rows on the periodic table. 87
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- Pharmaceuticals 649
- Phenylalanine (Phe, F), molecular structure of 655
- Phosgene gas, production and use 631
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- Phosphate ion, solubility of compounds with 317
- Phosphate rock, in furnace method 261
- Phosphide ion 236
- Phosphoric acid 356  
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 in photophor 272  
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- Phosphorus pentachloride, production and use 410
- Phosphorus tribromide 429
- Phosphorus trichloride, production and use 606
- Photons** Tiny, massless packets or particles of radiant energy. 130
- Photophor, empirical formula for 272
- Physical states, in chemical equations 301
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- Phytoplankton, global warming and 430–431
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- Plastic fingerprints 517
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 density of 48
- Plutonium (Pu), in creation of new elements 94
- Plutonium-239  
 half-life 703  
 in radioactive wastes 704  
 radioactive decay 703
- Polar covalent bond** A covalent bond in which electrons are shared unequally, leading to a partial negative charge on the atom that attracts the electrons more and to a partial positive charge on the other atom. 176  
 dipole-dipole attractions and 523–524  
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- Polarity**  
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 of bonds 524–525  
 of capsaicin 559  
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- Polar molecular substance, solubility and 554–555
- Polonium-210, radioactive decay of 700
- Polonium-218, in radioactive decay 705
- Poly(ethylene terephthalate) 671
- Poly(vinyl chloride), PVC 670–671
- Polyatomic ion** A charged collection of atoms held together by covalent bonds. 185–187  
 balancing equations and 303, 306  
 formulas and names 238  
 with hydrogen 238  
 nonsystematic names 238
- Polychlorinated biphenyl (PCB) 278
- Polyester 668–669
- Polyethylene 669
- Polymer** A large molecule composed of repeating units. 652  
 addition 669–670  
 formulas for 667  
 polysaccharides as 652–653  
 proteins as 656  
 synthetic 666–671
- Polypeptide 656. *See also Protein*  
 nylon as 667  
 silk as 666
- Polypropylene 670–671
- Polyprotic acid** An acid that can donate more than one hydrogen ion per molecule in a reaction. 250
- Polysaccharide** Molecule with many saccharide units. 652  
 digestion products 664
- Polystyrene 670–671
- Positron** A high-velocity anti-electron released from radioactive nuclides that have too few neutrons. 155, 697  
 discovery of 155
- Positron emission** In radioactive nuclides that have too few neutrons, the conversion of a proton to a neutron, which stays in the nucleus, and a positron, which is ejected from the nucleus. 697  
 nuclear equations for 699–701
- Positron emission tomography (PET) 155, 708
- Potassium-40  
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- Potassium hydroxide, production and use 341, 409
- Potassium nitrate  
 production and use 401  
 in voltaic cells 390
- Potassium perchlorate, production and use 445
- Potassium permanganate, production and use 447
- Potato chips 660
- Potential energy (PE)** A retrievable, stored form of energy an object possesses by virtue of its position or state. 122  
 chemical reactions and 321–323  
 electron orbitals and 138  
 in formation of water 321  
 stability and 122–124
- Precipitate** A solid that comes out of solution. 312
- Precipitation** The process of forming a solid in a solution. 312  
 tooth decay and 354
- Precipitation reaction** A reaction in which one of the products is insoluble in water and comes out of solution as a solid. 312–318  
 of calcium carbonate 312–315  
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**Precision** The closeness in value of a series of measurements of the same entity. The closer the values of the measurements, the more precise they are. 20

in reporting measured values 39

**Prefixes.** *See Metric prefixes*

**Preserving books** 355

**Presidential Green Chemistry Challenge Award** 597

**Pressure** Force per unit area. *See Gas pressure; See Gas, pressure*

**Pressure cooker** 520

**Primary battery** A battery that is not rechargeable. 392

**Primary protein structure** The sequence of amino acids in a protein molecule. 656

**Principal energy level** A collection of orbitals that have the same potential energy for a hydrogen atom, except for the first (lowest) principal energy level, which contains only one orbital ( $1s$ ). 138

**Probabilities**, electron behavior and 132, 136

**Products** The substances that form in a chemical reaction. Their formulas are on the right side of the arrow in a chemical equation. 301

**Progesterone**, molecular structure of 662

**Proline (Pro, P)**, molecular structure of 655

**Propane** 191

1,2,3-Propanetriol 639

**2-Propanol**

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**2-Propanone** 642

**Propionic acid**

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**Propylene**

hexane solubility of 557

in polypropylene 670

**Propylene glycol**, molecular structure of 554

**Protein** Natural polypeptide. 654–655, 656

alpha helix 656

beta sheet 656

digestion products 664

disulfide bond 658

hydrogen bond 658  
primary structure 656  
ribbon convention 657  
salt bridge 658  
secondary structure 656  
tertiary structure 657–658

**Proton** A positively charged particle found in the nucleus of an atom. 89  
in artificial elements 94  
in atoms 89–90  
in Bronsted-Lowry acids and bases 356  
in ions 90–91  
in isotopes 92–93  
mass number and 93  
MRI and 708  
nuclear stability and 694–695, 713  
in nuclides 692–693  
origin of the elements and 718

**Publication**, in scientific method 9

**Pure substance** A sample of matter that has constant composition. There are two types of pure substances: elements and compounds. 173

**Putrescine**, molecular structure of 643

## Q

**Quantum mechanics** 155

**Quick lime**, formation of 409

## R

Race cars and air density 475

**Radiant energy** Energy that can be described in terms of oscillating electric and magnetic fields or in terms of photons. 130–132  
spectrum 131  
the wave view 130  
wavelength 130

**Radiation**

effects on the body 706–707  
treatment for cancer 707

**Radiator coolants** 554

**Radioactive decay** One of several processes that transform a radioactive nuclide into a more stable product or products. 695  
effects on body 706–707  
rates and half-life 702–704

**Radioactive decay series** 704–705

**Radioactive emissions**

alpha particle 696  
beta emission 696  
gamma rays 698  
positron emission 697

**Radioactive nuclide** An unstable nu-

clide whose numbers of protons and neutrons place it outside the band of stability. 695

**Radioactive substances**

smoke detectors, pipe joint check,  
food irradiation, radioactive tracers 711  
uses 707–712

**Radioactive tracer** A radioactive nuclide that is incorporated into substances that can then be tracked through detection of the nuclide's emissions. 711

**Radiocarbon (or carbon-14) dating**

The process of determining the age of an artifact that contains material from formerly living plants or animals by analyzing the ratio of carbon-14 to carbon-12 in the object. 709–710

**Radio waves** 131

**Radium-226**

half-life 703  
radioactive decay 705  
use 712

**Radon-222**

half-life 703  
lung cancer and 704  
in radioactive decay series 705

**Rags**, in paper 355

**Rapture of the deep** 572

**Rate of chemical reaction** The number of product molecules that form (perhaps described as moles of product formed) per liter of container per second. 592–596  
concentration effect 593–594  
temperature and 592–593

**Rate of condensation** The number of particles moving from gas to liquid per second. 513

**Rate of evaporation** The number of particles moving from liquid to gas per second. 511–513, 512–513  
strengths of attractions and 512  
surface area and 512  
temperature and 513  
three factors that determine 512

**Rate of solution.** *See Solution, Rate of Ratio*

empirical formulas and 271

molar 270

neutron-to-protons 694–695

stoichiometric 422

**Rational drug design** 649

**Reactants** The substances that change in a chemical reaction. Their formulas are on the left side of the arrow in a

- chemical equation. 301  
 equilibrium disruption and 610–612  
 limiting 423–427
- Reaction.** *See* Chemical reaction
- Reaction Rate.** *See* Rate of chemical reaction
- Rechargeable batteries 392
- Recycling 670
- Red giant stars 719
- Red litmus paper, detecting bases with 348
- Redox reaction. *See* Oxidation-reduction reaction
- Reducing agent** A substance that loses electrons, making it possible for another substance to gain electrons and be reduced. 374
- Reduction** Any chemical change in which at least one element gains electrons, either completely or partially. 373, 375
- Relative atomic mass 102
- Relative solubilities 554
- Representative elements** The elements in groups 1, 2, and 13 through 18 (the “A” groups) on the periodic table; also called main-group elements. 86
- Research, in scientific method 8
- Research chemist 585
- Resonance** The hypothetical switching from one resonance structure to another. 207–209
- Resonance hybrid** A structure that represents the average of the resonance structures for a molecule or polyatomic ion. 208
- Resonance structures** Two or more Lewis structures for a single molecule or polyatomic ion that differ in the positions of lone pairs and multiple bonds but not in the positions of the atoms in the structure. 208
- Reversible reaction** A reaction in which the reactants are constantly forming products and, at the same time, the products are reforming the reactants. 251, 597–598  
 in chemical equilibrium 597–601  
 disruption of equilibrium for 610  
 equilibrium constants for 602  
 percent yield and 428
- Review Skills sections 6
- Rhodium, in catalytic converter 385
- Ribbon convention for proteins 657
- Ring forms, of monosaccharides 650–651
- Roasting 430
- Rohm and Haas Company 5
- Roman numeral, in naming monatomic cations 236
- Roots of nonmetal names 236
- Roscoelite 297
- Rounding off 39–47  
 for addition and subtraction 45–47  
 for multiplication and division 40–45
- Roundup 597
- RU-486 681
- Ruby 290
- S**
- s block, on periodic table 146–147
- Saccharide** Sugar, starch, and cellulose. Also called carbohydrates. 650–653.  
*See also* Carbohydrate
- Saliva, tooth decay and 354
- Salt. *See* Sodium chloride
- Salt bridge** (in proteins) A covalent bond between two sulfur atoms on cysteine amino acids in a protein structure. 658
- Salt bridge** (in voltaic cells) A device used to keep the charges in a voltaic cell balanced. 390
- Salt taste 345
- Salt water separation 82
- San Simeon, California, protection from acid rain in 255
- Saturated solution** A solution that has enough solute dissolved to reach the solubility limit. 568, 568–569  
 dynamic equilibrium and 564–569  
 formation of 568–569
- Saturated triglyceride** A triglyceride with single bonds between all of the carbon atoms. 659
- Scale, calcium carbonate in 320
- Schrodinger, Erwin 134
- Science  
 chemistry as 7–9  
 existence of matter and 155
- Scientific Method 7–9
- Scientific model** A simplified approximation of reality. 76, 98, 187
- Scientific notation 4–5
- Scuba diving, gas solubility and 572
- Sea-Nine antifoulant 5
- Seaborg, Glenn 701
- Sea of electrons model for metals 99
- Seawater, pH and 347
- Second (s), as unit of measurement 11
- Secondary (or storage) battery** A rechargeable battery. 392
- Secondary protein structure** The arrangement of atoms that are close to each other in a polypeptide chain. Examples of secondary structures are alpha helix and beta sheet. 656–657
- Second period elements, electrons in 143–145
- Selenide ion 236
- Selenium  
 covalent bond formation 194  
 ion formation 182–183
- Semimetals** The elements that have some but not all of the characteristics of metals. 86
- Serine (Ser, S)  
 hydrogen bonds between 658  
 molecular structure of 655
- Shape.** *See* Molecular shape
- Shell 138. *See also* Principal energy level
- Shroud of Turin 710
- Side-chain, in anion acid 654
- Significant figures** The number of meaningful digits in a value. The number of significant figures in a value reflects the value’s degree of uncertainty. A larger number of significant figures indicates a smaller degree of uncertainty. 39–47  
 counting the number of 41–42  
 zeros and 42
- Silicon (Si) 300  
 electronics grade 425  
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 from silicon dioxide 423
- Silicon dioxide  
 citrine as 294  
 in furnace method 261  
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- Silk  
 molecular structure of 666  
 nylon as substitute for 666
- Silver (Ag)  
 density of 48  
 ion charges of 237  
 melting point of 60
- Silver ion, solubility of compounds with 317
- Silver nitrate, in precipitation reaction 318
- Single-displacement reaction** Chemical change in which atoms of one element displace (or replace) atoms of another element in a compound. 386–387

Sinkhole 368  
**SI System of Measurement.** *See International System of Measurement*  
 Sixth principal energy level, electron orbitals of 141  
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   reaction with acid 343  
   uses 343  
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 Sodium chloride  
   electrolysis and 391  
   formation 178  
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   formula unit of 264  
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 Sodium fluoride, in toothpaste 181  
 Sodium hydrogen carbonate  
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   reaction with acids 343  
 Sodium hydrogen sulfate, production and use 453  
 Sodium hydroxide  
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   formation 185  
   in neutralizing phosphoric acid 436  
   reaction with nitric acid 349–353  
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 Sodium hypochlorite, production 485, 528, 536, 556, 557  
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Sodium perbromate, production and use 407  
 Sodium sulfate, production and use 407, 493  
 Sodium tripolyphosphate, production and use 456  
 Soft drink, why bubbles form 572  
 “Solar system” model of the atom 132  
**Solid** The state in which a substance has a definite shape and volume at a constant temperature. 76–77  
   densities of 47–48  
   expansion when heated 77  
   heterogeneous equilibrium and 606–607  
 Solid acid, in meals ready to eat 549  
 Solid elements 87, 98–99  
**Solubility** The maximum amount of solute that can be dissolved in a given amount of solvent. 554–560  
   gas 570–571  
   guidelines 554  
   like dissolves like 554–555  
   soaps and detergents and 562–563  
   in water 316–317, 569  
   guidelines 316  
**Solute** The gas in a solution of a gas in a liquid. The solid in a solution of a solid in a liquid. The minor component in other solutions. 311  
   gas as 570–571  
   in saturated solution 564  
**Solution** A mixture whose particles are so evenly distributed that the relative concentrations of the components are the same throughout. Solutions can also be called homogeneous mixtures.  
   chemical reactions in 549  
   dynamic equilibrium and 564–569  
   formation of 552–553  
   of ionic compounds 309–311  
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     surface area 565–566  
     temperature effect 568  
   saturated 568–569  
   solute and solvent 311  
   unsaturated 568  
   why form 550–553  
**Solvent** The liquid in a solution of a gas in a liquid. The liquid in a solution of a solid in a liquid. The major component in other solutions. 311  
 Sour taste 345  
**Space-filling model** A way of repre-  
   senting a molecule to show a somewhat realistic image of the electron-charge clouds that surround the molecule's atoms. 96, 210  
 Spandex (R), synthesis of 278  
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   Molecular Shapes, Intoxicating Liquids, and the Brain 214  
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   Precipitation, Acid-Base Reactions, and Tooth Decay 354  
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   Rehabilitation of Old Drugs and Development of New Ones 649  
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   The Origin of the Elements 718  
   Wanted: A New Kilogram 11  
   Why Create New Elements? 94  
   Why Does Matter Exist, and Why Should We Care About This Question? 155  
 Zinc-Air Batteries 393

**Spectator ions** Ions that play a role in delivering other ions into solution to react but that do not actively participate in the reaction themselves. 315

**Spectrum**, of radiant energy 131–132

**Spin**. *See* Electron spin

**Spinels** 291

**Spodumene** 297

**Spray paint** 490

**Stability** A relative term that describes the resistance to change. 96, 122–124

**Standard kilogram** 11

**Standard pressure** 479

**Standard temperature** 479

**Standard temperature and pressure (STP)** 479

gas stoichiometry and 479

gas stoichiometry for conditions other than 480–481

**Standing waves** 132–134

**Starch** 650, 652

**Stars**, element formation and 719

**State, physical** 301

**Stationary wave** 133

**Steam re-forming** 442, 598

**Stearic acid**

molecular structure of 640

solubility of 559

**Step-growth (or condensation) polymer**

A polymer formed in a reaction that releases small molecules, such as water. This category includes nylon and polyester. 667

**Sterno** 187

**Steroid** Compounds containing a four-ring structure. 661–662

**Stirring**, rate of solution and 565–567

**Stockings** 666

**Stoichiometric ratio** 422

**Stoichiometry**. *See* **Equation stoichiometry**

**Stomach**

hydrochloric acid in 482

role in digestion 665

**Stomach acid** 482

**Storage battery** 392

**Strong acid** An acid that donates its  $\text{H}^+$  ions to water in a reaction that goes completely to products. Such a compound produces close to one  $\text{H}_3\text{O}^+$  ion in solution for each acid molecule dissolved in water. 251, 253, 340

identifying 344

reactions of strong base with 349–353

**Strong base** A substance that generates

at least one hydroxide ion in solution for every unit of substance added to water. 341

identifying 344

reactions of strong acids with 349–353

**Strong force** The force that draws nucleons (protons and neutrons) together. 694

**Strontium-90** 706

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balancing chemical equations 303

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writing complete electron configura-

tions and orbital diagrams for uncharged atoms 149

writing equations for combustion reactions 384

**Styrene**, in polystyrene 670

**Sublevel or subshell** A given type (or shape) of orbital available at a given principal energy level. 139

**Sublimation**, of dry ice 125, 126

**Subshell**, of atomic orbitals 139

**Substance**, base unit of 10–11

**Substances**

densities of common 48

equation stoichiometry and 414–421

hydrophilic and hydrophobic 558

solubilities of 554–555

uses for radioactive 707–710

**Substrate** A molecule that an enzyme causes to react. 666

**Subtraction**, rounding off and 45–47

**Sucrase**, in digestion 664

**Sucrose**, solubility in water 569

**Sugar** 650–652

rate of solution 566

taste of 345

**Sulfate ion**, solubility of compounds with 317

**Sulfur** 85–86

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**Sulfur dioxide**

acid rain and 255

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as pollutant and removal 454

**Sulfur hexafluoride**, threshold limit value, or TLV 498

**Sulfuric acid** 254

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**Sulfur trioxide**, in acid rain 255

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**Supercritical carbon dioxide**

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**Supercritical fluid** 490

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 Surface area, rate of solution and 565–566  
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   for elements 83  
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 Synthesis reactions 382  
 Synthetic polymers 666–671

**T**

Tanzanite 294  
 Taste 345  
 Technical University of Munich 617  
 Television waves 131  
 Tellurium (Te), bonding patterns of 199  
**Temperature** A measure of the average internal kinetic energy of an object. 17–19, 129  
 absolute zero 18  
 base unit of 11  
 boiling-point 520  
 Celsius scale 18  
 coldest 19  
 common scales 19  
 in condensation 510  
 critical 490  
 density and 47  
 effect on rate of solution 568  
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 Kelvin scale 18–19  
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 normal boiling-point 521  
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 range of 19  
 rate of reaction and 592–594  
 rate of solution and 568  
 standard 479  
 volume and 465  
 Temperature conversions 58–60  
 Terephthalic acid, in polyester formation 668

**Tertiary protein structure** The overall arrangement of atoms in a protein molecule. 657

Testosterone 662

Tetraboron carbide, production and use 446, 447

Tetrachloroethene 421

**Tetrahedral** The molecular shape that keeps the negative charge of four electron groups as far apart as possible. This shape has angles of 109.5° between the atoms. 210

Tetrahedral molecules 210

Tetramethylene glycol 279

Tetrapeptide 656

Tetraphosphorus decoxide, in furnace method 261

Tetraphosphorus trisulfide 305

Thalidomide 296, 649

**Theoretical yield** The calculated maximum amount of product that can form in a chemical reaction. 428

Thermometers 18–19

Thiocyanate 444

Thionyl chloride, production and use 454

Thoburn, Steve 38

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Threonine (Thr, T), molecular structure of 655

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Tin(II) sulfide, melting point of 60

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Tin isotopes 93–94

Titanium(IV) oxide

  production 504

  production and use 457

Titanium (Ti) 98

  production and use 411

Titanium carbide 427

Titanium dioxide 608

  production and use 402

Titration, Web site for 438

Tooth decay, acid-base reactions and 354

Tooth enamel, composition of 354

Toothpaste, chemicals in 226

Torr, as unit of pressure 461

Trailing zeros, measurement uncertainty and 22

**Transition metals** The elements in groups 3 through 12 (the “B” groups) on the periodic table. 86

  as catalysts 596

  in catalytic converters 385

  in periodic table 86

Transition state, in chemical reactions 587

Triacylglycerol 560–561

**Triglyceride** A compound with three hydrocarbon groups attached to a three carbon backbone by ester functional groups. 560–561, 659–661

**Trigonal planar** (often called triangular planar) The geometric arrangement that keeps three electron groups as far apart as possible. It leads to angles of 120° between the groups. 213

**Trigonal pyramid** The molecular geometry formed around an atom with three bonds and one lone pair. 212

Trimethylamine 644

2,2,4-Trimethylpentane 637

Trinitrotoluene (TNT) 638–639

**Triple bond** A link between atoms that results from the sharing of 6 electrons. It can be viewed as three 2 electron covalent bonds. 192

**Triprotic acid** An acid that can donate three hydrogen ions per molecule in a reaction. 250, 340

Tristearin 560

Tritium 92–93

Trypsin 664

Tryptophan (Trp, W), molecular structure of 655

Tungsten (W), in light bulb filaments 472

Tyrosine (Tyr, Y), molecular structure of 655

**U**

Ultraviolet radiation 131

Umami taste 345

Uncertainty 21

  in measurements 20–22

  significant figures and 39–47

Unified mass unit. *See* Atomic mass unit

**Unit** A defined quantity based on a standard. 9–18, 1–3

  abbreviations 1

  conversions among 34–60

  of energy 127

  in international system of measurement 10–12

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**Unit analysis** A general technique for doing unit conversions. 34–38, 132–136, 142–146, 267–275, 414–418, 422–426

  equation stoichiometry and 416

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"something per something" 57  
 common 54–58  
 density and 49, 56, 477, 479–482, 527  
 English-metric 37–38, 56  
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 percentage and 53, 57

**Universal gas constant, R** The constant in the ideal gas equation. 470  
 in gas stoichiometry 481–485  
 in ideal gas equation 470–475

**Universe**  
 hottest temperatures in 19  
 origin of elements in 718–719

University of California, Berkeley 701  
 University of Regensburg 617  
 Unpaired electrons 190  
 in valence-bond model 188

**Unsaturated solution** A solution that has less solute dissolved than is predicted by the solubility limit. 568

**Unsaturated triglyceride** A triglyceride that has one or more carbon-carbon double bonds. 659

Uranium 427  
 alpha emission 696  
 production 448  
 uranium-238 decay series 705

Uranium(IV) oxide 427  
 Uranium-234 716  
 Uranium-235 716  
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Uranium-238  
 in fission reactors 716  
 half-life 703  
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 radioactive decay series 705

Uranium-239  
 in nuclear reactors 716  
 in nuclear fission 714

Uranium hexafluoride 413, 427  
 Urea 457  
 use and production 502, 630

**V**

Valence-bond model 188–193  
**Valence electrons** The electrons that are most important in the formation of chemical bonds. The highest energy *s* and *p* electrons for an atom. 188

Valine (Val, V), molecular structure of 654

**Value** A number and unit that together represent the result of a measurement

or calculation. 10  
 Vanadium(V) oxide, in catalytic converter 385

**Vapor** A gas derived from a substance that is liquid at normal temperatures and pressures. It is also often used to describe gas that has recently come from a liquid. 510

**Vaporization** The conversion of a liquid to a gas. 79

**Vapor pressure.** *See* Equilibrium vapor pressure

Vegetable oil 561

**Velocity**  
 of gas particles 460  
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**Vinegar**  
 acetic acid in 250  
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Vinyl chloride, in poly(vinyl chloride) 670

Visible fingerprints 517

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Vitamin C, aging and 376

Vitamin E, aging and 376

**Volatile organic compounds (VOCs)** 490

**Voltage** 391

**Voltaic cell** A system in which two half-reactions for a redox reaction are separated, allowing the electrons transferred in the reaction to be passed between them through a wire. 388–393  
 anode 389  
 cathode 389  
 common examples 393  
 electrode 389  
 electrolyte 390  
 primary battery 392  
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 pH of 347  
 as polar molecule 308, 529  
 producing hydrogen gas from 597–599  
 in protein formation 656  
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**Water dissociation constant ( $K_w$ )** The equilibrium constant for the reaction:  $H_2O(l) \rightleftharpoons H^{+}(aq) + OH^{-}(aq)$  608

Water purification 420  
 Water solubility 316–317  
 Water treatment 366

**Wave**  
 electrons as 134–141  
 for guitar strings 132  
 radiant energy as 130–132  
 standing 132–133

**Waveform** A representation of the shape of a wave.  
 of electron 134  
 of guitar strings 133

**Wavelength** The distance in space over which a wave completes one cycle of its repeated form. 130–131

**Weak acid** A substance that is incompletely ionized in water due to the reversibility of the reaction that forms hydronium ions,  $H_3O^+$ , in water. Weak acids yield significantly less

- than one  $\text{H}_3\text{O}^+$  ion in solution for each acid molecule dissolved in water. 251, 252, 340
- Weak base** A substance that produces fewer hydroxide ions in water solution than particles of the substance added. 342–343
- ammonia as 341–342
  - identifying 344
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  - for animation of a single-displacement reaction 386
  - for animation of dissolving ethanol in water 553
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  - for predicting molecular polarity 529
  - for predicting relative strengths of attractions 536
  - for resonance 209
  - for temperature effect on solid and gas solubility 569, 573
  - for writing complete ionic and net ionic equations 319
- Weight** A measure of the force of gravitational attraction between an object and a significantly large object, such as the earth or the moon. 16
- Weighted average** A mass calculated by multiplying the decimal fraction of each component in a sample by its mass and adding the results of each multiplication together. 100
- Wine
- pH of 347
  - sediment formation 555
- Work** What is done to move an object against some sort of resistance. 120
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- ## Y
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