

GLOSSARY/INDEX

A

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

Absolute zero Zero kelvins (0 K), the lowest possible temperature, equivalent to $-273.15\text{ }^{\circ}\text{C}$. 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

Acetaldehyde, determining Lewis structure 206–207

Acetamide 644

Acetate ion, solubility of compounds with 317

Acetic acid 250–253, 640

dissolved in water 252

formulas 250

freezing point of 250

glacial 250

molecular structure of 250

as organic acid 250

production 504, 630

solubility in water 569

taste of 248

uses 250, 630

as weak acid 251

Acetone 642

boiling point of 522

evaporation of 512

use 543

vapor pressure of 516

Acetylene 192, 638

molecular structure of 192

water solubility of 556

Acid. *See also* Arrhenius acid

binary. *See* Binary acid

bleach and 356

Brønsted-Lowry 356–360

conjugate acids and bases 357

carboxylic acid. *See* Carboxylic acid

characteristics 248

classification of strong or weak 254, 344–345

defined 356

diprotic. *See* Diprotic acid

identifying 344–345

monoprotic. *See* Monoprotic acid

names and formulas of 256–258

oxyacid. *See* Oxyacid

pH 346–347

polyprotic. *See* Polyprotic acid

in saliva 345

strong 253, 340

Study Sheet, indentifying 344

taste of 345

triprotic. *See* Triprotic acid

types 250

weak 251–253

Acid-base reaction 348–356

strong acid with hydroxide base 349–353

uses 348

writing equations 351

Acidic paper, preserving books with 355

Acidic solution A solution with a significant concentration of hydronium ions, H_3O^+ . 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

Adams, Mike 650

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

Adipic acid 276

Adults

effects of ionizing radiation on 706

fingerprints of 517

Aerosol can 517

Agent Orange 295

Aging, oxidizing agents and 376

Agitation, rate of solution and 566–567

AIDS 649

Air 485–486

density of 48

gases in 486

in lungs 469

internal combustion engine and 468

Air bags 502

Air pollution

catalytic converters and 385

volatile organic solvents and 490

Alanine (Ala, A)

silk and 666

structure of 654

Alar 292

Alcohol Compounds that contain a hydrocarbon group with one or more -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 -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

Aluminum 86

ion formation 91, 183

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 R₃N, 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
covalent bond formation 192
hydrogen bonds and 531
molecular shape of 211
origin of life and 617
pH of 347
production 480, 597
uses 341, 546
weak base 341–342
- Ammonium carbonate, use 629
- Ammonium chloride, crystal structure of 186
- Ammonium ion
covalent bond formation 192
solubility of compounds with 316
- 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
- Analogies, to electron behavior 132
- Anastas, Paul T. 5
- Anderson, Carl 155
- Androstenedione 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
formation 182–183
in batteries 389–390
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
writing formulas 242–243
- 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, H₃O⁺, when added to water. 248–255, 340–347. *See also* Acid
binary acid 250
compared to Bronsted/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⁻, when added to water. 342–346. *See also* Base
compared to Bronsted/Lowry bases 356–360
defined 341
reactions with acids 348–355
strong and weak 341–344
- Arsenic (As)
bonding patterns of 193
- Asparagine (Asn, N), structure of 655
- Aspartame 681, 687
- Aspartic acid (Asp, D)
in salt bridges 658
structure of 655
- 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
atomic numbers of 93
chemical bonds between 175–179
in chemical reactions 300–302
counting by weighing 100–103
electron 90
electron configuration 142
electron configurations and orbital diagrams 149, 198
excited and ground state 138
as formula unit 264
mass numbers of 93–94
molar mass of 104–105
nuclear reactions of 696–700
nuclear stability of 694
orbital diagram 142
oxidation numbers of 377–384
protons, neutrons, and electrons 89
radioactive decay of 696–700
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.
calculations 105
defined 102
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
in nuclear equations 698–702
in nuclides 692–693
- Atomic orbitals
1s 134–136
2p 139
2s 137–138
3d 140
electron cloud 136
electron spin and 144
for first 10 elements 145
order of filling 143, 146–148
probability and 136
relative energies 138
shapes 137
- Atomic weight *See also* Atomic mass 102
- 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 6.022×10^{23} . 102–103
- B**
- Bacon, Roger 33
- Bacteria 400
tooth decay and 354
- 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
steps in 303
Study Sheet 303
- 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
of water 212, 308
- 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
Arrhenius 342
Brønsted-Lowry 356–360
carbonate 343
classification of strong or weak 344–345
conjugate 358
defined 341
identifying 343–344
in acid-base reactions 348–356
pH 346–347
strong 341
Study Sheet, indentifying 344
weak 342–343
- 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, 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
rechargeable 392
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
- Benzedrine 558
- Benzene 276
- Berkelium (Bk) 701
- Beryllium (Be)
electron configuration and orbital diagram 144
formation of 718
- 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
effects on body 706–707
penetration of the body 707
- Beta sheet 656
- Big Bang 718
- Binary acid** Substances that have the general formula of HX(aq), where X is one of the first four halogens: HF(aq), HCl(aq), HBr(aq), and HI(aq). 250
formulas 256
naming 256
- Binary covalent compound** A compound that consists of two nonmetallic elements.
memorized names 244
names without prefixes 246
naming 244–245
prefixes used to name 245
recognizing from formulas 244
recognizing from names 246
systematic names 244–246
writing formulas 246–247
- 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
amino acids and protein 654–658
carbohydrate 650–653
how form 616–618
steroid 661–662
triglycerides 659
- Bismuth, in the creation of element 111 94
- Bitter taste 345
- 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
 how bubbles form 518–520
- 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
 covalent bond formation 194
 covalent bonding pattern 195
 electron configuration and orbital diagram 144
 nuclear power plant control rods and 716
- 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^+ , in a Brønsted-Lowry acid-base reaction. *See* Acid, Brønsted-Lowry
- Brønsted-Lowry acid-base reaction** A chemical reaction in which a proton, H^+ , is transferred. *See* Acid-base reaction, Brønsted-Lowry
- Brønsted-Lowry base** A substance that accepts protons, H^+ , in a Brønsted-Lowry acid-base reaction. *See* Base, Brønsted-Lowry
- Bubbles
 in boiling liquid 520
 how form in liquid 518–520
 in soft drinks 572
- Bunsen burner, hottest part of flame 60
- Bureau International des Poids et Mesures (BIPM) 11
- Butadiene 500
- Butane, molecular structure of 191
- 1,4-Butanediol (BD) 279
- Butanoic acid
 molecular structure of 559, 640
 solubility of 559
- 2-Butanone 642
- Butylated hydroxytoluene (BHT) 638
- Butyl ethyl ether 636
- Butyric acid 640
- C**
- Cadaverine 643
- Cadmium (Cd)
 in nickel-cadmium batteries 392
 nuclear plant control rods and 716
- Caffeine 573
 removal from coffee 491
 taste of 339
- Calamine 296
- Calcium (Ca), ion formation 183
- Calcium carbide, production 448
- Calcium carbonate 300, 322, 592
 acid rain and 255
 as antacid 482
 formation in pipes of 320
 in limestone caverns 368
 natural sources of 320
 oil production and 354
 precipitation reaction 312–315
 solubility in water 569
- Calcium chloride 300
- 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
 combustion and 383
 covalent bond formation 190–191
 diamond as 89
 electron configuration and orbital diagram 144–145
 in heavy-ion therapy 94
 isotopes of 102
 medical use 94
 in pig iron 485
- 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
 reaction with acids 353
 solubility of compounds with 317
 in weak bases 343
- Carbon black 427
- Carbon dioxide
 as dry ice 125
 in automobile exhaust 173
 catalytic converter and 385
 in combustion reactions 383
 decaffeinating coffee and 491
 global warming and 430
 greenhouse gas 573
 polarity 528
 in soft drinks 572
 solid to gas 552
 solubility in water 569
 spray painting and 490
 supercritical 490
- Carbon dioxide torpedos 573
- Carbonic acid 573

- 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 -CO₂H) 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
- Celgene Corporation 649
- Cellulose 650, 652–653
 molecular structure of 653
- 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
- Chapter Objectives 6
- 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
- Chemical engineering 585
- Chemical equation 300–307
 for acid-base reactions 351–355
 balancing 302–307
 polyatomic ions 303, 306
 Study Sheet 303
 chemical calculations and 413
 complete 316
 complete ionic 315
 heat and 302
 interpreting 300–302
 molecular 316
 net ionic 316
 physical states and 301
 special conditions and 301–302
- 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
- Chemical nomenclature
 binary acids 256
 binary covalent compounds 244–248
 memorized Names 244
 names without prefixes 246
 naming 244–245
 prefixes used to name 245
 recognizing from formulas 244
 recognizing from names 246
 systematic names 244–246
 ionic 239–243
 oxyacids 257
 summary 259–260
- 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

- single-displacement 386
- synthesis 382
- types of 382–388
- Chemistry** The structure and behavior of matter. 4. *See also* Organic chemistry; Biochemistry
 - combinatorial 649
 - Green. *See* Green Chemistry
 - nuclear 691–701
 - organic 633–648
 - suggestions for studying 5
- Chemists 4
- Children
 - effects of ionizing radiation on 706
 - fingerprints of 517
- Chili peppers 559
- Chloral hydrate 206
- Chloride ion 91
 - in sodium chloride 172
 - solubility of compounds with 317
- Chlorine (Cl)
 - as anion 177–178
 - bleach and 356
 - catalyst for ozone destruction 594–596
 - diatomic molecules of 97
 - electrolysis and 391
 - ion formation 182
 - in ionic bonds 177
 - product of the electrolysis of salt 81
 - reaction with alkali metals 84
 - structure 97
 - threshold limit value, or TLV, and 498
 - use and production 501, 580
 - valence electrons 198
- Chlorine-36 710
- Chlorobutane, formation of 428
- 1-Chloropropane, melting point of 59
- Chocolate, taste of 345
- Cholesterol, structure of 661–662
- Chromite 430
- Chromium (Cr), sources of 297
- Chromium(III) oxide 243
 - as catalyst 598
 - catalytic converter and 385
 - empirical formula of 271
 - production and use 447, 454
- Chyme 664
- Chymotrypsin, in digestion 664
- Citric acid 248
 - taste of 345
- Citrine 294
- Clark, Desmond 709
- Classification of Matter 120–123, 172–175, 256–259, 300–303, 321–327, 346–351, 356–359, 372–375, 377–380, 382–385, 388–391
 - mixture 173
 - pure substance 173
 - Study Sheet 174, 476, 483, 488, 526
- Classifying compounds 180
- Clean Air Act of 1967 499
- Cleaning with soap and detergent 562–563
- Clinton, Bill 5
- Coal, acid rain and 255
- Cobalt-60
 - cancer radiation treatment and 707
 - food irradiation and 711
 - gamma ray emission and 698
- Coefficients** The numbers in front of chemical formulas in a balanced chemical equation. 301
- Coffee
 - pH of 347
 - removing caffeine 491
- 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
 - orientation 591
 - steps 586–588
 - summary 591–592
- 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
 - Study Sheet 384
- 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
 - binary covalent 244
 - binary ionic 239
 - classification 180
 - element versus 172
 - ionic 180
 - molar masses of 261–265, 267–271
 - 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
 - disruption of equilibrium and 610
 - 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^+ ion is added to a molecule or ion. 357
- Conjugate acid-base pair** Two molecules or ions that differ by one H^+ ion. 357–358
- Conjugate base** The molecule or ion that forms when one H^+ 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
 formula mass as 265
 from percentage 52
 metric-metric 35
 molecular mass as 262
 percentage 52
- Cooling, in evaporation 512–513
- Copper(II) ion, voltaic cells and 388–390
- Copper(II) oxide, in catalytic converter 385
- Copper sulfate, reaction with zinc 386–387
- Corliss, Jack 617
- Corundum 290
- Counting by weighing 100–102
- Covalent bond** A link between atoms that results from their sharing two electrons. 96
 common bonding patterns 195
 formation of 176
 polar or nonpolar 524
- 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
 substance identification and 48
 temperature and 47
 units of 48
- 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
- Diatom** Composed of paired atoms. The diatomic elements are H₂, N₂, O₂, F₂, Cl₂, Br₂, and I₂. 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

like guitar strings 132–134

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 1.6×10^{-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

electron configurations and orbital diagrams 149, 198

electronegativities of 524

isotopes of 92–93

list of common 83

magic numbers for 713

making new elements 94

metallic 98–99

metalloids or semimetals 86

metals 85

molar masses of 104–105

names of 82, 83–84

naturally occurring isotopes 93
nonmetals 85

nuclear stability of 694–695

in ordinary substances 171

origin of 718

oxidation numbers of 377–382

particle interactions 534

periodic table of 84–88

as pure substances 173

solids, liquids, and gases 87

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
endergonic (or endogonic) changes 123

of events 128

exergonic (or exogonic) changes 124

exothermic 322

in food 128

heat 128–129

nuclear 713–718

of photons 130–132

potential 122–123

radiant 130–132

storage in the body 650

units of 127

water formation and 127

Energy diagram 590–591

Energy level. *See* Principal energy level

Engineering, chemical 585

English-metric unit conversion factors 38, 415

- English system, metric system versus 14, 37
- Environment, chemistry and 4
- Environmentally Benign Chemistry.
See Green Chemistry
- Environmental Protection Agency 5, 704
- Enzyme** A naturally occurring catalyst. 594, 664–666
digestive 664–666
metallic cations in 185
why specific 666
- Epictetus 34
- 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
molarity and 434–438
Study Sheet 437
- Equilibrium 597–598
disruption of 610–616
dynamic 514–516
effect of catalyst 614–615
effect on changing concentrations 610–613
gas solutions and 570–571
heterogeneous 606–607
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 describes the extent to which reversible reactions proceed toward products before 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 partial pressure of vapor above a liquid in a closed system with a dynamic equilibrium between the rate of evaporation and the rate of condensation. 515–516
in bubble formation 519–520
temperature and 516
- Ester** A compound with two hydrocarbon groups surrounding an oxygen atom. 642–643
in fingerprints 517
olestra as 660–661
- Estradiol, structure of 662
- Ethanamide 644
- Ethane 191
solubility in hexane 557
- 1,2-Ethanedione 639
- Ethanoic acid 640
- Ethanol (or ethyl alcohol)
in combustion reactions 383
density of 47
hydrogen bonds in 530–531
as intoxicating liquid 214
Lewis structure 196
mixing with water 552–553
production of 604
solubility in water 569
- Ethene. *See* Ethylene
- Ether** A compound with two hydrocarbon 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 41
- 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
- Expansion, of solids 77
- Experimentation, in scientific method 8–9
- External kinetic energy 128
- F**
- f*block, of elements 147
- Fahrenheit scale 18–19
Fahrenheit to Celsius conversion 58–59
- Family** All the elements in a given column on the periodic table; also called group. 85
- Fat 659
digestion products 664
- Fertilizer
ammonia and 597
nitric acid and 472
- Feynman, Richard 136
- 15-minute rule 6, 7
- Fingerprints 517
- Fire extinguishers, sodium carbonate in 343
- Fireworks
calcium nitrate in 243
light emitted from 139
- Fission** Nuclear reaction that yields energy by splitting larger atoms to form more stable, smaller atoms. 714–715
- Flame retardant, phosphates in 238
- Flashtubes 499
- Flerov Laboratory of Nuclear Reactions 94
- Fluorapatite, tooth decay and 354
- Fluoride ion, tooth decay and 354
- Fluorine (F)
covalent bond formation 188–189
diatomic molecules of 97
electron configuration and orbital diagram 145
how made 297
hydrogen bonds and 529
oxidation numbers and 378
production of 442–443
structure of 97
valence electrons of 188
- Fluorine-18
positron emission tomography and 708
- Food
Calories in 128
digestion of 664–666

food, important substances in 650–661
Food and Drug Administration (FDA) 491

Food irradiation 711

Force, weight as 16

Forensic chemistry 517

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 aminobutanoic 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

breathing and 469

calculations

equation stoichiometry 478

Study Sheet 483–484

using the combined gas law

equation 476–478

Study Sheet 476

using the ideal gas equation

470–475

Study Sheet 471

using the molar volume at STP

479

Charles' Law 465

concentration effect on reaction rates 593

Dalton's Law of Partial Pressures

485–489, 523–527

Study Sheet 488

densities of 48

equilibrium constants and 602–603

expansion 551

Gay-Lussac's Law 464

greenhouse gases 430–431

heterogeneous equilibria and

606–608

ideal 461

ideal gas calculations 470–478

instrument-carrying balloons and

469

internal combustion engine and

468

liquids changing from and into

510–512

model 460

molar volume 479

noble 85

partial pressure of 485–489, 571

particle collisions 460

pressure 461

pressure and industrial safety

477–478

properties of 461

race cars and air density 475

real 460

relationship between number of gas

particles and pressure 466

relationship between number of gas

particles and volume 467

relationship between pressure and

temperature 464

relationship between volume and

pressure 462–463

relationship between volume and

temperature 465

relationships between properties

460–467

solubility of 570–571

typical particle velocities 460

universal gas constant 470

vapor as 510

volume occupied by particles 460

Gaseous elements 87

Gasoline 385, 637

in catalytic converters 385

combustion of 383

composition of 191

in internal combustion engines 468

Gas pressure. *See also* Gas

boiling-point temperature and external 518–520

breathing and 469

in bubble formation 518–520

in combined gas law equation

476–478

Dalton's Law of partial pressures

485–489

equilibrium vapor 515–517

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

Geometric sketch 210

Geometry 209–213. *See* Molecular shape

Study Sheet 215

German Cancer Research Center 94

Gesellschaft für Schwerionenforschung (GSI) 94

Gide, Andre 75

Giga (G) prefix 13

Girard, Georges 11

Glacial acetic acid 250

Glioma 717

Global warming 430–431, 573, 597, 649, 663, 717

Glucose 650–651

empirical and molecular formulas of 271

- Glutamic acid, structure of 655
- Glutamine, structure of 655
- Glycerol or glycerin 639
- Glycine, structure of 654
- Glycogen 652–653
- Gold (Au)
- atom of 89
 - as malleable 85
 - origin of name 83
 - scanning tunneling microscope image of 88
- Gold-198, radioactive decay of 700
- Graduated cylinder 21
- Gravitational attraction, weight and 16
- Green Chemistry 5
- decaffeinating coffee and 491
 - Designing Safer Chemicals Award 5
 - development of new and better catalysts 597, 649, 663, 717
 - Green Chemistry Challenge Awards 5
 - Green Chemistry Program 5
 - 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
- Hearst, William Randolph 255
- 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
 - as energy 129
 - transfer 129–130
- Heat of reaction 322
- Heavy-ion therapy 94
- Heavy water, freezing point of 59
- Heidelberg Radiology Clinic 94
- Helium
- to avoid the bends 572
 - formation 718
- Helium-4, in treating brain cancer 717.
- See also* Alpha particles
- Hematite 294
- Hemoglobin 385
- carbon monoxide poisoning and 385
 - iron ions in 185
- 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
- Hydrazine, production and use 456
- Hydride ion 236
- Hydriodic acid
- forming name of 256
 - production and use 453, 630
- Hydrobromic acid, forming name of 256
- Hydrocarbon** Compounds that contain only carbon and hydrogen. 191, 533
- catalytic converters and 385
 - in combustion reactions 383
 - in internal combustion engines 468
 - London forces among 532–533
 - solubility of 555
- Hydrochloric acid 248–249, 597
- as binary acid 250
 - dissolving basic hydroxides 352
 - dissolving in water 248
 - dissolving limestone 354
 - in formation of magnesium chloride 411
 - forming name of 256
 - in gastric juices 482
 - in processing corn syrup 235
 - production and use 71, 176, 249, 400, 501
 - reaction with calcium carbonate 300
 - as strong acid 251, 253, 254, 340
- Hydrofluoric acid
- forming name of 254
 - light bulbs and 401
 - used to make CFCs 400
- Hydrogen (H)
- in acid-base reactions 348–360
 - acids and 248–253
 - atomic orbitals 134–141
 - from Big Bang 718
 - in Brønsted-Lowry acids and bases 356–358
 - combustion 300, 321, 383
 - covalent bond formation 190
 - electronegativity of 524
 - formation from water 383
 - formation of hydrogen molecules 190
 - in formation of water 300–301
 - ion formation 182
 - isotopes of 92–93
 - nuclear fusion of 718
 - oxidation number of 378
 - position on periodic table 87
 - production and use 408, 597–600
 - structure 96
 - in synthesis gas 598
- 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 waveforms 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

- in ethanol/water solutions 552
 - predicting existence of 535
 - in proteins 658
 - Hydrogen bromide, threshold limit value, or TLV 498
 - Hydrogen carbonate ion
 - as amphoteric 359
 - as weak base 343
 - Hydrogen chloride 176
 - chemical bonds in 176
 - dipole-dipole attractions 523
 - dissolved in water 248
 - solubility in water 569
 - Hydrogen cyanide 597
 - molecular geometry of 213
 - Hydrogen fluoride
 - hydrogen bonds and 529
 - Hydrogen halides, as polar molecules 529
 - Hydrogen peroxide
 - aging and 376
 - composition of 175
 - dark bottles and 407
 - empirical and molecular formulas of 271
 - as oxidizing agent 376
 - 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** H_3O^+ 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
 - covalent bond formation 193
 - solubility of compounds with 317
 - Hydroxides** Compounds that contain hydroxide ions. 341
 - Hydroxyapatite, in tooth enamel 354
 - 3-Hydroxybutanal 645
 - 17-Hydroxyprogesterone, molecular structure of 662
 - Hypochlorite ion
 - in bleach 356
 - sunlight and swimming pools 405
 - Hypothesis, in scientific method 8–9
- ## I
- 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
 - Industrial chemistry 4, 5
 - Infrared (IR) radiation 131
 - Inner transition metals** The 28 elements at the bottom of the periodic table. 86
 - Insoluble substances 316–317, 554–557
 - Instantaneous dipole 532
 - Intermolecular attraction** Attraction between molecules. 529–533
 - dipole-dipole attraction 523
 - hydrogen bonds 529–531
 - London forces 532–533
 - Internal combustion engine 468
 - effects of weather on 474
 - gases and 468
 - International System of Measurement 10–19
 - abbreviations 13
 - metric prefixes 12–13
 - units derived from base units 12
 - Intestines 665
 - Intoxicating liquids 214
 - Iodide ion, solubility of compounds with 317
 - Iodine (I)
 - beta emission and 696
 - diatomic molecules of 97
 - electron capture and 697
 - London forces and 532
 - name of 83
 - production and use 399
 - structure of 97
 - tincture of 532
 - Iodine-125
 - electron capture by 712
 - radioactive decay of 697
 - iodine-131 706–707
 - Iodine pentafluoride, production and use 407, 451
 - Ion** Any charged particle, whether positively or negatively charged. 90–92
 - anion 91. *See also* Anion
 - cation 91. *See also* Cation
 - charges on monatomic 184
 - formation of 177
 - monatomic anion charges 182
 - monatomic anion names 236
 - monatomic cation. *See* Cation, monatomic
 - polyatomic. *See* Polyatomic ion
 - predicting charges 182–185
 - size of 185
 - spectator 315–316
 - symbols for 91
 - Ionic bond** The attraction between a cation and an anion. 177–179
 - in ionic compounds 180
 - predicting existence of 524–527
 - 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
 - formulas to names 239–241
 - names to formulas 242–243
 - polyatomic ions is 185–187
 - reactions of acids with 349
 - recognizing from formulas 239
 - solubility of 317
 - solution of 309–311
 - as strong and weak bases 343
 - structure of 185–187
 - types of 239
 - uses of 181, 186
 - 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)
 - electron configuration and orbital

- diagram for 150
formation of 719
formation of pig 382, 485
global warming and 430–431
as limiting reactant in global warming 430
- Iron(II) sulfate, in global warming experiments 431
- Iron(III) sulfate, formula mass calculations for 266, 268
- Iron-59 712
- Island of stability, of nuclides 695
- 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
of carbon 102
mass numbers of 93
in nuclear reactions 698
symbol for 692–693
- Isovaleraldehyde 641–642
- J**
- Jeans, James Hopwood 90
- 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
solution of ammonium nitrate and 322
velocity and 121
- Kinetic molecular theory. *See* Particle nature of matter
- Knockout drops 206
- Krypton, light bulbs and 475
- Krypton-81 693, 710
- L**
- Lactase, in digestion 664
- Lactic acid, in cosmetic lotion 368
- Lactose, or milk sugar 652
- Laskowski, Edward 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
resonance and 207–209
simple procedure 196–198
Study Sheet 198–199
- Libraries, of drugs 649
- Life
hydrogen bonds and 530
origin of 616–617
- Light bulbs
argon gas in 488
filament evaporation in 472, 475
flash tubes 499
fluorescent 497
- “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
heterogeneous equilibria and 606–607
- 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
 Lye. *See* Sodium hydroxide
 Lye soap 562
 Lysine (Lys, K)
 molecular structure of 655
 in salt bridges 658

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
 Measurement 9, 9–23
 digital readouts 23
 International System of 10–11
 reporting values from 20
 trailing zeros and 22
 uncertainty in 20–23, 39
 Medicine, uses of radioactive substances in 707–708
 Mega (M) prefix 13
 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
 sea of electrons model 99
 Meter 10, 11
 Methamphetamine, molecular structure of 558–559
 Methamphetamine hydrochloride 558–559
 Methane 187, 191
 combustion of 120
 covalent bond formation 191
 in hydrogen gas production 597–600
 molecular shape 210–211
 solubility in water 569
 Methanethiol, in natural gas 383
 Methanoic acid 640
 Methanol 187
 density of 50
 hydrogen bonds and 531
 as polar molecule 529
 production and use 408, 503, 603
 water solubility of 556
 Methionine (Met, M), structure of 655
 Methyl alcohol 196. *See also* Methanol
 Methyl bromide
 determining Lewis structure 200–201
 ozone layer and 3
 threshold limit value, or TLV, and 498
 3-Methylbutanal 641–642
 Methyl cyanoacrylate, molecular structure of 216
 Methylene chloride, in decaffeinating coffee 491
 Methyl ethyl ketone or MEK, molecular structure of 642
 2-Methylpropene 638
 Metric-metric unit conversions 35–37

- Metric prefixes 12–13
table of 13
- Metric system 10. *See also* International System of Measurement
- MeV (million electron volts) 713
- micro (μ) 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 Cl^- , O^{2-} , and 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 Na^+ , Ca^{2+} , and 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
rounding off for 40–45
significant figures for 40–45
- Mylar, as polyester 669
- N**
- Names
for acids 256–258
for binary covalent compounds 235
for chemical compounds 259–260
for elements 82–83
for ionic compounds 236–244
for organic compounds 637
- 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
resonance and 207–209
solubility of compounds with 317
- Nitric acid
acid rain and 255
formation of 616
forming name of 257
production and use 405
reaction with sodium hydroxide 349–351, 349–353
solution of 349
as strong acid 253
- Nitride ion, forming name of 236
- Nitril hydratase 597
- Nitrogen (N)
covalent bond formation 192
diatomic molecules of 97
electron configuration and orbital diagram 145
ion formation 182
liquid 127
London forces and 534
structure of 97
- Nitrogen-13, radioactive decay of 700
- Nitrogen-14, in radiocarbon dating 702
- Nitrogen dioxide
acid rain and 255
nitric acid and 616
threshold limit value, or TLV and 498
- Nitrogen molecules, velocities of 460
- Nitrogen monoxide 596
in acid rain 255
catalytic breakdown of 596
how made 472
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
- Note** 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
uses for radioactive (table) 712
- Numbers, exact or not 41
- Nutrients, for phytoplankton 430
- Nylon 667
molecular structure of 667
production of 275, 667–668
- Nylon-66 275–276
- O**
- “Oil rig” mnemonic 373
- Objectives 6
- Observation, in scientific method 8–9
- Octane rating 637
- Octet of electrons 189–190, 199–200
- Oil 354, 532–533
- 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
amide 644
amine 643–644
arene 638–639
carboxylic acid 640
condensed formula 635
ester 642–643
ether 641
how to describe 634–636
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
electronegativity of 524
in formation of water 300–301
in internal combustion engines 468
ion formation 182–183
oxidation numbers for 378
structure 97
- Ozone
chlorine catalyzed destruction 594–596
as greenhouse gas 430
process of destruction 586–590
- P**
- p* block, of elements 146–148
- 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
summary 534–535
- Particle nature of matter 76–80
gas 76, 79–80
liquid 76, 78
solids 76–77
- Particles
in atoms 89
attractive forces among 523–536
in collision theory 586
in condensation 510
in evaporation 511–512
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
in calculating molecular formulas 278
- 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

- metals, nonmetals, and metalloids 86
- modern model of the atom and 146–154
- periods 87
- representative (or main-group) elements, transition metals, and inner transition metals 86
- Periods** The horizontal rows on the periodic table. 87
- Peroxides, oxidation numbers of 378
- Petroleum 532–533
- pH 346–347
- acid rain and 346
- Pharmaceuticals 649
- Phenylalanine (Phe, F), molecular structure of 655
- Phosgene gas, production and use 631
- Phosphate, production 377
- Phosphate ion, solubility of compounds with 317
- Phosphate rock, in furnace method 261
- Phosphide ion 236
- Phosphoric acid 356
- forming name of 257
- furnace method of preparation 261
- neutralizing 436
- production of 414
- reaction with sodium hydroxide 352
- in toilet bowl cleaners 356
- uses 235, 250
- Phosphorus (P)
- covalent bond formation 193
- in furnace method 414
- ion formation 182
- London forces in 534
- in oxidation-reduction reactions 379
- in photophor 272
- production of 377, 454
- 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
- Physics
- chemistry and 76
- of electrons 132–141
- origin of matter and 616–617
- Phytoplankton, global warming and 430–431
- Pico (p) prefix 13
- Pig iron, formation of 485
- Plastic fingerprints 517
- Platinum (Pt) 98
- as catalyst 616
- in catalytic converters 385, 596
- 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
- predicting in molecules 524–528
- Polarity
- of amphetamine and epinephrine 558
- of bonds 524–525
- of capsaicin 559
- molecular 528
- predicting in molecules 528–529
- solubility and 554
- 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
- radioactive decay of 697
- uses for 697
- Potassium carbonate, empirical formula determination 274
- Potassium chlorate, production and use 444
- 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
- Study Sheet 318
- writing equations for 318–319

- 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
hydrogen bonds in 530
Lewis structure 196
molecular structure of 530
- 2-Propanone 642
- Propionic acid
molecular structure of 556
water solubility 556
- Proportionality
direct 463
inverse 463
- 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 nuclide 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
 metallurgical grade 425
 purifying 425–426
 from silicon dioxide 423
- Silicon dioxide
 citrine as 294
 in furnace method 261
 purifying silicon from 425–426
- 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
- Slaked lime 409
- Smelling salts 629
- Smog
nitrogen dioxide in 605
- Smoke detectors 711
- Soap 560, 562–563
- Society for Heavy-Ion Research 94
- Sodium (Na)
electrolysis and 391
formation from sodium chloride 383
ion 177–178
ion formation 182
- Sodium aluminum sulfate, in baking powder 175
- Sodium bromide, use 576
- Sodium carbonate
reaction with acid 343
uses 343
- Sodium chlorate, production and use 408
- Sodium chloride
electrolysis and 391
formation 178
formula mass of 265
formula unit of 264
oxidation-reduction and 372–373
solubility in water 569
solution in water 309–311
structure of 185, 185–186
taste of 345
- Sodium chromate 430
- Sodium dichromate, production and use 446, 454
- sodium dodecyl sulfate (SDS), as detergent 563
- Sodium fluoride, in toothpaste 181
- Sodium hydrogen carbonate
production and use 343, 405
reaction with acids 343
- Sodium hydrogen sulfate, production and use 453
- Sodium hydroxide
aqueous solution of 341
formation 185
in neutralizing phosphoric acid 436
reaction with nitric acid 349–353
uses of 185, 341
- Sodium hypochlorite, production 485, 528, 536, 556, 557
- Sodium ions 91
taste and 345
- 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
molarity and 431–438
rate of 565–568
agitation 567
factors that effect 565
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 representing 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
- Special conditions, in chemical equations 301–302
- Special topics
Acid Rain 255
A Greener Way to Spray Paint 490
Air Pollution and Catalytic Converters 385
A New Treatment for Brain Cancer 717
Be Careful with Bleach 356
Big Problems Require Bold Solutions - Global Warming and Limiting Reactants 430
Chemistry and Your Sense of Taste 345
Chemistry Gets the Bad Guys 517
Gas Solubility, Scuba Diving, and Soft Drinks 572
Global Warming, Oceans, and CO₂ Torpedoes 573
Green Chemistry 5
Green Chemistry - Making Chemicals from Safer Reactants 276
Green Chemistry - The Development of New and Better Catalysts 597
Green Decaf Coffee 491
Hard Water and Your Hot Water Pipes 320
Harmless Dietary Supplements or Dangerous Drugs 663
Molecular Shapes, Intoxicating Liquids, and the Brain 214
Olestra and Low-Fat Potato Chips 660–661
Oxidizing Agents and Aging 376
Precipitation, Acid-Base Reactions, and Tooth Decay 354
Recycling Synthetic Polymers 670
Rehabilitation of Old Drugs and Development of New Ones 649
Safe and Effective? 279
Saving Valuable Books 355
The Big Question - How Did We Get Here? 616
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
- Spinel 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 H^+ ions to water in a reaction that goes completely to products. Such a compound produces close to one H_3O^+ 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
- Studying chemistry 5
- Study Sheets
- abbreviated electron configuration 151–154
- assignment of oxidation numbers 378
- balancing chemical equations 303
- basic equation stoichiometry - converting mass of one substance in a reaction to mass of another 418–419
- calculating empirical formulas 273
- calculating molecular formulas 277
- calculations using unit analysis 54
- classification of matter 174
- combustion reaction 384
- converting between mass of element and mass of compound containing the element 270
- drawing Lewis structures from formulas 198–199
- electron configurations and orbital diagrams 149, 198
- electronegativity, types of chemical bonds, and bond polarity 526
- equation stoichiometry 418–419, 437, 483–484
- equation stoichiometry problems 437
- identification of strong and weak acids and bases 344
- limiting reactant problems 426
- predicting molecular geometry 215
- predicting precipitation reactions and writing precipitation equations 318
- rounding off numbers calculated using addition and subtraction 45
- rounding off numbers calculated using multiplication and division 41
- using Dalton's Law of Partial Pressures 488
- using the combined gas law equation 476
- using the ideal gas equation 471
- writing complete electron configurations 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
- combustion and 383
- covalent bond formation 194
- ion formation 182–183
- production 408
- use and production 501
- Sulfur dioxide
- acid rain and 255
- air pollution and 499
- in combustion reactions 383
- as pollutant and removal 454
- Sulfur hexafluoride, threshold limit value, or TLV 498
- Sulfuric acid 254
- acid rain and 255
- in acrylamide synthesis 597
- forming name of 257
- as oxyacid 250
- production 402
- reaction with sodium hydroxide 352
- as strong acid 254, 340
- uses 254
- Sulfur trioxide, in acid rain 255
- Sun, nuclear fusion and 718
- Supercritical carbon dioxide
- decaffeinating coffee and 491
- spray paint and 490
- Supercritical fluid 490

Super glue 216
 Supernovas 719
 Surface area, rate of solution and 565–566
 Sweet taste 345
 Symbols
 for elements 83
 for nuclides 692
 Synthesis gas 598
 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
 equilibrium constants and 608–609
 equilibrium vapor pressure and 516–517
 in evaporation 512–513
 Fahrenheit scale 18–19
 gases and 461
 Kelvin scale 18–19
 measuring 18
 normal boiling-point 521
 pressure and 464
 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
 Thortveitite 296
 Threonine (Thr, T), molecular structure of 655
 Threshold limit value, or TLV 498
 Time, base unit of 11
 Tin(II) sulfide, melting point of 60
 Tincture of iodine 532
 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
 length 14
 mass 16
 the importance of putting into equations 473
 volume 15
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
 gas stoichiometry and 481
 Study Sheet 54–55
 summary of 54–58
 Unit conversions 34–38, 132–136, 142–146, 267–271, 271–275, 414–418, 422–426

“something per something” 57
 common 54–58
 density and 49, 56, 477, 479–482, 527
 English-metric 37–38, 56
 metric-metric 35–37, 56
 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
 enrichment 427
 in fission reactors 716
 half-life 703

Uranium-238
 in fission reactors 716
 half-life 703
 nuclide symbol 693
 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
 kinetic energy and 121
 of particles in evaporation 511

Vinegar
 acetic acid in 250
 taste of 345

Vinyl chloride, in poly(vinyl chloride) 670

Visible fingerprints 517

Visible light 131

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
 salt bridge 390
 secondary battery 392
 zinc-air batteries 393

Volume (V) 15–16
 density and 47
 English-metric conversion factors for 38
 of gases 461
 of ideal gas particles 461
 measurement, graduated cylinder 21
 number of gas particles and 467
 pressure and 462–463
 range of 16
 temperature and 465

Volume unit, liter 12

W

Wächtershäuser, Günter 617

Water 172
 acids and 248–249, 251–252, 340–341
 ammonia and 341–342
 attractions 308
 bases and 341
 boiling point of 18–19, 521
 as compound 173
 condensation of 510–511
 in condensation reactions 665
 covalent bond formation 193
 density of 48
 dissolving sodium chloride in 310–311
 evaporation of 511
 hard 320
 heavy 59
 hydrogen bonds in 530
 ionizing radiation and 706–707
 liquid 308–309
 melting point of 18–19
 mixing with ethanol 552–553
 molecular shape 307–308
 in nylon formation 667
 pH of 347
 as polar molecule 308, 529
 producing hydrogen gas from 597–599
 in protein formation 656
 rate of solution in 565–569
 solubility in 554–559

Water dissociation constant (K_w) The equilibrium constant for the reaction:

$$\text{H}_2\text{O}(l) \rightleftharpoons \text{H}^+(aq) + \text{OH}^-(aq)$$
 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 H_3O^+ 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
- Weather balloon 478
- Web site
- for acid-base titration 438
 - for acid nomenclature 257
 - for animation of acid-base reaction 353
 - for animation of a single-displacement reaction 386
 - for animation of dissolving ethanol in water 553
 - for animation of element structure 98
 - for animation of precipitation reaction 316
 - for animation of solution of sodium chloride 310
 - for animation of strong and weak acids 254
 - for animation of the particle nature of matter 80
 - for animation of water structure 309
 - for balancing redox equations 382, 386
 - for calculating element percentages 271
 - for changing volume and gas reactions 613
 - for combustion analysis 278
 - for conversion between element names and formulas 83
 - for different electron configurations 154
 - for enzyme mechanism 666
 - for equilibrium calculations, including pH 609
 - for isotope notation 94
 - for gas stoichiometry shortcut 482
 - for how addition polymers are made 669
 - for London forces and polar molecules 534
 - for mixtures and equation stoichiometry 421
 - for polyatomic ions 238
 - 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
- X**
- X-ray crystallography 649
 - X-rays 131
 - Xenon (Xe), reactions 406
 - Xenon difluoride 443
- Y**
- Yield. *See* Actual yield, Theoretical yield, and Percent yield
- Z**
- Zeros and significant figures 42
 - Zinc (Zn) 98
 - batteries and 388–391
 - reaction with copper sulfate 386–387
 - single-displacement reaction and 386–387
 - voltaic cells and 388–390
 - Zinc-air batteries 393
 - Zinc oxide
 - in book preservation 355
 - oxidation-reduction and 372–373
 - in zinc-air batteries 393
 - Zinc phosphate 306

