

# GLOSSARY/INDEX

## A

Abbreviated electron configuration, of multi-electron atoms 433–436

**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

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Acetamide 668

Acetate ion, solubility of compounds with 183

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**Acidic solution** A solution with a significant concentration of hydronium ions,  $\text{H}_3\text{O}^+$ . 202

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Acrylamide 621

Activated complex 611

**Activation energy** The minimum energy necessary for reactants to reach the activated complex and proceed to products. 612

**Active site** A specific section of the protein structure of an enzyme in which the substrate fits and reacts. 690

**Actual yield** The amount of product that is actually obtained in a chemical reaction. 382

Adams, Mike 674

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). 693–694

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**Alcohol** Compounds that contain a hydrocarbon group with one or more  $-\text{OH}$  groups attached. 126, 663. *See also* Methanol, Ethanol, and 2-propanol  
hydrogen bonds and 555

**Aldehyde** A compound that has a hydrogen atom or a hydrocarbon group connected to a  $-\text{CHO}$  group. 665

Aldol, molecular structure of 669

Alka-Seltzer 526

**Alkaline earth metals** Group 2 (or 2A) on the periodic table; *See also* Beryllium, Magnesium, and Calcium 85  
ion charges of 139

**Alkali metals** Group 1 (or 1A) on the periodic table; *See also* Lithium, Sodium, Potassium, and Cesium 85  
ion charges of 138–139

**Alkane** A hydrocarbon (a compound composed of carbon and hydrogen) in which all of the carbon-carbon bonds are single bonds. 661

**Alkene** A hydrocarbon that has one or more carbon-carbon double bonds. 662

**Alkyne** A hydrocarbon that has one or more carbon-carbon triple bonds. 662

**Alpha emission** The process of releasing an alpha particle by atoms that have too many protons to be stable. 720  
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Alpha helix 680–681

**Alpha particle** The emission from radioactive nuclides that is composed of two protons and two neutrons in the form of a helium nucleus. 720  
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Aluminum fluoride, production and use 401

Aluminum hydroxide, dissolving in acid 226

Aluminum oxide 174

- Aluminum sulfate  
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- Amide** A compound with the general formula  $RCONR$ , in which each R represents hydrogen atoms or hydrocarbon groups. 668  
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 as peptide bond 680
- Amine** A compound with the general formula  $R_3N$ , in which R represents a hydrogen atom or a hydrocarbon group (and at least one R group being a hydrocarbon group). 667–668
- 1-Aminobutane 667
- Aminopeptidase 688
- Amino acid The monomer that forms the protein polymers. They contain an amine functional group and a carboxylic acid group separated by a carbon. 678–679  
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- Ammonia 215–216  
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- Ammonium chloride, crystal structure of 143
- Ammonium ion  
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- Ammonium nitrate, in cold packs 306
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- Ammonium phosphate, fertilizers and 255
- Ammonium sulfide, use 150
- Amount of substance, base unit of 10
- Amphere, as unit of measure 11
- Amphetamine 582
- Amphoteric substance** A substance that can act as either a Bronsted-Lowry acid or a Bronsted-Lowry base, depending on the circumstances. 233
- Amylase 688
- Amylopectin 676–677
- Amylose 676–677
- Analogies, to electron behavior 414
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- Androstenedione 686, 687
- Aniline, production and use 399, 402
- Animal fat 585
- Anion** An ion formed from an atom that has gained one or more electrons and thus has become negatively charged. 91  
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 in classifying types of compounds 120  
 in ionic bond formation 117–118  
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- Anode** The electrode at which oxidation occurs in a voltaic cell. It is the source of electrons and is the negative electrode. 267
- Antacid 168, 506
- Antarctica, ozone hole over 313
- Anthropogenic sources, of methyl bromide 314
- Anti-electron (positron) 437
- Antimatter 437
- Antioxidant, aging and 254
- Antiparticle 437
- Antiseptic, iodine as 556
- Application, in scientific method 8–9
- Aquamarine 362
- Aqueous solution** A solution in which water is the solvent. 176
- Arene** (or aromatic compound) A compound that contains the benzene ring. 662–663
- Arginine (Arg, R), structure of 680
- Argon  
 in air 510  
 in incandescent light bulbs 496  
 in neon lights 509
- Aromatic.** *See* Arene A compound that contains the benzene ring.
- Aromatic compounds Compounds that contain the benzene ring. *See* Arene
- Arrhenius, Svante August 202
- Arrhenius acid According to the Arrhenius theory, any substance that generates hydronium ions,  $H_3O^+$ , when added to water. 202–209. *See also* Acid  
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- Arrhenius base** A substance that produces hydroxide ions,  $OH^-$ , when added to water. 216–220. *See also* Base  
 compared to Bronsted/Lowry bases 230–234  
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- Arsenic (As)  
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- Asparagine (Asn, N), structure of 680
- Aspartame 705, 711
- Aspartic acid (Asp, D)  
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- Asphalt, London forces in 556–557
- Asymmetry, in polar molecules 552, 553
- Atmosphere, layers 310
- Atmosphere (atm), as unit of pressure 485
- Atmospheric pressure 485  
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- Atom** The smallest part of the element that retains the chemical characteristics of the element itself. 88–90  
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 oxidation numbers of 255–262  
 protons, neutrons, and electrons 89  
 radioactive decay of 720–724

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size of nucleus 89  
structure of 88–92
- Atomic mass** The weighted average of the masses of the naturally occurring isotopes of an element.  
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relative 333
- 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, 332–333
- Atomic number** The number of protons in an atom's nucleus. It establishes the element's identity. 93  
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- Atomic orbitals  
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2p 421  
2s 419–420  
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- Atomic weight 333. *See also* Atomic mass
- Attraction. *See also* Gravitational attraction; Electrostatic attraction; Strong force; Particle-particle attractions  
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particle-particle attraction 547–562
- Aurum 83
- Automobile Exhaust 113
- Average, weighted 331
- Avogadro's Law** Volume and the number of gas particles are directly proportional if the temperature and pressure are constant. 491
- Avogadro's number** The number of atoms in 12 g of carbon 12. To four significant figures, it is  $6.022 \times 10^{23}$ . 333–334
- B**
- Bacon, Roger 33
- Bacteria 278
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- Baking powder 115
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- Balancing chemical equations 170–175  
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- Ball-and-stick model** A representation of a molecule that uses balls for atoms and sticks for covalent bonds. 96  
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for acetylene 471  
for boron trifluoride 470  
for ethane 471  
for methane 468  
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- Band of stability** On a graph of the numbers of neutrons versus protons in the nuclei of atoms, the portion that represents stable nuclides. 719
- Barium ion, solubility of compounds with 183
- Barium sulfate 185
- Barnes, Randy 687
- Base 215–219. *See also* Arrhenius base  
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weak 216–217
- 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<sup>-</sup>. 215
- 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. 266–271. *See also* Voltaic cell  
defined 266, 267  
dry cell 268–269  
nickel-cadmium batteries 270  
rechargeable 270  
zinc-air 271
- Beef fat 584–585
- Bends, the 596
- Benitoite 362
- 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. 469
- Benzedrine 582
- Benzene 351
- Berkelium (Bk) 725
- Beryllium (Be)  
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- Beta emission** The conversion of a neutron to a proton, which stays in the nucleus, and an electron, called a beta particle in this context, which is ejected from the atom. 720  
nuclear equations for 723–725
- Beta particle** A high-velocity electron released from radioactive nuclides that have too many neutrons. 720  
effects on body 730–731  
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- Beta sheet 680
- Big Bang 742
- 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). 204  
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- Binary covalent compound** A compound that consists of two nonmetallic elements.  
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recognizing from names 135  
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writing formulas 135–136
- Binary ionic compound** An ionic compound whose formula contains one symbol for a metal and one symbol for a nonmetal. 146

- Binding energy** The amount of energy released when a nucleus is formed. 737
- Biocatalyst 621
- Biochemistry The chemistry of biological systems. 674–687
- Biomolecule 674–687  
amino acids and protein 678–682  
carbohydrate 674–677  
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- Bleach  
dangerous combination with acid 230  
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- Blocks, in periodic table 428–429
- Blood  
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- Blue litmus paper, detecting acids with 222
- Boiling** The conversion of liquid to vapor anywhere in the liquid rather than just at the top surface. 542–546  
defined 544  
how bubbles form 542–544
- 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. 544  
effect of external pressure 544–546  
strengths of attractions and 546
- Bond. *See* Chemical bond
- Bond angle** The angle formed by straight lines (representing bonds) connecting the nuclei of three adjacent atoms. 128, 468
- Bond dipole** A polar covalent bond, which has an atom with a partial positive charge and an atom with a partial negative charge. 549
- Bond polarity, predicting 548–552
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nuclear plant control rods and 740
- Boron trifluoride 453
- Bovine pancreatic trypsin inhibitor (BPTI) 680–682
- 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. 486–487
- Brain, intoxicating liquids and 131
- Brain cancer, treatment for 741
- Brandes, Jay A. 641
- Breathing 493
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- Bromine (Br)  
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- Bromomethane, and threshold limit value, or TLV 522
- Brønsted-Lowry acid** A substance that donates protons,  $H^+$ , in a Bronsted-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 Bronsted-Lowry acid-base reaction. *See* Base, Brønsted-Lowry
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- Calcium hydrogen sulfite, production and use 285
- Calcium nitrate 150, 179–180
- Calcium phosphide (or photophor), empirical formula for 348
- Calorie (with an uppercase C), Cal**  
The dietary calorie. In fact, a Calorie is a kilocalorie or 4184 joules. 299
- calorie (with a lowercase c), cal** A common energy unit. Equivalent to 4.184 joules. 299
- Cancer, boron fusion and 741
- Capsaicin 583
- Carbohydrate** Sugar, starch, and cellulose. Also called saccharides. 674–677
- Carbon-13 733
- Carbon-14, radioactive decay of 733
- 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. 733–734
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  - incomplete combustion and 263
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  - in synthesis gas 622
- Carbon tetrachloride, use and production 526
- Carboxylic acid** A compound that have a hydrogen atom or a hydrocarbon group connected to a -COOH (or -CO<sub>2</sub>H) group. 204, 227, 664
  - in acid-base reactions 227
  - forming name of 211
- Carboxypeptidase, in digestion 688
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- Catalyst** A substance that speeds a chemical reaction without being permanently altered itself. 312, 618–621, 621
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  - green chemistry and 621
  - homogeneous and heterogeneous 620–621
  - nitrogen oxides as 312
  - in producing hydrogen gas 622
- Catalytic converter 263, 620–621
- Cathode** The electrode at which reduction occurs in a voltaic cell. It is the
  - positive electrode. 267
- Cation** An ion formed from an atom that has lost one or more electrons and thus has become positively charged. 91
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  - Celsius to Kelvin conversion 58–60
- Cesium (Cs), electron configuration of 434
- Cesium-137 730
- Cesium chloride, crystal structure of 143–144
- 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). 693
- Chain reaction** A process in which one of the products of a reaction initiates another identical reaction. 739
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  - in hydrogen bonds 553
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  - in London forces 556
  - in molecules 552–553
  - in water molecules 129
- Charge cloud, for electrons 90, 418–421
- 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. 489
- Chemical bond** An attraction between atoms or ions in chemical compounds. Covalent bonds and ionic bonds are examples. 115–119. *See also* Ionic bond; Covalent bond
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  - net ionic 182
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- Chemical equilibrium. *See* Equilibrium
- Chemical formula** A concise written description of the components of a chemical compound. It identifies the elements in the compound by their symbols and indicates the relative number of atoms of each element with subscripts. 112–113. *See also* Chemical nomenclature
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- Chemical reaction** The conversion of one or more pure substances into one or more different pure substances. 168
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  - reversible 205, 621–622
  - reversible reaction and equilibrium 621–625
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- Chemistry** The structure and behavior of matter. 4. *See also* Organic chemistry; Biochemistry
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  - Green. *See* Green Chemistry
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- Chlorofluorocarbon, CFC** Compound composed of just carbon, chlorine, and fluorine. 312–314
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- Coefficients** The numbers in front of chemical formulas in a balanced chemical equation. 169
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- Collision theory** A model for the process of chemical change. 610–616, 658–664, 674–680, 688–696, 716–722
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- Combination (or synthesis) reaction** The joining of two or more elements or compounds into one product. 260
- Combinatorial chemistry 673
- Combined gas law equation 500
- Combustion analysis, empirical and molecular formulas from 353
- Combustion reaction** Rapid oxidation accompanied by heat and usually light. 261–262
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- Complete (or molecular) equation** A chemical equation that includes uncharged formulas for all of the reactants and products. The formulas include the spectator ions, if any. 182
- Complete combustion 261–262
- Complete electron configuration 430–432
- 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. 181
- Completion reaction 206
- Compound** A substance that contains two or more elements, the atoms of these elements always combining in the same whole-number ratio. 112
- binary covalent 132
  - binary ionic 146
  - classification 120
  - element versus 112
  - ionic 120
  - molar masses of 337–341
  - molecular 120
  - as pure substance 112–115
- 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). 617  
 disruption of equilibrium and 634  
 equilibrium constants and 626–629  
 rate of reaction and 617–618
- Condensation** The change from vapor to liquid. 534  
 dynamic equilibrium between evaporation and 537–539  
 rate of 537
- Condensation (or step-growth) polymer** A polymer formed in a reaction that releases small molecules, such as water. This category includes nylon and polyester. 691
- 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. 680
- Condensed formula 659
- Confirmation, in scientific method 9
- Conjugate acid** The molecule or ion that forms when one  $H^+$  ion is added to a molecule or ion. 231
- Conjugate acid-base pair** Two molecules or ions that differ by one  $H^+$  ion. 231–232
- Conjugate base** The molecule or ion that forms when one  $H^+$  ion is removed from a molecule or ion. 232
- Conservation of Energy, Law of 294
- 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. 740
- Conversion factor** A ratio that describes the relationship between two units. 34–36  
 atomic mass as 335  
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 English-metric 38  
 in equation stoichiometry 372  
 formula mass as 340  
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 metric-metric 35  
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- Cooling, in evaporation 536–537
- Copper(II) ion, voltaic cells and 266–268
- Copper(II) oxide, in catalytic converter 263
- Copper sulfate, reaction with zinc 264–265
- Corliss, Jack 641
- Corundum 359
- Counting by weighing 331–333
- Covalent bond** A link between atoms that results from their sharing two electrons. 96  
 common bonding patterns 454  
 double bonds 125  
 formation of 116  
 most common bonding patterns 455  
 polar or nonpolar 548  
 triple bond 125
- Covalent bonding patterns 454–455
- Creatine 687
- Critical temperature 514
- Cronenberg, David 7
- Crude oil 556–557
- Crystals** Solid particles whose component atoms, ions, or molecules are arranged in an organized, repeating pattern. 181
- Cubic centimeter 15
- Cubic meter 12
- Cyanide ion, determining Lewis structure 461–462
- Cycle, in electromagnetic radiation 303
- Cyclopropane 713
- Cysteine (Cys, C)  
 disulfide bonds between 681  
 structure of 680
- D**
- d* block, on periodic table 428–429
- Dacron, as polyester 693
- 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. 509–513, 547–551, 621–625
- Dead Sea Scrolls 734
- Decaffeination 515
- 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. 261
- Denature To change the tertiary structure of a protein, causing it to lose its natural function. 689
- Density, mass** Mass divided by volume. 47–51  
 calculating for gases 498  
 of common substances 48  
 definition 47  
 determination of 50–51  
 substance identification and 48  
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- Designing Safer Chemicals Award 5
- Detergent 587  
 cleaning with 586–587  
 pH and 221
- Deuterium 92–93  
 in heavy water 59
- DEZ treatment 229
- Diamond 89  
 atoms in 90, 334  
 London forces in 558–559
- Diatomic** Composed of paired atoms. The diatomic elements are  $H_2$ ,  $N_2$ ,  $O_2$ ,  $F_2$ ,  $Cl_2$ ,  $Br_2$ , and  $I_2$ . 97
- Dichlorine monoxide, production and use 289
- Dichloromethane, in decaffeinating coffee 515
- Dietary calorie, Cal Equivalent to 4.184 kJ 299
- Dietary Supplement and Health Act of 1994 687
- Diethyl ether, structure of 665
- Diethyl zinc (DEZ), in book preservation 229
- Difference in electronegativity, in predicting bond type and polarity 548–549
- Digestion** The process of converting large molecules into small molecules that can move into the blood stream to be carried throughout the body. 688–690
- Digestive enzymes 688–690
- Digital readouts 23
- Dihydrogen phosphate, as amphoteric 233
- Dimensional analysis. *See* Unit analysis
- Dimethyl ether, Lewis structure for 464
- Dipole** A molecule that contains an asymmetrical distribution of positive and negative charges.  
 bond 549  
 induced 556–557  
 instantaneous 556–557

- Dipole-dipole attraction** The intermolecular attraction between the partial negative end of one polar molecule and the partial positive end of another polar molecule. 547  
hydrogen bonds and 554  
London forces and 556
- Diprotic acid** An acid that can donate two hydrogen ions per molecule in a reaction. 204
- Dirac, Paul Adrien 437
- Direct-contact method 515
- Disaccharide** Sugar molecule composed of two monosaccharide units. 676  
digestion products 688
- Dispersion forces. *See* London forces
- Disproof, in scientific method 9
- Disruption of equilibrium 634–640  
catalysts and 638–639  
concentrations and 634–637  
Le Chatelier's Principle 638–640
- Distance, between particles of gases 484
- Distillation, of salt water 81
- Disulfide bond** A covalent bond between two sulfur atoms on cysteine amino acids in a protein structure. 681
- Division, rounding off for 40
- DNA (deoxyribonucleic acid)  
aging and 254  
hydrogen bonding in 554
- Dolomite rock, hard water and 186
- Dopamine, Parkinson's disease and 8
- Double-displacement reaction** A chemical reaction that has the form:  
 $AB + CD \rightarrow AD + CB$  178  
acid-base 226  
precipitation 178–181
- 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. 125, 451
- Dow Chemical Company 314
- Dry cell battery, chemistry of 268–269
- Dry ice 576
- 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 691
- Earth, elemental composition of 743
- Electric cars, zinc-air batteries in 271
- Electric current, base unit of 11
- Electric field, in electromagnetic radiation 303
- Electric power plant, using nuclear fission 738–741
- Electric spark, ozone created by 308
- Electrode** A electrical conductor placed in the half-cells of a voltaic cell. 267
- 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. 269
- Electrolyte The portion of a voltaic cell that allows ions to flow. 268
- Electromagnetic radiation. *See* Radiant energy
- Electron** A negatively charged particle found outside the nucleus of an atom. 90, 414–418  
in atoms 90–92  
in batteries 266  
as beta decay 720–721  
in chemical bonds 116, 448–454  
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electronegativity and 548  
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in metallic elements 98  
in multi-electron atoms 424  
octets of 122  
in oxidation-reduction reactions 250–253  
particle interpretation of the wave character 418  
as standing wave 416  
valence 121  
waveform of 416
- Electron-dot symbol** A representation of an atom that consists of its elemental symbol surrounded by dots representing its valence electrons. 121–122, 125, 450
- Electronegativity** A measure of the electron attracting ability of an atom in a chemical bond. 548–551  
Study Sheet 550
- 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. 721  
nuclear equations for 723–725
- Electron cloud 90, 418
- Electron configuration** A description of the complete distribution of an element's electrons in atomic orbitals. 424, 426–427  
abbreviated 433–436  
Study Sheet 431, 456
- 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. 469
- Electron sharing, in chemical bonds 116
- Electron spin 424, 426
- Electron transfer, in chemical bond formation 117–118
- Electron volt (eV)** An energy unit equivalent to  $1.6 \times 10^{-19}$  joules. It is often used to describe the energy associated with nuclear changes. 737
- Electroplating 269
- Electrostatic force (or electromagnetic force)** The force between electrically charged particles. 718
- 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  
artificial 94  
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 symbols for 83  
 table of percent abundances in  
 Earth's crust, waters, and atmosphere 743
- Element 111, creation of 94  
 Element 114, creation of 94  
 Emerald 362
- Empirical formula** A chemical formula that includes positive integers that describe the simplest ratio of the atoms of each element in a compound. 346  
 calculating 346–350  
 converting to molecular formula 350–353  
 Study Sheet 348
- Enamel 228
- Endergonic changes Changes that absorb energy 295  
 energy diagram 614–615
- Endothermic change** A change that leads a system to absorb heat energy from the surroundings. 307
- Energy** The capacity to do work. 292–294  
 activation 612–614  
 chemical bonds and 295–296  
 chemical changes and 305–307  
 conservation of. *See* Law of Conservation of Energy  
 endergonic (or endogonic) changes 295  
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- English system, metric system versus 14, 37
- Environment, chemistry and 4  
 Environmentally Benign Chemistry. *See* Green Chemistry  
 Environmental Protection Agency 5, 728
- Enzyme** A naturally occurring catalyst. 618, 688–690  
 digestive 688–690  
 metallic cations in 142  
 why specific 690
- Epictetus 34  
 Epinephrine 582
- 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 371–375  
 ideal gases and 502–509  
 molarity and 388–392  
 Study Sheet 391
- Equilibrium 621–622  
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 heterogeneous 630–631  
 homogeneous 624  
 Le Chatelier's Principle and 638–640  
 reversible reactions and 621–633  
 saturated solution and 592–593  
 ski shop analogy for 625
- Equilibrium constant** A value that describes the extent to which reversible reactions proceed toward products before reaching equilibrium. 626–629  
 calculating values for 627–628  
 extent of reaction and 629  
 with heterogeneous equilibria 630–632  
 table of 628  
 temperature and 632–633  
 writing expressions for 626–627
- Equilibrium constant expression** An expression showing the ratio of the concentrations of products to the concentrations of reactants for a reversible reaction at equilibrium. 626
- 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. 539–540  
 in bubble formation 543–544  
 temperature and 540
- Ester** A compound with two hydrocarbon groups surrounding an oxygen atom. 666–667  
 in fingerprints 541  
 olestra as 684–685
- Estradiol, structure of 686
- Ethanamide 668
- Ethane 124  
 solubility in hexane 581
- 1,2-Ethandiol 663
- Ethanoic acid 664
- Ethanol (or ethyl alcohol)  
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 hydrogen bonds in 554–555  
 as intoxicating liquid 131  
 Lewis structure 126  
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- Ethene. *See* Ethylene
- Ether** A compound with two hydrocarbon groups surrounding an oxygen atom. 665
- Ethylene (or ethene) 451  
 polyethylene formation and 693
- Ethylene dibromide 314
- Ethylene glycol 663  
 in polyester formation 692
- Ethylene oxide, use and production 527
- Ethyl alcohol. *See* Ethanol
- Ethyl butanoate 667
- Ethyne. *See* Acetylene
- Evaporation** The conversion of a liquid to a gas. 79, 535–536  
 cooling and 536  
 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. 421
- Exercises, in this book 6

- Exergonic changes** Changes that release energy. 296  
energy diagram 614
- Exhaust 113
- Exhaust systems, catalytic converters and 263
- Exothermic change** A change that leads to heat energy being released from the system to the surroundings. 306
- Expansion, of solids 77
- Experimentation, in scientific method 8–9
- External kinetic energy 301
- F**
- f*block, of elements 429
- 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 683  
digestion products 688
- Fertilizer  
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- Feynman, Richard 418
- 15-minute rule 6, 7
- Fingerprints 541
- Fireworks  
calcium nitrate in 150  
light emitted from 421
- Fire extinguishers, sodium carbonate in 217
- Fission** Nuclear reaction that yields energy by splitting larger atoms to form more stable, smaller atoms. 738–739
- Flame retardant, phosphates in 145
- Flashtubes 523
- Flerov Laboratory of Nuclear Reactions 94
- Fluorapatite, tooth decay and 228
- Fluoride ion, tooth decay and 228
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- Fluorine-18  
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- Food and Drug Administration (FDA) 515
- Food irradiation 735
- Force, weight as 16
- Forensic chemistry 541
- Formaldehyde 652, 665  
determining Lewis structure 460–461  
in herbicide formation 621  
production and use 279, 653
- Formic acid, molecular structure of 664
- Formula. *See* Chemical formula; Empirical formula; Molecular formula
- 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. 340–341  
calculations 341
- 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. 339
- Fortrel (registered trademark) 693
- Fractional charge, in chemical bonds 116
- France, zinc-air batteries in 271
- Free radicals** Particles with unpaired electrons. 730
- Fructose 674–675
- Functional group** A small section of an organic molecule that to a large extent determines the chemical and physical characteristics of the molecule. 662
- Furnace method 368
- Fusion** Nuclear reaction that yields energy by combining smaller atoms to make larger, more stable ones. 738, 742
- G**
- Galactose 674–675
- Galapagos Islands, global warming experiments at 385
- Galileo Galilei 9
- Gallium-67, radioactive decay of 724
- Galvanizing nails 174
- Gamma aminobutanoic acid, gamma aminobutyric acid, or GABA 669  
intoxicating liquids and 131
- Gamma ray** A stream of high-energy photons. 303, 722  
antimatter and 437  
harmful effects of 730–731  
penetration of the body 731  
in radioactive decay 722
- Gas** The state in which a substance can easily change shape and volume. 76, 79–80. *See also* Gas pressure; *See also* Gas  
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- in gas stoichiometry 502–509
- in ideal gas equation 494
- internal combustion engine and 492
- number of gas particles and 490
- standard 503
- temperature and 488
- volume and 486–487
- Gas stoichiometry 502–509
- 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. 488
- Geometric sketch 128
- Geometry 467–471. *See* Molecular shape
- Study Sheet 472
- German Cancer Research Center 94
- Gesellschaft für Schwerionenforschung (GSI) 94
- Gide, Andre 75
- Giga (G) prefix 13
- Girard, Georges 11
- Glacial acetic acid 204
- Glioma 741
- Global warming 384–385, 597, 621, 673, 687, 741
- Glucose 674–675
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- Glutamic acid, structure of 680
- Glutamine, structure of 680
- Glycerol or glycerin 663
- Glycine, structure of 678
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- Gold-198, radioactive decay of 724
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- Greenhouse gases 384, 597
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- Green Chemistry Challenge Awards 5
- Green Chemistry Program 5
- Making Chemicals from Safer Reactants 351
- Sea-Nine antifoulant and 5
- spray paint and 514
- Ground state** The condition of an atom whose electrons are in the orbitals that give it the lowest possible potential energy. 421
- Group** All the elements in a given column on the periodic table; also called family. 85
- Guitar strings, like electrons 414–416
- H**
- Half-life** The time it takes for one-half of a sample to disappear. 726–728
- Half-reaction** Separate oxidation or reduction reaction equation in which electrons are shown as a reactant or product. 252
- Halogen
- bonding pattern 123
- covalent bond formation 454
- ion formation 137
- London forces in 556–557
- in periodic table 85
- Halons 314
- Hard water, soaps and detergents in 587
- Hearst, William Randolph 209
- Heat** The thermal energy that is transferred from a region of higher temperature to a region of lower temperature as a consequence of the collisions of particles. 302
- in chemical equations 170
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- as energy 302
- transfer 301–302
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- Heavy water, freezing point of 59
- Heidelberg Radiology Clinic 94
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- Helium-4, in treating brain cancer 741.
- See also* Alpha particles
- Hematite 363
- Hemoglobin 263
- carbon monoxide poisoning and 263
- iron ions in 142
- Heptane, octane rating and 661
- Heterogeneous catalyst** A catalyst that is in the same phase as the reactants (so that all substances are gases or all are in solution). 620
- Heterogeneous equilibrium** An equilibrium in which the reactants and products are not all in the same phase (gas, liquid, solid, or aqueous). 630–631
- Hexane, solubility in 578–581
- 1-Hexanol 660
- 3-Hexanol, molecular structure of 660
- High-density polyethylene (HDPE) 693
- Histidine, structure of 680
- Homogeneous catalyst** A catalyst that is in the same phase as the reactants (so that all substances are gases or all are in solution). 620
- Homogeneous equilibrium** An equilibrium system in which all of the components are in the same phase (gas, liquid, solid, or aqueous). 624
- Hormone 685
- Huber, Claudia 641
- Hydrazine, production and use 410
- Hydride ion 140

- Hydriodic acid  
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- Hydrobromic acid, forming name of 210
- Hydrocarbon** Compounds that contain only carbon and hydrogen. 124, 556  
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- Hydrochlorofluorocarbons (HCFCs) 314
- Hydrofluoric acid  
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- Hydrogenation** A process by which hydrogen is added to an unsaturated triglyceride to convert double bonds to single bonds. This can be done by combining the unsaturated triglyceride with hydrogen gas and a platinum catalyst. 683
- Hydrogen (H)  
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 oxidation number of 256  
 position on periodic table 87  
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 in synthesis gas 622
- Hydrogen atom, electron waveforms in 416–423
- 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. 553–555  
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- Hydrogen bromide, threshold limit value, or TLV 522
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- Hydrogen sulfate ion 230  
 as cleaning agent 230  
 as weak acid 208
- Hydrogen sulfide  
 Lewis structure of 123  
 threshold limit value, or TLV 522
- 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. 689
- Hydronium ion  $\text{H}_3\text{O}^+$  202–203  
 in acid-base reactions 222–227  
 acids and 202–208  
 pH and 220–222
- Hydrophilic (“water loving”)** A polar molecule or ion (or a portion of a molecule or polyatomic ion) that is attracted to water. 582
- Hydrophobic (“water fearing”)** A nonpolar molecule (or a portion of a molecule or polyatomic ion) that is not expected to mix with water. 582
- Hydrothermal vent 641–642
- Hydroxide ion  
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- Hydroxides** Compounds that contain hydroxide ions. 215
- Hydroxyapatite, in tooth enamel 228
- 3-Hydroxybutanal 669
- 17-Hydroxyprogesterone, molecular structure of 686
- Hypochlorite ion  
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- Ideal Gas** A gas for which the ideal gas model is a good description. 485  
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- Ideal gas constant (R) 494
- Ideal Gas Equation 494–499  
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- 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. 485
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- Induced dipole 556
- Industrial chemistry 4, 5
- Infrared (IR) radiation 304
- Inner transition metals The 28 elements at the bottom of the periodic table. 86
- Insoluble substances 182–183, 578–581
- Instantaneous dipole 556
- Intermolecular attraction** Attraction between molecules. 553–557  
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 Iodine-125  
   electron capture by 736  
   radioactive decay of 721  
 iodine-131 730–731  
 Iodine pentafluoride, production and use 285, 405  
**Ion** Any charged particle, whether positively or negatively charged. 90–92  
   anion 91. *See also* Anion  
   cation 91. *See also* Cation  
   charges on monatomic 140  
   formation of 117  
   monatomic anion charges 138  
   monatomic anion names 140  
   monatomic cation. *See* Cation, monatomic  
   polyatomic. *See* Polyatomic ion  
   predicting charges 137–140  
   size of 142  
   spectator 181–182  
   symbols for 91  
**Ionic bond** The attraction between a cation and an anion. 117–119  
   in ionic compounds 120  
   predicting existence of 548–551  
**Ionic compound** A compound that consists of ions held together by ionic bonds. 120, 136–150  
   as bases 217  
   binary 146, 149, 250–252  
   formulas to names 146–148  
   formula mass of 340–341

names to formulas 149–150  
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 solubility of 183  
 solution of 175–177  
   as strong and weak bases 217  
   structure of 142–144  
   types of 146  
   uses of 136, 144  
**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. 730  
 Iridium (Ir), in catalytic converter 263  
 Iridium-192, checking pipe joints and 735  
 Iron(II) sulfate, in global warming experiments 385  
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   as limiting reactant in global warming 384  
 Island of stability, of nuclides 719  
 Isobutene, use 662  
 Isoleucine (Ile, I), molecular structure of 678  
**Isomers** Compounds that have the same molecular formula but different molecular structures. 464  
   Lewis structures of 464–465  
   of organic compounds 658  
 Isooctane 661  
 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  
   of artificial elements 94  
   atomic numbers of 93  
   of carbon 333  
   mass numbers of 93  
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**J**

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 Kelvin, a temperature unit 19  
 Kelvin scale 11, 18–19  
   gas temperature and 485  
   temperature conversions for 58–60  
 Kerosene, London forces and 556  
**Ketone** A compound that have a hydrogen atom or a hydrocarbon group connected to a -CHO group. 666  
 Kettering, Charles F. 414  
 Khirbat Qumrân 734  
 Kilocalorie (kcal, Cal) 299  
 Kilogram (kg) 11  
 Kilojoule (kJ) 300  
 Kilometer (km) 13  
 Kilopascal (kPa) 485  
 Kilo (k) prefix 13  
**Kinetic energy, KE** The capacity to do work resulting from the motion of an object. 293  
   chemical reactions and 305–306  
   in formation of water 305  
   internal and external 301  
   mass and 293  
   of reactant molecules 611–612  
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 Lactose, or milk sugar 676  
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**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. 294  
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- Lead(II) ion, solubility of compounds with 183
- lead-206, in radioactive decay series 729
- Lead-acid batteries, chemistry of 271
- Lead (Pb)  
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- Leclanché cell 268–269
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- Leucine (Leu, L), structure of 678
- Levi, Primo 3
- Levodopa, in Parkinson's disease 8
- Levodopa, in Parkinson's disease 8
- Lewis electron-dot symbols 121
- 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. 122–126, 450, 455–465  
general steps for drawing 458, 484  
resonance and 465–467  
simple procedure 125–127  
Study Sheet 456–457
- 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. 638–640
- Libraries, of drugs 673
- Life  
hydrogen bonds and 554  
origin of 640–641
- Light bulbs  
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- “Like dissolves like” guideline, for solubility 578–581
- Lime 287
- Limestone 228, 616  
acid rain and 209  
increasing permeability of 203
- Limestone caverns 246
- Limiting reactant** The reactant that runs out first and limits the amount of product that can form. 376–381  
global warming and 384–385  
how chosen 376–377  
Study Sheet 380
- Linear geometry** The geometric arrangement that keeps two electron groups as far apart as possible. It leads to angles of 180° between the groups. 471
- Linear molecules 471, 472
- Line drawing 582, 659
- 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  
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dissolving gases in 594  
dissolving solids in 588–593  
dynamic equilibrium between vapors and 595  
heterogeneous equilibria and 630–631
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- Liquid elements 87
- Liter 12
- Lithium-7, in treating brain cancer 741
- Lithium (Li)  
from Big Bang 742  
electron configuration and orbital diagram 426  
formation of 742
- Lithium batteries 271
- Lithium hydroxide, uses 215
- Litmus, detecting acids and bases with 222
- London forces** The attractions produced between molecules by instantaneous and induced dipoles. 556–557  
molecular size and 556
- 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. 122, 450
- Los Angeles, photochemical smog in 308
- Low-density polyethylene (LDPE) 693
- Lucretius 219
- Luminous intensity, base unit for 11
- Luminous tubes 501
- Lungs, gases in 493
- Lye. *See* Sodium hydroxide
- Lye soap 586
- Lysine (Lys, K)  
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- M**
- “Mickey Finn” sedative 464
- Magic numbers and nuclear stability 94, 737
- Magnesium (Mg), meals ready to eat (MREs) and 573
- Magnesium chloride, production and use 289
- Magnesium oxide 148
- Magnesium sulfate, use 247
- Magnetic field, in electromagnetic radiation 303
- Magnetic resonance imaging (MRI) 732
- 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 688
- Maltose, molecular structure of 676
- Manganese (Mn)  
in dry cell batteries 268–269  
how made 360
- Manganese(II) oxide, naming 147
- Manganese(II) phosphate  
production and use 284  
uses 247
- Manganese dioxide, in dry cell batteries 268–269
- Marble, acid rain and 209
- Margarine 683
- Martin, John 384–385
- 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 342–346  
English-metric unit conversions of 55  
kinetic energy and 293  
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percentage by 52–53  
range of 17  
weighted average 331  
weight and 16–17
- 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 738

- in nuclear equations 723  
in nuclides 716
- Mass percentage 52
- Matches, chemicals in 173
- Matter** Anything that has mass and takes up space. 16  
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origin of 742  
as solid, liquid, or gas 76–80
- Mayo Clinic 687
- McGwire, Mark 687
- Meals ready to eat (MRE) 573
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- Medicine, uses of radioactive substances in 731–732
- Mega (M) prefix 13
- Meitner, Lise 82
- Meniscus, in measurement 21
- Menstrual cycles, hormones in 686
- Menthol 584
- Metal-nonmetal compounds  
bonds in 549  
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- 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. 558
- Metallic elements 86  
attractive forces in 558–559  
ion charges of 138–140
- Metalloids or semimetals** The elements that have some but not all of the characteristics of metals. 86  
bonding patterns of 457  
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  
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- Meter 10, 11
- Methamphetamine, molecular structure of 582–583
- Methamphetamine hydrochloride 582–583
- Methane 124, 447  
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- Methanethiol, in natural gas 261
- Methanoic acid 664
- Methanol 447  
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- Methionine (Met, M), structure of 680
- 3-Methylbutanal 665–666
- Methylene chloride, in decaffeinating coffee 515
- 2-Methylpropene 662
- Methyl alcohol 125. *See also* Methanol
- Methyl bromide 314  
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- Methyl cyanoacrylate, molecular structure of 473
- Methyl ethyl ketone or MEK, molecular structure of 666
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- Microwaves 304
- micro ( $\mu$ ) prefix 13
- Mifepristone 705
- Milk, pH of 221
- Millimeter of mercury (mmHg), as unit of pressure 485
- milli (m) prefix 13
- Miscible** Can be mixed in any proportion without any limit to solubility. 576
- Mixture** A sample of matter that contains two or more pure substances and has variable composition. 113  
of gases 509
- Model** A simplified approximation of reality. *See also* Scientific model  
calculating 387  
collision theory as 610–616  
of gases 79  
ideal gas 485  
of liquids 78  
of metallic elements 98  
of solids 76–77  
strengths and weaknesses of 448  
valence-bond 449–454
- Moderator** A substance in a nuclear reactor that slows neutrons as they pass through it. 740
- Molarity (abbreviated M)** Moles of solute per liter of solution. 387–392  
equation stoichiometry and 388–392
- Molar mass** The mass in grams of one mole of substance. 335–338  
from atomic mass 335  
calculations using atomic mass 336  
calculations using ionic formula mass 341  
calculations using molecular mass 338  
in equation stoichiometry 370–374  
in ideal gas equation 495  
from ionic formula mass 340  
from molecular mass 337–338
- Molar volume at STP 503
- Mole (mol)** The amount of substance that contains the same number of particles as there are atoms in 12 g of carbon-12. 11, 333–334  
in equation stoichiometry 502–509  
in ideal gas equation 503
- Molecular compound** A compound composed of molecules. In such compounds, all of the bonds between atoms are covalent bonds. 120  
attractive forces in 559  
in oxidation-reduction reactions 253  
water solubility of 579
- Molecular dipole** A molecule with an asymmetrical distribution of positive and negative charge. 547
- 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. 346  
from empirical formula 350–353  
empirical formulas versus 346  
Study Sheet 352
- 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. 467–474. *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. 337–338  
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 in calculating molecular formulas 350–351
- Molecular models 96
- Molecular polarity, predicting 552
- Molecular Shape 128–130  
 ball-and-stick model 128  
 geometric sketch 128  
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- Molecular size, London forces and 556–557
- Molecule** An uncharged collection of atoms held together with covalent bonds. 96  
 covalent bonds in 448–454  
 diatomic 97  
 as formula unit 339  
 of hydrogen 96  
 in molar mass 337  
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- Momentum, of particles in evaporation 535
- Monatomic anions** Negatively charged particles, such as  $\text{Cl}^-$ ,  $\text{O}^{2-}$ , and  $\text{N}^{3-}$ , that contain single atoms with a negative charge. 138. *See also* Anion, monatomic  
 charges 138  
 naming 140
- Monatomic cation** Positively charged particles, such as  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Al}^{3+}$ , that contain single atoms with a positive charge. 139. *See also* Cation, monatomic  
 formation 138–139  
 naming 141  
 roles in body 142
- Monatomic ion, charges 140
- Monoethanolamine 637
- Monomer** The repeating unit in a polymer. 676  
 in addition polymers 693  
 in polysaccharides 676–677  
 in proteins 678
- Monoprotic acid** An acid that donates one hydrogen ion per molecule in a reaction. 204
- Monosaccharide** Sugar molecule with one saccharide unit. 674
- Monosodium glutamate (MSG), taste and 219
- Monsanto Company 621
- Moss Landing Marine Laboratories 384
- Mount Everest, atmospheric pressure at the top 545
- MTBE 665
- Multiplication  
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- Mylar, as polyester 693
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- Sodium 83
- Natural gas 447
- Nature, elements found in 82
- Neon (Ne)  
 electron configuration and orbital diagram 427  
 luminous tubes and 501  
 in neon lights 501, 513
- Nerve cells  
 intoxicating liquids and 131  
 taste and 219
- Net ionic equation** A chemical equation for which the spectator ions have been eliminated, leaving only the substances actively involved in the reaction. 182
- Net rate of solution 589–591
- 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 738–739  
 as nuclear glue 718  
 nuclear stability and 718–719
- 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 722
- Nickel-cadmium battery, chemistry of 270
- Nicotine 361
- Nippoldt, Todd B. 687
- Nitrate ion  
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- Nitric acid  
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- Nitride ion, forming name of 140
- Nitril hydratase 621
- Nitrogen-13, radioactive decay of 724
- Nitrogen-14, in radiocarbon dating 726
- Nitrogen (N)  
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- Nitrogen molecules, velocities of 484
- Nitrogen monoxide 620  
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- Nitrogen narcosis 596
- Nitrogen oxides  
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- Nitroglycerine, in decomposition reactions 261
- Nitrosyl chloride, production and use 655
- Nitrosyl fluoride, molecular geometry 473
- Nitrous oxide, formation of 172
- Noble gases, structure 95
- Node** The locations in a waveform where the intensity of the wave is always zero. 415
- 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 137  
 most common bonding patterns 125
- 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. 116  
 predicting existence of 548–551
- Nonpolar molecular substance, solubility and 578–579
- Normal boiling-point temperature** The temperature at which the equilibrium vapor pressure of the liquid equals one atmosphere. 545
- Notation, for nuclides 716–717
- Nuclear chemistry** The study of the properties and behavior of atomic nuclei. 715
- 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. 729
- Nuclear energy 737–742
- 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). 722–726
- Nuclear fission 738–739
- Nuclear fusion 742
- Nuclear power plant 740–741
- 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). 722–726
- Nuclear reactors 738–741
- Nuclear stability 718–719, 737–738
- Nucleons** The particles that reside in the nucleus of atoms (protons and neutrons). 716
- 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. 716
- Nucleus** The extremely small, positively charged core of the atom. 89  
 of atom 89  
 creation of new elements and 94  
 electrons around 416–422  
 of helium atoms 95  
 mass number and 93  
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- Nuclide** A particular type of nucleus that is characterized by a specific atomic number (*Z*) and nucleon number (*A*). 716  
 band of stability of 719  
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- Olestra 684–685, 742–743
- Oligopeptide 680
- Open-chain forms, of monosaccharides 674–675
- Orange juice, pH of 221
- Orbitals. *See* Atomic orbitals
- Orbitals** The locations in a waveform where the intensity of the wave is always zero.. *See* Atomic orbitals
- 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. 424, 426–427  
 Study Sheet 431, 456
- Organic acid Carbon-based acids. 204
- Organic chemistry** The branch of chemistry that involves the study of carbon-based compounds. 124, 658–672
- Organic compound 658–672  
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 aldehyde 665  
 alkane 661  
 alkene 662  
 alkyne 662  
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 how to describe 658–660  
 ketone 666  
 line drawing 582, 659  
 table of types 670–671
- Organophosphorus compounds 361
- Oxalic acid 664  
 uses 202
- Oxidation** Any chemical change in which at least one element loses electrons, either completely or partially. 250–251, 253
- 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. 250–253  
 within batteries 266–271  
 half-reaction 252  
 oxidation 250  
 oxidation numbers (or states) 255–260  
 reduction 251  
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- Oxidation number (or state)** A tool for keeping track of the flow of electrons in redox reactions. 255–260  
 assignment of oxidation numbers 256  
 Study Sheet 256
- Oxidation state. *See* Oxidation number
- Oxidizing agent** A substance that gains electrons, making it possible for another substance to lose electrons and be oxidized. 252  
 aging and 254  
 defined 252  
 oxidation numbers and 255–260  
 ozone as 308
- 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. 204  
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- in combustion reactions 261–263
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## Pancreatic lipase, in digestion 688

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## Partially hydrogenated triglycerides 683–684

## Partial charge

- in chemical bonds 116, 548–551
- in hydrogen bonds 553
- in London forces 556–557

## Partial electron transfer in oxidation-reduction reactions 253

**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. 509

- effect on gas solubility 595
- equilibrium vapor pressure as 539–540

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## Pascal (Pa), pressure unit 485

## Pearl ash, empirical formula for 349

## Pentane

- hexane solubility of 578
- in solution 178
- water solubility of 578

## Pepper, spiciness of 583

## Pepsin, in digestion 688

**Peptide** A substance that contains two or more amino acids linked together by peptide bonds. 680

- how form 640–642

**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. 680

## Percentage 52–53

- as conversion factor 52
- by mass, definition 52
- by volume 52

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**Percent yield** The actual yield divided by the theoretical yield times 100. 382–384

- why less than 100% 382–383

## Periodic table of the elements 84–88

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**Periods** The horizontal rows on the periodic table. 87

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Phosphorus pentachloride, production and use 288

Phosphorus tribromide 383

Phosphorus trichloride, production and use 630

Photochemical smog, formation of 308–309

**Photons** Tiny, massless packets or particles of radiant energy. 302

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- Phytoplankton, global warming and 384–385
- Pico (p) prefix 13
- Pig iron, formation of 509
- Plastic fingerprints 541
- Platinum (Pt) 98
- as catalyst 640
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- Plutonium-239
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- Plutonium (Pu), in creation of new elements 94
- Polarity
- of amphetamine and epinephrine 582
  - of bonds 548–549
  - of capsaicin 583
  - molecular 552
  - predicting in molecules 552–553
  - solubility and 578
- 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. 116
- dipole-dipole attractions and 547–548
  - predicting in molecules 548–552
- Polar molecular substance, solubility and 578–579
- Polonium-210, radioactive decay of 724
- Polonium-218, in radioactive decay 729
- Poly(ethylene terephthalate) 695
- Poly(vinyl chloride), PVC 694–695
- Polyatomic ion** A charged collection of atoms held together by covalent bonds. 143–145
- balancing equations and 171, 174
  - formulas and names 145
  - with hydrogen 145
  - Lewis structures 143
  - nonsystematic names 145
- Polychlorinated biphenyl (PCB) 353
- Polyester 692–693
- Polyethylene 693
- Polymer** A large molecule composed of repeating units. 676
- addition 693–694
  - formulas for 691
  - polysaccharides as 676–677
  - proteins as 680
  - synthetic 690–695
- Polypeptide 680. *See also* Protein
- nylon as 691
  - silk as 690
- Polypropylene 694–695
- Polyprotic acid** An acid that can donate more than one hydrogen ion per molecule in a reaction. 204
- Polysaccharide Molecule with many saccharide units. 676
- digestion products 688
- Polystyrene 694–695
- chlorofluorocarbons and 314
- Positron** A high-velocity anti-electron released from radioactive nuclides that have too few neutrons. 437, 721
- discovery of 437
- 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. 721
- nuclear equations for 723–725
- Positron emission tomography (PET) 437, 732
- Potassium-40
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- Potassium chlorate, production and use 398
- Potassium hydroxide, production and use 215, 287
- Potassium nitrate
- production and use 279
  - in voltaic cells 268
- Potassium perchlorate, production and use 399
- Potassium permanganate, production and use 401
- Potassium phosphate 183
- Potato chips 684
- Potential energy (PE)** A retrievable, stored form of energy an object possesses by virtue of its position or state. 294
- chemical reactions and 305–307
  - electron orbitals and 420
  - in formation of water 305
  - stability and 294–296
- Precipitate** A solid that comes out of solution. 179
- Precipitation** The process of forming a solid in a solution. 179
- tooth decay and 228
- Precipitation reaction** A reaction in which one of the products is insoluble in water and comes out of solution as a solid. 179–185
- of calcium carbonate 179–182
  - Study Sheet 184
  - writing equations for 184–185
- 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 229
- Presidential Green Chemistry Challenge Award 314, 621
- Pressure Force per unit area. *See* Gas pressure; *See* Gas, pressure
- Pressure cooker 544
- Primary battery** A battery that is not rechargeable. 270
- Primary protein structure** The sequence of amino acids in a protein molecule. 680
- 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). 420
- Probabilities, electron behavior and 414, 418
- Products** The substances that form in a chemical reaction. Their formulas are on the right side of the arrow in a chemical equation. 169
- Progesterone, molecular structure of 686
- Proline (Pro, P), molecular structure of 680
- Propane 124
- 1,2,3-Propanetriol 663
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- 2-Propanone 666
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   hexane solubility of 581  
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 Protein Natural polypeptide. 678–679, 680  
   alpha helix 680  
   beta sheet 680  
   digestion products 688  
   disulfide bond 681  
   hydrogen bond 682  
   primary structure 680  
   ribbon convention 681  
   salt bridge 682  
   secondary structure 680  
   tertiary structure 681–682  
**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 230  
   in ions 90–91  
   in isotopes 92–93  
   mass number and 93  
   MRI and 732  
   nuclear stability and 718–719, 737  
   in nuclides 716–717  
   origin of the elements and 742  
 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. 113  
 Putrescine, molecular structure of 667

## Q

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 Quick lime, formation of 287

## R

Race cars and air density 499  
**Radiant energy** Energy that can be described in terms of oscillating electric and magnetic fields or in terms of photons. 302–304  
   spectrum 304  
   the wave view 303  
   wavelength 303  
 Radiation  
   effects on the body 730–731  
   treatment for cancer 731  
 Radiator coolants 578  
**Radioactive decay** One of several

processes that transform a radioactive nuclide into a more stable product or products. 719  
   effects on body 730–731  
   rates and half-life 726–728  
 Radioactive decay series 728–729  
 Radioactive emissions  
   alpha particle 720  
   beta emission 720  
   gamma rays 722  
   positron emission 721  
**Radioactive nuclide** An unstable nuclide whose numbers of protons and neutrons place it outside the band of stability. 719  
 Radioactive substances  
   smoke detectors, pipe joint check, food irradiation, radioactive tracers 735  
   uses 731–736

**Radioactive tracer** A radioactive nuclide that is incorporated into substances that can then be tracked through detection of the nuclide's emissions. 735

### **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. 733–734

Radio waves 303, 304  
 Radium-226  
   half-life 727  
   radioactive decay 729  
   use 736  
 Radon-222  
   half-life 727  
   lung cancer and 728  
   in radioactive decay series 729

Rags, in paper 229

Rapture of the deep 596

**Rate of chemical reaction** The number of product molecules that form (perhaps described as moles of product formed) per liter of container per second. 616–620  
   concentration effect 617–618  
   temperature and 616–617

**Rate of condensation** The number of particles moving from gas to liquid per second. 537

**Rate of evaporation** The number of particles moving from liquid to gas per second. 535–537, 536–537  
   strengths of attractions and 536  
   surface area and 536

temperature and 537  
   three factors that determine 536  
 Rate of solution. *See* Solution, Rate of Ratio

empirical formulas and 346  
 molar 345  
 neutron-to-protons 718–719  
 stoichiometric 376

Rational drug design 673

**Reactants** The substances that change in a chemical reaction. Their formulas are on the left side of the arrow in a chemical equation. 169  
   equilibrium disruption and 634–636  
   limiting 377–381

Reaction. *See* Chemical reaction

Reaction Rate. *See* Rate of chemical reaction

Rechargeable batteries 270

Recycling 694

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. 252

**Reduction** Any chemical change in which at least one element gains electrons, either completely or partially. 251, 253

Red giant stars 743

Red litmus paper, detecting bases with 222

Reilly, William K. 312

Relative atomic mass 333

Relative solubilities 578

**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 609

**Resonance** The hypothetical switching from one resonance structure to another. 465–467

**Resonance hybrid** A structure that represents the average of the resonance structures for a molecule or polyatomic ion. 466

**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. 466

- Reversible reaction** A reaction in which the reactants are constantly forming products and, at the same time, the products are reforming the reactants. 205, 621–622  
 in chemical equilibrium 621–625  
 disruption of equilibrium for 634  
 equilibrium constants for 626  
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- Roasting 384
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- Roots of nonmetal names 134
- Roscolite 365
- Rounding off 39–47  
 for addition and subtraction 45–47  
 for multiplication and division 40–45
- Roundup 621
- RU-486 705
- Ruby 359
- S**
- s block, on periodic table 428–429
- Saccharide** Sugar, starch, and cellulose. Also called carbohydrates. 674–677. *See also* Carbohydrate
- Saliva, tooth decay and 228
- Salt. *See* Sodium chloride
- Salt bridge (in proteins)** A covalent bond between two sulfur atoms on cysteine amino acids in a protein structure. 682
- Salt bridge (in voltaic cells)** A device used to keep the charges in a voltaic cell balanced. 268
- Salt taste 219
- Salt water separation 82
- San Simeon, California, protection from acid rain in 209
- Saturated solution** A solution that has enough solute dissolved to reach the solubility limit. 592, 592–593  
 dynamic equilibrium and 588–593  
 formation of 592–593
- Saturated triglyceride** A triglyceride with single bonds between all of the carbon atoms. 683
- Scale, calcium carbonate in 186
- Schrodinger, Erwin 416
- Science  
 chemistry as 7–9  
 existence of matter and 437  
 mathematics in 413
- Scientific Method 7–9
- Scientific model** A simplified approximation of reality. 76, 98, 448. *See also* Model
- Scientific notation 4–5
- Scuba diving, gas solubility and 596
- Sea-Nine antifoulant 5
- Seaborg, Glenn 725
- Seawater, pH and 221
- Sea of electrons model for metals 99
- Second (s), as unit of measurement 11
- Secondary (or storage) battery** A rechargeable battery. 270
- 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. 680–681
- Second period elements, electrons in 425–427
- Selenide ion 140
- Selenium  
 bonding pattern 123  
 covalent bond formation 453  
 ion formation 137–138  
 most common bonding pattern 455
- Semimetals** The elements that have some but not all of the characteristics of metals. 86
- Serine (Ser, S)  
 hydrogen bonds between 682  
 molecular structure of 680
- Shape. *See* Molecular shape
- Shell 420. *See also* Principal energy level
- Shroud of Turin 734
- Side-chain, in anion acid 678
- 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) 168  
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 from silicon dioxide 377
- Silicon dioxide  
 citrine as 362  
 in furnace method 330  
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- Silk  
 molecular structure of 690  
 nylon as substitute for 690
- Silver (Ag)  
 density of 48  
 ion charges of 141  
 melting point of 60
- Silver ion, solubility of compounds with 183
- Silver nitrate, in precipitation reaction 184
- Single-displacement reaction** Chemical change in which atoms of one element displace (or replace) atoms of another element in a compound. 264–265
- Sinkhole 246
- Sixth principal energy level, electron orbitals of 423
- SI System of Measurement. *See* International System of Measurement
- Slaked lime 287
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- Smog  
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- Smoke detectors 735
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- Sodium aluminum sulfate, in baking powder 115
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- Sodium carbonate  
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- Sodium chlorate, production and use 286
- Sodium chloride  
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- Sodium chromate 384

- Sodium dichromate, production and use 400, 408
- sodium dodecyl sulfate (SDS), as detergent 587
- Sodium fluoride, in toothpaste 137
- Sodium hydrogen carbonate  
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- Sodium hydrogen sulfate, production and use 407
- Sodium hydroxide  
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- Sodium hypochlorite, production 509, 552, 560, 580, 581
- Sodium ions 91  
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- Sodium perbromate, production and use 285
- Sodium sulfate, production and use 285, 517
- Sodium tripolyphosphate, production and use 410
- Soft drink, why bubbles form 596
- “Solar system” model of the atom 414
- 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 630–631
- Solid acid, in meals ready to eat 573
- Solid elements 87, 98–99
- Solubility** The maximum amount of solute that can be dissolved in a given amount of solvent. 578–584  
gas 594–595  
guidelines 578  
like dissolves like 578–579  
soaps and detergents and 586–587  
in water 182–183, 593  
guidelines 183
- 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. 178  
gas as 594–595  
in saturated solution 588
- 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 573  
dynamic equilibrium and 588–593  
formation of 576–577  
of ionic compounds 175–177  
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factors that effect 589  
surface area 589–590  
temperature effect 592
- saturated 592–593  
solute and solvent 178  
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why form 574–577
- 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. 178
- Sour taste 219
- 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, 128
- Spandex (R), synthesis of 353
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The Origin of the Elements 742  
Wanted: A New Kilogram 11  
Why Create New Elements? 94  
Why Does Matter Exist, and Why Should We Care About This Question? 437  
Zinc-Air Batteries 271
- 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. 181
- Spectrum, of radiant energy 303–304
- Spin. *See* Electron spin
- Spinel 359
- Spodumene 365
- Spray paint 514
- Stability** A relative term that describes the resistance to change. 96, 294–296
- Standard kilogram 11
- Standard pressure 503
- Standard temperature 503
- Standard temperature and pressure (STP) 503  
gas stoichiometry and 503  
gas stoichiometry for conditions other than 504–505
- Standing waves 414–416
- Starch 674, 676
- Stars, element formation and 743
- State, physical 169
- Stationary wave 415
- Steam re-forming 396, 622
- Stearic acid  
molecular structure of 664  
solubility of 583

**Step-growth (or condensation) polymer** A polymer formed in a reaction that releases small molecules, such as water. This category includes nylon and polyester. 691

Sterno 447

**Steroid** Compounds containing a four-ring structure. 685–686

Stirring, rate of solution and 589–591

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Stoichiometric ratio 376

Stoichiometry. *See* Equation stoichiometry

Stomach

hydrochloric acid in 506

role in digestion 689

Stomach acid 506

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**Stratosphere** The second layer of the earth's atmosphere. It extends from about 10 km to about 50 km above sea level. 310

destruction of ozone in 311–313

ozone hole in 313

removal of UV radiation in 311

**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. 205, 207

identifying 218

reactions of strong base with 223–227

**Strong base** A substance that generates at least one hydroxide ion in solution for every unit of substance added to water. 215

identifying 218

reactions of strong acids with 223–227

**Strong force** The force that draws nucleons (protons and neutrons) together. 718

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writing complete electron configurations and orbital diagrams for uncharged atoms 431

writing equations for combustion reactions 262

Styrene, in polystyrene 694

**Sublevel or subshell** Orbitals that have the same potential energy, same size, and same shape. 421

Sublimation, of dry ice 297, 298

Subshell, of atomic orbitals 421

Substance, base unit of 10–11

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densities of common 48

equation stoichiometry and 368–375

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uses for radioactive 731–734

**Substrate** A molecule that an enzyme causes to react. 690

Subtraction, rounding off and 45–47

Sucrase, in digestion 688

Sucrose, solubility in water 593

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- Temperature** A measure of the average internal kinetic energy of an object. 17–19, 301  
 absolute zero 18  
 base unit of 11  
 boiling-point 544  
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 in condensation 534  
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 Terephthalic acid, in polyester formation 692  
**Tertiary protein structure** The overall arrangement of atoms in a protein molecule. 681  
 Testosterone 686  
 Tetraboron carbide, production and use 400, 401  
 Tetrachloroethene 375  
**Tetrahedral** The molecular shape that keeps the negative charge of four electron groups as far apart as possible. This shape has angles of  $109.5^\circ$  between the atoms. 128  
 Tetrahedral molecules 128, 468–469  
 Tetramethylene glycol 354  
 Tetrapeptide 680  
 Tetraphosphorus decoxide, in furnace method 330  
 Tetraphosphorus trisulfide 173  
 Thalidomide 364, 673  
**Theoretical yield** The calculated maximum amount of product that can form in a chemical reaction. 382  
**Thermal energy** The energy associated with the random motion of particles. 301. *See also* Heat  
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 Toothpaste, chemicals in 158  
 Tooth decay, acid-base reactions and 228  
 Tooth enamel, composition of 228  
 Torr, as unit of pressure 485  
 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 620  
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 Transition state, in chemical reactions 611  
 Triacylglycerol 584–585  
 Triangular planar. *See* Trigonal planar  
**Triglyceride** A compound with three hydrocarbon groups attached to a three carbon backbone by ester functional groups. 584–585, 683–685  
**Trigonal planar (often called triangular planar)** The geometric arrangement that keeps three electron groups as far apart as possible. It leads to angles of  $120^\circ$  between the groups. 470  
**Trigonal pyramid** The molecular geometry formed around an atom with three bonds and one lone pair. 469  
 Trimethylamine 668  
 2,2,4-Trimethylpentane 661  
 Trinitrotoluene (TNT) 662–663  
**Triple bond** A link between atoms that results from the sharing of 6 electrons. It can be viewed as three 2 electron covalent bonds. 125, 451  
 Triprotic acid An acid that can donate three hydrogen ions per molecule in a reaction. 205  
 Tristearin 584  
 Tritium 92–93  
**Troposphere** The lowest layer of the earth’s atmosphere. It extends from the surface of the earth to about 10 km above the earth. 310  
 Trypsin 688  
 Tryptophan (Trp, W), molecular structure of 680  
 Tungsten (W), in light bulb filaments 496  
 Tyrosine (Tyr, Y), molecular structure of 680
- U**
- Ultraviolet radiation 304  
 Umami taste 219  
 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  
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**Unit analysis** A general technique for doing unit conversions. 34–38, 330–334, 342–350, 368–372, 376–380, 414–418, 424–428, 448–452  
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- Universal gas constant, R** The constant in the ideal gas equation. 494  
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- University of California, Berkeley 725
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- Unpaired electrons 121  
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- Unsaturated solution** A solution that has less solute dissolved than is predicted by the solubility limit. 592
- Unsaturated triglyceride** A triglyceride that has one or more carbon-carbon double bonds. 683
- Uranium 381  
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- Uranium(IV) oxide 381
- Uranium-234 740
- Uranium-235 740  
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- Uranium-239  
 in nuclear reactors 740  
 in nuclear fission 738
- Uranium hexafluoride 367, 381
- Urea 411  
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- UV-A** Ultraviolet radiation in the range of about 320 to 400 nm wavelengths. This is the part of the ultraviolet spectrum that reaches the earth and provides energy for the production of vitamin D. 310
- UV-B** Ultraviolet radiation in the range of about 290 to 320 nm wavelengths. Most of this radiation is filtered out by the earth's atmosphere, but some reaches the surface of the earth. 310
- UV-C** Ultraviolet radiation in the range of about 40 to 290 nm wavelengths. Almost all UV-C is filtered out by our atmosphere. 310
- V**
- Valence-bond model 449–454
- Valence electrons** The electrons that are most important in the formation of chemical bonds. The highest energy  $s$  and  $p$  electrons for an atom. 121, 449  
 electron dot symbol 121–122
- Valine (Val, V), molecular structure of 678
- Value** A number and unit that together represent the result of a measurement or calculation. 10
- Vanadium(V) oxide, in catalytic converter 263
- 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. 534
- Vaporization The conversion of a liquid to a gas. 79
- Vapor pressure. *See* Equilibrium vapor pressure
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- 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. 266–271  
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 producing hydrogen gas from 621–623  
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 rate of solution in 589–593  
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- Water dissociation constant ( $K_w$ )** The equilibrium constant for the reaction:  

$$\text{H}_2\text{O}(l) \rightleftharpoons \text{H}^+(aq) + \text{OH}^-(aq)$$
  
 632
- Water purification 374
- Water solubility 182–183
- Water treatment 244
- Wave  
 electrons as 416–423  
 for guitar strings 414  
 radiant energy as 302–304  
 standing 414–415

- Waveform** A representation of the shape of a wave.  
 of electron 416  
 of guitar strings 415
- Wavelength** The distance in space over which a wave completes one cycle of its repeated form. 303–304
- Weak acid** A substance that is incompletely ionized in water due to the reversibility of the reaction that forms hydronium ions,  $\text{H}_3\text{O}^+$ , in water. Weak acids yield significantly less than one  $\text{H}_3\text{O}^+$  ion in solution for each acid molecule dissolved in water. 205, 206
- Weak base** A substance that produces fewer hydroxide ions in water solution than particles of the substance added. 216–217  
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 for polyatomic ions 145  
 for predicting molecular polarity 553  
 for predicting relative strengths of attractions 560  
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- 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. 331
- Wine  
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- Work** What is done to move an object against some sort of resistance. 292
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- Y**
- Yield. *See* Actual yield, Theoretical yield, and Percent yield
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