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A

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

Absolute zero Zero kelvins (K), the lowest possible temperature, equivalent to −273.15 °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 464–465

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taste of 177 triprotic. See Triprotic acid types 162 weak 163–165

Acid-base reaction 180–188 strong acid with hydroxide base 181–185 uses 180 writing equations 183

Acidic paper, preserving books with 187

Acidic solution A solution with a significant concentration of hydronium ions, H₃O⁺. 160

Acid rain 167 pH and 178

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 299–300

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

Adipic acid 351

Adults effects of ionizing radiation on 730 fingerprints of 541

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Air pollution catalytic converters and 221 ozone and 266–267 volatile organic solvents and 514

Alanine (Ala, A) silk and 690 structure of 678

Alar 361

Alcohol Compounds that contain a hydrocarbon group with one or more -OH groups attached. 84, 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 -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 43 ion charges of 97

Alkali metals Group 1 (or 1A) on the periodic table; See also Lithium, Sodium, Potassium, and Cesium 43 ion charges of 96–97

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 nuclear equations for 723–725

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 effects on body 730–731 penetration of the body 731

Alternate Synthetic Pathways Award 621

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Aluminum fluoride, production and use 401
Amphoteric substance A substance that can act as either a Bronsted-Lowry acid or a Bronsted-Lowry base, depending on the circumstances. 191
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Anion An ion formed from an atom that has gained one or more electrons and thus has become negatively charged. 49
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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. 225
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Appliances, electrical 48
Aquaporin 48
Aqueous solution A solution in which water is the solvent. 134
Arene (or aromatic compound) A compound that contain the benzene ring. 662–663
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Aromatic. See Arene A compound that contain the benzene ring.
Aromatic compounds. Compounds that contain the benzene ring. See Arene
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Arrhenius acid According to the Arrhenius theory, any substance that generates hydronium ions, H₃O⁺, when added to water. 160–167. See also Acid
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names and formulas for 168–170
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Arrhenius base A substance that produces hydroxide ions, OH⁻, when added to water. 174–178. See also Base
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Atom The smallest part of the element that retains the chemical characteristics of the element itself. 46–48
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protons, neutrons, and electrons 47
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size of nucleus 47
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Atomic mass The weighted average of the masses of the naturally occurring isotopes of an element.
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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. 47, 332–333
Atomic number The number of protons in an atom’s nucleus. It establishes the element’s identity. 51 in nuclear equations 722–726 in nuclides 716–717
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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

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Ball-and-stick model A representation of a molecule that uses balls for atoms and sticks for covalent bonds. 54
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for boron trifluoride 470
for ethane 471
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of ammonia 87
of methane 87
of water 88
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
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in acid-base reactions 180–188
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Base units The seven units from which all other units in the SI system of measurement are derived. 10–11

Basic solution A solution with a significant concentration of hydroxide ions, OH\(^{-}\). 173
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. 224–229. See also Voltaic cell defined 224, 225
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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
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Benzene 351
Berkelium (Bk) 725
Beryllium (Be) electron configuration and orbital diagram 426
formation of 742
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
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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). 162
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Binary covalent compound A compound that consists of two nonmetallic elements. memorized names 90
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Binary ionic compound An ionic compound whose formula contains one symbol for a metal and one symbol for a nonmetal. 104
A polar covalent bond, which has an atom with a partial positive charge and an atom with a partial negative charge. 549
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  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
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Bronsted-Lowry acid  A substance that donates protons, H+, in a Bronsted-Lowry acid-base reaction. See Acid, Bronsted-Lowry
Bronsted-Lowry acid-base reaction  A chemical reaction in which a proton, H+, is transferred. See Acid-base reaction, Bronsted-Lowry
Bronsted-Lowry base  A substance that accepts protons, H+, in a Bronsted-Lowry acid-base reaction. See Base, Bronsted-Lowry
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Calcium hydrogen sulfite, production and use 243
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Calcium phosphate (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. 257
calorie (with a lowercase c), cal A common energy unit. Equivalent to 4.184 joules. 257
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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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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Carboxylic acid A compound that have a hydrogen atom or a hydrocarbon group connected to a -COOH (or -CO_2H) group. 162, 185, 664
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Catalyst A substance that speeds a chemical reaction without being permanently altered itself. 270, 618–621
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Cation An ion formed from an atom that has lost one or more electrons and thus has become positively charged. 49
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Cesium chloride, crystal structure of 101–102
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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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. 73–77. See also Ionic bond; Covalent bond angles between 86–88, 468–474
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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. 70–71. 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.  
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**Chemistry**  The structure and behavior of matter. 4. See also Organic chemistry; Biochemistry

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**Chlorobutane, formation of**

**Chlorination**

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**Chlorofluorocarbon, CFC** Compound composed of just carbon, chlorine, and fluorine. 270–272

**Chromate (CrO4)2–**

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**Chromia**

- empirical formula of 83

**Chromium (III) oxide** 108

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**Coal, acid rain and** 167

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**Coefficients** The numbers in front of chemical formulas in a balanced chemical equation. 127

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- pH of 179
- removing caffeine 515

**Cold-start emissions, catalytic converters and** 221

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**Combination (or synthesis) reaction** The joining of two or more elements or compounds into one product. 218

**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. 219–220

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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. 140

**Complete combustion** 219–220

**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. 139

**Completion reaction** 164

**Compound** A substance that contains two or more elements, the atoms of these elements always combining in the same whole-number ratio. 70

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- binary ionic 104
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**Concentration** The number of particles per unit volume. For gases, it is usu-
ally 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

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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
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**Conjugate acid** The molecule or ion that forms when one H\(^+\) ion is added to a molecule or ion. 189

**Conjugate acid-base pair** Two molecules or ions that differ by one H\(^+\) ion. 189–190

**Conjugate base** The molecule or ion that forms when one H\(^+\) ion is removed from a molecule or ion. 190

**Conservation of Energy, Law of** 252

**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. 288–290

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formula mass as 340
from percentage 306
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Copper(II) oxide, in catalytic converter 221
Copper sulfate, reaction with zinc 222–223
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Counting by weighing 331–333

**Covalent bond** A link between atoms that results from their sharing two electrons. 54
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double bonds 83
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most common bonding patterns 455
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Critical temperature 514

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**Crystals** Solid particles whose component atoms, ions, or molecules are arranged in an organized, repeating pattern. 139

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Cysteine (Cys, C) disulfide bonds between 682 structure of 679

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**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

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**Decomposition reaction** The conversion of one compound into two or more simpler substances. 219

**Denature** To change the tertiary structure of a protein, causing it to lose its natural function. 689

**Density, mass** Mass divided by volume. 301–305
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in heavy water 313

DEZ treatment 187

Diamond 47
atoms in 48, 334
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**Diatomic** Composed of paired atoms. The diatomic elements are H\(_2\), N\(_2\), O\(_2\), F\(_2\), Cl\(_2\), Br\(_2\), and I\(_2\). 55

Dichlorine monoxide, production and use 247

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Diethyl ether, structure of 665

Diethyl zinc (DEZ), in book preservation 187

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**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

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Dihydrogen phosphate, as amphoteric 191

**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. 162
Dirac, Paul Adrien 437
Direct-contact method 515

Disaccharide  Sugar molecule composed of two monosaccharide units. 676
digestion products 688
Dispersal 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 39

Disulfide bond  A covalent bond between two sulfur atoms on cysteine amino acids in a protein structure. 682
Division, rounding off for 294
DNA (deoxyribonucleic acid)
agging and 212
hydrogen bonding in 554
Dolomite rock, hard water and 144
Dopamine, Parkinson's disease and 8

Double-displacement reaction  A chemical reaction that has the form:
AB + CD to AD + CB 136
acid-base 184
precipitation 136–139
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. 83, 451
Dow Chemical Company 272
Drug design 673
Dry cell battery, chemistry of 226–227
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
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Electric cars, zinc-air batteries in 229
Electric current, base unit of 11
Electric field, in electromagnetic radiation 261
Electric power plant, using nuclear fission 738–741
Electric spark, ozone created by 266
Electrode  A electrical conductor placed in the half-cells of a voltaic cell. 225

Electrolysis  The process by which a redox reaction is pushed in the 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. 227

Electrolyte  The portion of a voltaic cell that allows ions to flow. 226

Electromagnetic radiation. See Radiant energy

Electron  A negatively charged particle found outside the nucleus of an atom. 48, 414–418
in atoms 48–50
in batteries 224
as beta decay 720–721
in chemical bonds 74, 448–454
constructing Lewis structures and 456
electronegativity and 548
in ions 48–50
in isotopes 50–51
like guitar strings 414–416
in metallic elements 56
in multi-electron atoms 424
octets of 80
in oxidation-reduction reactions 208–211
particle interpretation of the wave character 418
as standing wave 416
valence 79
waveform of 416

Electron-dot symbol  A representation of an atom that consists of its elemental symbol surrounded by dots representing its valence electrons. 79–80, 83, 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 48, 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 74
Electron spin 424, 426

Electron transfer, in chemical bond formation 75–76

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. 737

Electroplating 227

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. 38–57
artificial 52
atomic mass of 335
compound versus 70–71
diatomic 55
electronegativities of 548
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nonmetals 43
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728

Enzyme A naturally occurring catalyst. 
618, 688–690
digestive 688–690
metallic cations in 100
why specific 690

Epitectus 288

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
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Equilibrium 621–622

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effect of catalyst 638–639
effect on changing concentrations 
634–637
gas solutions and 594–595
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 de- 
scribes the extent to which reversible 
reactions proceed toward products be- 
fore 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 con- 
centrations of reactants for a reversible 
reaction at equilibrium. 626

Equilibrium vapor pressure  The par- 
tial pressure of vapor above a liquid in 
a closed system with a dynamic equi- 
librium 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 hydrocar- 
bon groups surrounding an oxygen 
atom. 666–667
in fingerprints 541
olestra as 684–685

Estadiol, structure of 686

Ethamidene 668

Ethene 82

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Ethanolic acid 664

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solubility in water 593

Ethene. See Ethylene

Ether A compound with two hydrocar- 
bon groups surrounding an oxygen 
atom. 665

Ethylene (or ethene) 451
polyethylene formation and 693

Ethylene dibromide 272

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. 37, 535–536
cooling and 536
rate of. See Rate of evaporation

Exact numbers, significant figures and 
295

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 low- 
est possible potential energy. 421

Exercises, in this book 6
Exergonic changes  Changes that release energy.  254  
energy diagram  614  
Exhaust  71  
Exhaust systems, catalytic converters and  221  
Exothermic change  A change that leads to heat energy being released from the system to the surroundings.  264  
Expansion, of solids  35  
Experimentation, in scientific method  8–9  
External kinetic energy  259  

F  
f block, of elements  429  
Fahrenheit scale  18–19  
    Fahrenheit to Celsius conversion  312–313  
Family  All the elements in a given column on the periodic table; also called group.  43  
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    digestion products  688  
Fertilizer  
    ammonia and  621  
    nitric acid and  496  
Feynman, Richard  418  
15-minute rule  6, 7  
Fingerprints  541  
Fireworks  
    calcium nitrate in  108  
    light emitted from  421  
Fire extinguishers, sodium carbonate in  175  
Fission  Nuclear reaction that yields energy by splitting larger atoms to form more stable, smaller atoms.  738–739  
Flame retardant, phosphates in  103  
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Fluorapatite, tooth decay and  186  
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    Formaldehyde  652, 665  
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        in herbicide formation  621  
        production and use  237, 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®  693  
    Fractional charge, in chemical bonds  74  
    France, zinc-air batteries in  229  
    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  
Gamma ray  A stream of high-energy photons.  261, 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.  34, 37–38.  
    Avogadro's Law  491  
    in book preservation  187  
    breathing and  493  
    calculations  502  
    equation stoichiometry  502  
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in ideal gas equation 494
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number of gas particles and 490
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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
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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. 43
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 in which electrons are shown as a reactant or product. 210
Halogen bonding pattern 81
covalent bond formation 454
ion formation 95
London forces in 556–557
in periodic table 43
Halons 272
Hard water, soaps and detergents in 587
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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. 260
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Heat of reaction 264
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Helium-4, in treating brain cancer 741.
See also Alpha particles
Hematite 363
Hemoglobin 221
carbon monoxide poisoning and 221
iron ions in 100
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 679
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
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- as strong acid 163, 165, 166

Hydrochlorofluorocarbons (HCFCs) 272

Hydrofluoric acid
- forming name of 166
- light bulbs and 237
- used to make CFCs 236

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)
- in acid-base reactions 180–192
- acids and 160–165
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- from Big Bang 742
- in Bronsted-Lowry acids and bases 188–190
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- electronegativity of 548
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- formation of hydrogen molecules 450
- in formation of water 126–127
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- oxidation number of 214
- position on periodic table 45
- production and use 244, 621–624
- structure 54
- in synthesis gas 622

Hydrogen atom, electron wavefunctions 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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- in proteins 682

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- Lewis structure of 81

Hydrogen halides, as polar molecules 553

Hydrogen iodide, Lewis structure of 81

Hydrogen peroxide
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- as oxidizing agent 212

Hydrogen sulfate ion
- as cleaning agent 188
- as weak acid 166

Hydrogen sulfide
- Lewis structure of 81
- 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
- H₃O⁺ 160–161
- in acid-base reactions 180–185

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
- covalent bond formation 453
- Lewis structure of 101
- solubility of compounds with 141

Hydroxides
- Compounds that contain hydroxide ions. 173

Hydroxyapatite, in tooth enamel 186

3-Hydroxybutanal

Hydroxyapatite, in tooth enamel

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Ideal Gas
- A gas for which the ideal gas model is a good description. 485
- calculations involving 494–502 equation stoichiometry and 502–507

Ideal gas constant (R) 494

Ideal Gas Equation
- combined gas law equation and 500 equation stoichiometry and 504–509

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

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Inner transition metals
- The 28 elements at the bottom of the periodic table. 44

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Instantaneous dipole 262

Intermolecular attraction
- Attraction between molecules. 553–557 dipole-dipole attraction 547 hydrogen bonds 553–555
Ion  
Any charged particle, whether positively or negatively charged. 48–50
  anion 49. See also Anion
cation 49. See also Cation
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formation of 75
monatomic anion charges 96
monatomic anion names 98
monatomic cation. See Cation,
  monatomic
polyatomic. See Polyatomic ion
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Ionic bond  
The attraction between a cation and an anion. 75–77
  in ionic compounds 78
  predicting existence of 548–551

Ionic compound  
A compound that consists of ions held together by ionic
  bonds. 78, 94–108
  as bases 175
  binary 104, 107, 208–210
  formulas to names 104–106
  formula mass of 340–341
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  as strong and weak bases 175
  structure of 100–102
  types of 104
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Ionizing radiation  
Alpha particles, beta particles, and gamma photons, which
  are all able to strip electrons from atoms as they move through matter,
  leaving ions in their wake. 730
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Iridium-192, checking pipe joints and 735
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Compounds that have the same molecular formula but different
  molecular structures. 464
  Lewis structures of 464–465
  of organic compounds 658
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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. 50–52
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  atomic numbers of 51
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Ketone  
A compound that have a hydrocarbon group connected to a -CHO group. 666

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Kilogram (kg) 11
Kilojoule (kJ) 258
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. 251
  chemical reactions and 263–264
  in formation of water 263
  internal and external 259
  mass and 251
  of reactant molecules 611–612
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Lactic acid, in cosmetic lotion 205
Lactose, or milk sugar 676
Laskowski, Edward R. 687
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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. 252
groups as far apart as possible. It leads to angles of 180° between the groups.

Linear molecules 471, 472

Line drawing 582, 659

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**Liquid** The state in which a substance has a constant volume at a constant temperature but can change its shape. 34, 36

boiling 542–544

dissolving gases in 594

dissolving solids in 588–593

dynamic equilibrium between vapors and 595

heterogeneous equilibria and 630–631

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Lithium (Li)

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electron configuration and orbital diagram 426

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Lithium batteries 229

Lithium hydroxide, uses 173

Litmus, detecting acids and bases with 180

**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. 80, 450

Los Angeles, photochemical smog in 266

Low-density polyethylene (LDPE) 693

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Luminous intensity, base unit for 11

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Magic numbers and nuclear stability 52, 737

Magnesium (Mg), meals ready to eat (MREs) and 573

Magnesium chloride, production and use 247

Magnesium oxide 106

Magnesium sulfate, use 205

Magnetic field, in electromagnetic radiation 261

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. 44

Malleable Capable of being extended or shaped by the blows of a hammer. 43

Maltase, in digestion 688

Maltose, molecular structure of 676

Manganese (Mn)

in dry cell batteries 226–227

how made 360

Manganese(II) oxide, naming 105

Manganese(II) phosphate production and use 242

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Manganese dioxide, in dry cell batteries 226–227

Marble, acid rain and 167

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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 301–303

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percentage by 306–307

range of 17

weighted average 331

weight and 16–17

**Mass density** Mass divided by volume (usually called density). 301–305

as conversion factor 303–305

**Mass number** The sum of the number of protons and neutrons in an atom’s nucleus. 51

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Lead(II) ion, solubility of compounds with 141

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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 79

**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. 80–84, 450, 455–465

general steps for drawing 458, 484

resonance and 465–467

simple procedure 83–85

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**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

argon gas in 512

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fluorescent 521

“Like dissolves like” guideline, for solubility 578–581

Lime 245

Limestone 186, 616

acid rain and 167

increasing permeability of 161

Limestone caverns 204

**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

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**Linear geometry** The geometric arrangement that keeps two electron
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Millimeter of mercury (mmHg), as unit of pressure 485
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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. 71
gases 509
Model A simplified approximation of reality.
calculating 387
collision theory as 610–616
gases 37
ideal gas 485
of liquids 36
of metallic elements 56
of solids 34–35
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
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calculations using ion formula mass 341
calculations using molecular mass 338
in equation stoichiometry 370–374
in ideal gas equation 495
from ion 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. 78
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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
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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
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Monosaccharide Sugar molecule with one saccharide unit. 674
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N Names for acids 168–170 for binary covalent compounds 90 for chemical compounds 171–172 for elements 40–41 for ionic compounds 98–106 for organic compounds 661
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Natrium 41
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Nature, elements found in 40
Neon (Ne) electron configuration and orbital diagram 427 luminous tubes and 501 in neon lights 501, 513
Nerve cells intoxicating liquids and 89 taste and 177
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. 47 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 52 Nickel-60, gamma ray emission by 722 Nickel-cadmium battery, chemistry of 228 Nicotine 361 Nippoldt, Todd B. 687 Nitrate ion resonance and 465–467 solubility of compounds with 141 Nitric acid acid rain and 167 formation of 640 forming name of 169 production and use 241 reaction with sodium hydroxide 181–183, 181–185 solution of 181 as strong acid 165 Nitride ion, forming name of 98 Nitril hydratase 621 Nitrogen-13, radioactive decay of 724 Nitrogen-14, in radiocarbon dating 726 Nitrogen (N) covalent bond formation 451 diatomic molecules of 55 electron configuration and orbital diagram 427 ion formation 96 Lewis structure 83 liquid 257 London forces and 558 most common bonding pattern 81, 455 structure of 55 triple bonds in 83 Nitrogen dioxide acid rain and 167 nitric acid and 640 ozone production and 266–267 threshold limit value, or TLV and 522 Nitrogen molecules, velocities of 484 Nitrogen monoxide 620 in acid rain 167 catalytic breakdown of 620 how made 496 oxidation-reduction and 211 Nitrogen narcosis 596 Nitrogen oxides in automobile exhaust 257 ozone and 266–267 Nitroglycerine, in decomposition reactions 219 Nitrosyl chloride, production and use 655 Nitrosyl fluoride, molecular geometry 473 Nitrous oxide, formation of 130 Noble gases, structure 53 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. 43
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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. 74
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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
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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
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
Nucleons The particles that reside in the nucleus of atoms (protons and neutrons). 716
Nucleus The extremely small, positively charged core of the atom. 47
of atom 47
creation of new elements and 52
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of helium atoms 53
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Nuclide A particular type of nucleus that is characterized by a specific atomic number (Z) and nucleon number (A). 716
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Orbitals 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
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Organic acid Carbon-based acids. 162
Organic chemistry The branch of chemistry that involves the study of carbon-based compounds. 82, 658–672
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alkane 661
alkene 662
alkyne 662
amine 668
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ether 665
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ketone 666
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Oxidation Any chemical change in which at least one element loses electrons, either completely or partially. 208–209, 211
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. 208–211
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oxidation 208
oxidation numbers (or states) 213–218
reduction 209
uses of 207
Oxidation number (or state) A tool for keeping track of the flow of electrons in redox reactions. 213–218
assignment of oxidation numbers 214
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Oxidation state. See Oxidation number
Oxidizing agent A substance that gains electrons, making it possible for another substance to lose electrons and be oxidized. 210
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defined 210
oxidation numbers and 213–218
ozone as 266
Oxoacid. See Oxyacid
Oxyacid (oxoacid) Molecular substances that have the general formula H₂XₐOₖ. In other words, they contain hydrogen, oxygen, and one other element represented by X; the a, b, and c represent subscripts. 162
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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. 74
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Polar molecular substance, solubility and 578–579
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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. 101–103
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Polychlordrinated biphenyl (PCB) 353
Polyester 692–693
Polyethylene 693
Polymer A large molecule composed of repeating units. 676
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polysaccharides as 676–677
proteins as 680
synthetic 690–695
Polypeptide 680. See also Protein
nylon as 691
silk as 690
Polypropylene 694–695
Polypropionic acid An acid that can donate more than one hydrogen ion per molecule in a reaction. 162
Polysaccharide Molecule with many saccharide units. 676
digestion products 688
Polystyrene 694–695
chlorofluorocarbons and 272
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
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Positron emission tomography (PET) 437, 732
Potential energy (PE) A retrievable, stored form of energy an object possesses by virtue of its position or state. 252
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electron orbitals and 420
in formation of water 263
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Precipitate A solid that comes out of solution. 137
Precipitation The process of forming a solid in a solution. 137
tooth decay and 186
Precipitation reaction A reaction in which one of the products is insoluble in water and comes out of solution as a solid. 137–143
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Precision The closeness in value of a series of measurements of the same entity. The closer the values of the measurements, the more precise they are. 20
in reporting measured values 293
Prefixes. See Metric prefixes
Preserving books 187
Presidential Green Chemistry Challenge Award 272, 621
Pressure Force per unit area. See Gas pressure
Pressure cooker 544
Primary battery A battery that is not rechargeable. 228
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
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Products The substances that form in a chemical reaction. Their formulas are on the right side of the arrow in a chemical equation. 127
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  beta sheet 680
  digestion products 688
  disulfide bond 682
  hydrogen bond 682
  primary structure 680
  ribbon convention 681
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Proton  A positively charged particle
  found in the nucleus of an atom. 47
  in artificial elements 52
  in atoms 47–48
  in Bronsted-Lowry acids and bases 188
  in ions 48–49
  in isotopes 50–51
  mass number and 51
  MRI and 732
  nuclear stability and 718–719, 737
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  origin of the elements and 742

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Pure substance  A sample of matter that
  has constant composition. There are
  two types of pure substances: ele-
  ments and compounds. 71
Putrescine, molecular structure of 667

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Quick lime, formation of 245

R
Race cars and air density 499

Radiant energy  Energy that can be de-
  scribed in terms of oscillating electric
  and magnetic fields or in terms of
  photons. 260–262
  spectrum 262
  the wave view 261
  wavelength 261
Radiation
  effects on the body 730–731
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Radiator coolants 578

Radioactive decay  One of several
  processes that transform a radioac-
  tive 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 nu-
  clide whose numbers of protons and
  neutrons place it outside the band of
  stability. 719
Radioactive substances
  smoke detectors, pipe joint check,
  food irradiation, radioactive trac-
  ers 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

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Radon-222
  half-life 727
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  in radioactive decay series 729
Rags, in paper 187
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Rate of chemical reaction  The number
  of product molecules that form (per-
  haps 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

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Rate of solution. See Solution, Rate of
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Reactants  The substances that change
  in a chemical reaction. Their formulas
  are on the left side of the arrow in a
  chemical equation. 127
  equilibrium disruption and 634–
  636
  limiting 377–381
  Reaction. See Chemical reaction
  Reaction Rate. See Rate of chemical
  reaction
  Rechargeable batteries 228
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  reaction

Reducing agent  A substance that loses
electrons, making it possible for an-
other substance to gain electrons and
be reduced. 210

Reduction  Any chemical change in
  which at least one element gains elec-
trons, either completely or partially. 209, 211

Red giant stars 743
Red litmus paper, detecting bases with
  180
Reilly, William K. 270
Relative atomic mass 333
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Representative elements  The elements
  in groups 1, 2, and 13 through 18
  (the “A” groups) on the periodic table;
  also called main-group elements. 44
  Research, in scientific method 8
  Research chemist 609

Resonance  The hypothetical switch-
ing from one resonance structure to
another. 465–467

Resonance hybrid  A structure that
  represents the average of the reso-
nance 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. 163, 621–622

in chemical equilibrium 621–625
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**S**

Saccharide Sugar, starch, and cellulose. Also called carbohydrates. 674–677.

See also Carbohydrate

Saliva, tooth decay and 186

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. 226

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Salt water separation 40

San Simeon, California, protection from acid rain in 167

Saturated solution A solution that has enough solute dissolved to reach the solubility limit. 592, 592–593
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Saturated triglyceride A triglyceride with single bonds between all of the carbon atoms. 683

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**Scientific model** A simplified approximation of reality. See also Model 34, 56, 448

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**Secondary (or storage) battery** A rechargeable battery. 228

**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

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Selenide ion 98

Selenium

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Semia metals The elements that have some but not all of the characteristics of metals. 44

Serine (Ser, S) hydrogen bonds between 682

molecular structure of 679

Shape. See Molecular shape

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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. 293–301

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Silver (Ag)
density of 302

ion charges of 99

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Silver ion, solubility of compounds with 141

Silver nitrate, in precipitation reaction 142

**Single-displacement reaction** Chemical change in which atoms of one element displace (or replace) atoms of another element in a compound. 222–223

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Sixth principal energy level, electron orbitals of 423

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Sodium perbromate, production and use 243
Sodium sulfate, production and use 243, 517
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Soft drink, why bubbles form 596
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**Solid** The state in which a substance has a definite shape and volume at a constant temperature. 34–35
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heterogeneous equilibrium and 630–631
Solid acid, in meals ready to eat 573
Solid elements 45, 56–57

**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
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**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. 136
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
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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. 136
Sour taste 177

**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. 54, 86

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Why Create New Elements? 52
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**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. 139

**Spectrum, of radiant energy** 261–262
Spin. See Electron spin
Spins 359
Spodumene 365
Spray paint 514

**Stability** A relative term that describes the resistance to change. 54, 252–254

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**Standard pressure** 503
**Standard temperature** 503
**Standard temperature and pressure (STP)** 503
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State, physical 127
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**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
Stockings 690
Stoichiometric ratio 376
Stomach. See Equation stoichiometry
Stomach  hydrochloric acid in 506
role in digestion 689
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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. 268
destruction of ozone in 269–271
ozone hole in 271
removal of UV radiation in 269
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 H₂O⁺ ion in solution for each acid molecule dissolved in water. 163, 165
identifying 176
reactions of strong base with 181–185
Strong base  A substance that generates at least one hydroxide ion in solution for every unit of substance added to water. 173
identifying 176
reactions of strong acids with 181–185
Strong force  The force that draws nucleons (protons and neutrons) together. 718
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Styrene, in polystyrene 694
Sublevel or subshell  Orbitals that have the same potential energy, same size, and same shape. 421
Sublimation, of dry ice 255, 256
Subshell, of atomic orbitals 421
Substance, base unit of 10–11
Substances  densities of common 302
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 299–301
Sucrase, in digestion 688
Sucrose, solubility in water 593
Sugar 674–676
rate of solution 590
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Tellurium (Te), bonding patterns of 457

**Temperature** A measure of the average internal kinetic energy of an object. 17–19, 259
  - absolute zero 18
  - base unit of 11
  - boiling-point 544
  - Celsius scale 18
  - coldest 19
  - common scales 19
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  - rate of reaction and 616–618
  - rate of solution and 592
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  - volume and 489

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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

Tetrachloroethylene 375

Tetrahaloethanes 86, 468–469

**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. 86

Tetramethylene glycol 354

Tetrapetide 680

Tetraphosphorus deoxide, in furnace method 330

Tetraphosphorus trisulfide 131

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. 259. *See also Heat*

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Thionyl chloride, production and use 408

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Thornepetite 364

Threonine (Thr, T), molecular structure of 679

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  - production and use 411

Titanium (Ti) 56
  - production and use 247

Titanium carbide 381

Titanium dioxide 632
  - production and use 238

Titration, Web site for 392

Toothpaste, chemicals in 393

**Umami taste** See also 177

**Uncertainty** 21
  - in measurements 20–22
  - significant figures and 293–301

Unified mass unit. *See Atomic mass unit*

**Unit** A defined quantity based on a standard. 9–18, 1–3
  - abbreviations 1
  - conversions among 288–314
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  - length 14
  - mass 16
  - the importance of putting into equations 497
  - volume 15

United States, ozone concentrations in 267


**Equation stoichiometry and** 370

**Gas stoichiometry and** 505

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**Summary of** 308–312


“something per something” 311

**Common** 308–312

**Density and** 303, 310, 501-506, 551

**English-metric** 291–292, 310

**Metric-metric** 289–291, 310

**Percentage and** 307, 311

**Triprotic acid** An acid that can donate three hydrogen ions per molecule in a reaction. 163

Tritetra 584

Tritium 50–51

**Troposphere** The lowest layer of the earth’s atmosphere. It extends from the surface of the earth to about 10 km above the earth. 268

Trypsin 688

Tryptophan (Trp, W), molecular structure of 679

Tungsten (W), in light bulb filaments 496

Tyrosine (Tyr, Y), molecular structure of 679

U

**Ultraviolet radiation** 262

**Umami taste** 177

**Uncertainty** 21
  - in measurements 20–22
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**Density and** 303, 310, 501-506, 551

**English-metric** 291–292, 310

**Metric-metric** 289–291, 310

**Percentage and** 307, 311
Universal gas constant, $R$  The constant in the ideal gas equation. 494
in gas stoichiometry 505–509
in ideal gas equation 494–499

Universe
hottest temperatures in 19
origin of elements in 742–743
University of California, Berkeley 725
University of Regensburg 641
Unpaired electrons 79
in valence-bond model 449

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
alpha emission 720
production 402
uranium-238 decay series 729
Uranium(IV) oxide 381
Uranium-234 740
Uranium-235 740
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radioactive decay series 729
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Uranium hexafluoride 367, 381
Urea 411
use and production 526, 654

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. 268

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. 268

UV-C  Ultraviolet radiation in the range of about 40 to 290 nm wavelengths. Almost all UV-C is filtered out by our atmosphere. 268

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. 79, 449
electron dot symbol 79–80
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 221

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. 37

Vapor pressure. See Equilibrium vapor pressure

Vegetable oil 585
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of gas particles 484
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Vinegar
acetic acid in 162
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Vinyl chloride, in poly(vinyl chloride) 694
Visible fingerprints 541
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Vitamin C, aging and 212
Vitamin E, aging and 212

Volatile organic compounds (VOCs) 514

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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. 224–229
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cathode 225
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as polar molecule 88, 553
producing hydrogen gas from 621–623
in protein formation 680
rate of solution in 589–593
solubility in 578–583
structure of 87–88

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 140–141
Water treatment 202

Wave
electrons as 416–423
for guitar strings 414
radiant energy as 260–262
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. 261–262
Weak acid  A substance that is incompletely ionized in water due to the reversibility of the reaction that forms hydronium ions, H$_3$O$^+$, in water. Weak acids yield significantly less than one H$_3$O$^+$ ion in solution for each acid molecule dissolved in water. 163, 164
Weak base  A substance that produces fewer hydroxide ions in water solution than particles of the substance added. 174–175
    ammonia as  173–174
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    for acid nomenclature  169
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    for polyatomic ions  103
    for predicting molecular polarity  553
    for predicting relative strengths of attractions  560
    for resonance  467
    for temperature effect on solid and gas solubility  597
    for writing complete ionic and net ionic equations  143
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  pH of  179
    sediment formation  579
Work  What is done to move an object against some sort of resistance.  250
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