A DICTIONARY OF PHYSICAL SCIENCES

Edited by

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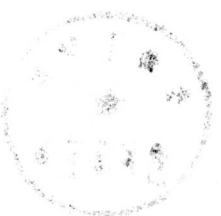

A DICTIONARY OF PHYSICAL SCIENCES

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A Dictionary of Life Sciences, edited by
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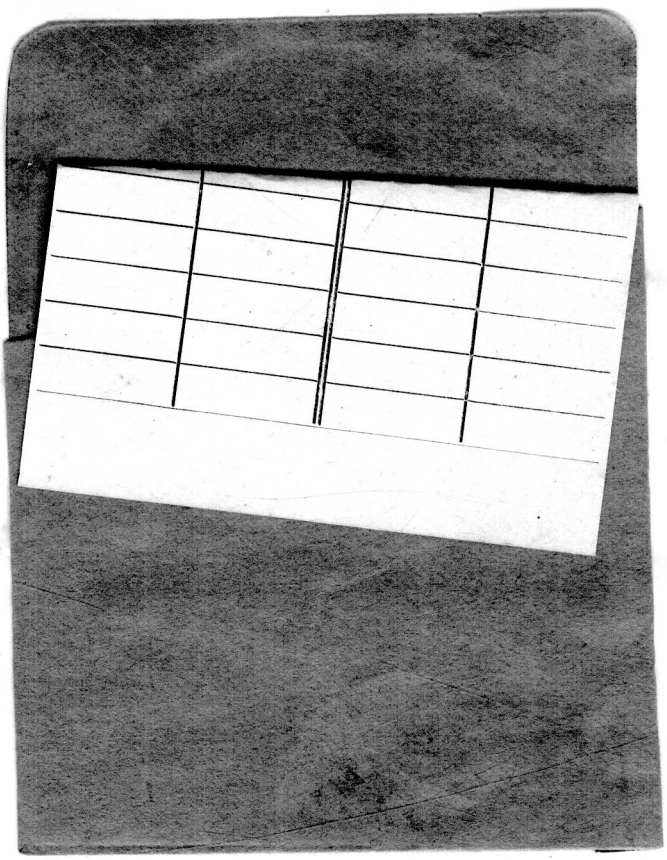


Key to Symbols

Asterisks before words in the text denote cross-references to entries that will provide additional information. Entries are defined under the most commonly used term, with synonyms shown in brackets.

Unless otherwise stated, melting and boiling points are given for standard temperature and pressure; relative densities of liquids are taken at 20°C relative to water at 4°C; relative densities of gases relate to air at standard temperature and pressure. The chemical terminology used is that recommended by the International Union of Pure and Applied Chemistry.

A

ab-. Prefix placed in front of the name of a practical electrical unit to name the corresponding *electromagnetic unit. Thus the e.m.u. of current is the abampere.

Abbe condenser. A simple two-lens system used as a condenser in microscopes. [After Ernst Abbe (1840–1905), German physicist.]

aberration. 1. Any of certain defects in lenses, telescopes, or other optical systems, in which a true image is not formed. The types of aberration are classified into *chromatic aberration, *spherical aberration, *astigmatism, *curvature of field, *distortion, and *coma.
2. An apparent displacement of a star's position due to the fact that light travelling at finite velocity reaches not a stationary earth but one that is moving in orbit.

A-bomb. *See* nuclear weapon.

abrasive. A substance used for wearing away a solid surface, as in polishing or cleaning. Common examples are emery and pumice.

abscissa. The x coordinate of a point on a two-dimensional Cartesian graph: i.e. the distance of a point from the y axis, measured along the x axis from the origin; a value of the independent variable of a function of x. *Compare* ordinate.

absolute alcohol. Pure alcohol: i.e. ethanol containing little or no water.

absolute expansion. *See* expansion.

absolute humidity. *See* humidity.

absolute zero. The zero value of *thermodynamic temperature, equal to 0 kelvin or −273.15 °C. It may be regarded as the temperature at which molecular motion ceases. *See also* zero-point energy.

absorptance (absorption factor). Symbol: α. A measure of the extent to which something can absorb radiation, equal to the ratio of the absorbed *flux to the flux incident on the body. For a *black body, the absorptance is 1. The quantity was formerly called the *absorptivity*. *See also* Kirchoff's law.

absorption. 1. Solution of a gas in a solid or liquid. The gas permeates into the bulk of the material: this process is distinguished from *adsorption*, in which the gas in held on the surface. Absorption in solids is sometimes called *sorption*.
2. Conversion of the energy of electromagnetic or sound waves into some other form of energy in a medium. A beam of light, for example, passing through matter loses intensity. Part of the loss may result from excitation of atoms or molecules. This process is distinguished from *diffusion*, in which light is scattered out of the beam. In absorption, the process occurring depends on the way the radiation interacts with the material: infrared radiation, for instance, is converted directly into heat by exciting vibrations of the atoms.

absorption spectrum. A *spectrum produced by absorption of electromagnetic radiation by matter. In producing an absorption spectrum, a continuous source of radiation is used: i.e. one having a range of wavelengths. This is passed through the sample and the emerging beam is dispersed using a prism or grating. The electromagnetic radiation is absorbed at certain frequencies, these being capable of exciting the atoms or molecules of the sample from their ground state to an excited state. Thus, in the case of visible light, the absorption spectrum consists of dark lines or bands on the bright continuous background. The frequency (ν) at which a line occurs depends on the difference ΔE between the energy of the ground

state and that of the excited state: $\Delta E = h\nu$, where h is the Planck constant. *See also* emission spectrum, Fraunhofer lines.

absorptivity. *See* absorptance.

abundance. 1. Symbol: *C*. The concentration of a given isotope in a mixture of isotopes, equal to the ratio of the number of atoms of the isotope to the total number of atoms; often expressed as a percentage.
2. The concentration of a specified element in the earth's crust, the universe, etc.

a.c. *See* alternating current.

acceleration. The rate of change of velocity with time. Linear acceleration (symbol: *a*) is measured in metres per second per second, etc. Angular acceleration (symbol: ω) is measured in radians per second per second, etc.

acceleration of free fall. Symbol: *g*. The acceleration of a body falling freely, i.e. with no air resistance, at a specified point on the earth's surface as a result of the gravitational attraction of the earth. This acceleration, which is often called the *acceleration due to gravity*, varies from place to place because of different distances from the earth's surface to its centre. The standard value of *g* is 9.806 65 m s^{-2} (32.174 ft s^{-2}).

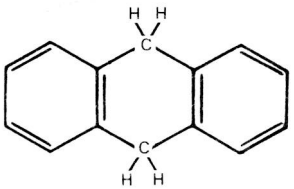
accelerator. 1. A machine for increasing the velocity (and thus the energy) of charged elementary particles and ions. Accelerators are used in fundamental research in nuclear and particle physics for producing a high-energy beam of particles which is directed onto a target, usually within a *bubble chamber. The particles are initially produced from a hot filament (in the case of electrons) or from an ion source.
The simplest method of accelerating charged particles is to use a high potential difference, the energy being gained by the particle in the electric field. This method is used in the *Van de Graaff accelerator. Higher energies are achieved by increasing the particle velocity in stages by a series of small electric fields—the method used in *linear accelerators, in which the particles follow a straight path down an evacuated tube. A similar technique is used in the *cyclotron and *synchrocyclotron, which employ magnetic fields to cause the particles to travel in spiral paths.
Cyclic accelerators of this type have the advantage that long path lengths can be used without making the accelerator impractically large. The *betatron is a cyclic accelerator in which energy is gained by magnetic induction produced by a varying magnetic field. *Synchrotrons work by a combination of electric and varying magnetic fields. The proton synchrotron is the most powerful type of accelerator, producing protons in the GeV range.
Particle energies can be effectively increased by the use of *storage rings*, which are large evacuated toroidal rings into which the particles are injected. It is possible to build up an intense beam of particles and maintain it circulating around the ring for many months. It is also possible to produce two beams, as of electrons and positrons, travelling in opposite directions and to arrange for them to intersect in the ring. In this way particle interactions can be studied at energies of up to 1700 GeV.
2. A substance added to increase the rate of a chemical reaction: i.e. to act as a catalyst. Accelerators are used to increase the rate of vulcanization of rubber.

acceptor. 1. An atom that accepts electrons in an extrinsic *semiconductor, thus producing holes in the conduction band.
2. The atom or molecule that contributes no electrons in forming a *coordinate bond. *Compare* donor.

access time. The time necessary for information to be supplied from a computer store for processing.

accommodation. *See* eye.

accumulator (storage battery). A device designed for storing electricity, consisting of one or more secondary *cells in series. Common examples are the *lead-acid accumulator and the *nife cell.



Acenaphthene

acenaphthene. A white crystalline solid, $C_{10}H_6(CH_2)_2$, obtained from coal tar and used in the manufacture of dyes and plastics. M.pt. 96.2°C; b.pt. 279°C; r.d. 1.02.

acetal. Any of a class of organic compounds with the general formula RCH(OR′)(OR″), where R, R′, and R″ are organic groups. Acetals are formed by addition of an alcohol to an aldehyde. The reaction proceeds in two steps. The first is addition of one alcohol molecule to form a *hemiacetal*, with further reaction forming the full acetal. The reaction is catalysed by acid.
Ketones react similarly to yield *ketals. The term *acetal* is often applied to *1,1-diethoxyethane*, $CH_3CH(OC_2H_5)_2$. B.pt. 103.2°C; r.d. 0.83.

acetaldehyde (ethanal). A colourless liquid *aldehyde, CH_3CHO, made by the oxidation of ethanol and used in manufacturing many other compounds. M.pt. -124.6°C; b.pt. 20.8°C; r.d. 0.78.

acetaldol (aldol, 3-hydroxybutanal). A colourless syrupy liquid, $CH_3CHOHCH_2CHO$, made by the condensation of acetaldehyde and used in medicine as a sedative and hypnotic. M.pt. below 0°C; b.pt. 83°C; r.d. 1.11.

acetamide (ethanamide). A colourless deliquescent crystalline *amide, CH_3CONH_2, with a mouse-like odour. It is manufactured from ethyl acetate and ammonia and used as a solvent and wetting agent. M.pt. 82.3°C; b.pt. 221.2°C; r.d. 1.0.

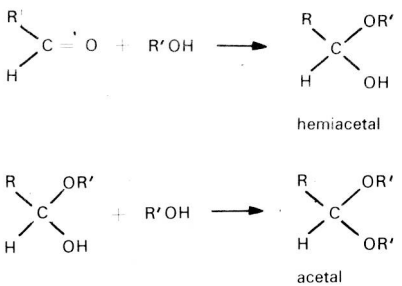
acetanilide An odourless white powder, $C_6H_5NH(COCH_3)$, made by the acetylation of aniline and used in the preparation of drugs, dyes, and lacquers. M.pt. 114.3°C; b.pt. 304°C; r.d. 1.22.

acetate. 1. Any salt or ester of acetic acid. **2.** *See* cellulose acetate.

acetate rayon. *See* rayon.

acetic acid (ethanoic acid). A colourless liquid carboxylic acid, CH_3COOH, manufactured by bacterial oxidation of ethanol (*see* vinegar) or by the oxidation of acetaldehyde. The anhydrous liquid is known as *glacial* acetic acid. Acetic acid is used in the manufacture of dyes, rubbers, plastics, and many other prod-

Acetal formation



ucts. M.pt. 16.6°C; b.pt. 117.9°C; r.d. 1.05.

acetic anhydride (ethanoic anhydride). A colourless liquid organic anhydride, $(CH_3CO)_2O$, used as a dehydrating and acetylating agent (*see* acetylation). M.pt. -73.1°C; b.pt. 139.6°C; r.d. 1.08.

acetolysis. The reaction of an organic compound with glacial acetic acid to exchange one of its groups for an acetyl group. A tertiary alkyl halide, for example, reacts to give an ester: $(CH_3)_3CCl + CH_3COOH = CH_3COOC(CH_3)_3 + HCl$. Acetolysis is a type of *solvolysis.

acetone (propanone). A colourless flammable volatile liquid *ketone, $CH_3CO\text{-}CH_3$, manufactured from propene and extensively used as a solvent. It is also a raw material for the production of many organic compounds. M.pt. -95.4°C; b.pt. 56.2°C; r.d. 0.79.

acetonitrile (methyl cyanide). A colourless flammable liquid *nitrile, CH_3CN, manufactured by the dehydration of acetamide and used in the synthesis of some pharmaceuticals. M.pt. -45.7°C; b.pt. 81.6°C; r.d. 0.79.

acetophenone (phenyl methyl ketone). A colourless liquid *ketone, $C_6H_5CO\text{-}CH_3$, with a sweet pungent odour and taste, used in perfumery. M.pt. 20.5°C; b.pt. 202°C; r.d. 1.03.

acetylation. The introduction of an acetyl group (CH_3CO-) into an organic compound in a chemical reaction. Acetylations are thus a special type of *acylation reaction. Most acetylations involve replacement of the hydrogen atom of a hydroxyl group (-OH) or amino group ($-NH_2$) by the acetyl group. Common acetylating agents are acetic anhydride, acetyl chloride, and ketene.

acetyl chloride (ethanoyl chloride). A colourless flammable pungent liquid *acid chloride, CH_3COCl, used as an acetylating agent (*see* acetylation). M.pt -112°C; b.pt. 50.9°C; r.d. 1.11.

acetylene (ethyne). 1. A colourless highly flammable gaseous *alkyne, C_2H_2, produced by the Wulff process or by the action of water on calcium carbide. It is used in the manufacture of acrylic plastics and PVC and in oxy-acetylene welding and cutting. M.pt -82°C (820 mmHg); b.pt. -84°C; r.d. 0.91.
2. *See* alkyne.

acetyl group. The organic group CH_3CO-.

acetylide. A *carbide that yields acetylene on hydrolysis.

acetylsalicylic acid. *See* asprin.

achromat. *See* achromatic.

achromatic. 1. Having no colour. *Achromatic colours* are colours such as black, white, and various greys, which have no hue.
2. Having no chromatic aberration. An *achromatic lens* is one made by combining lenses of different types of glass, so that the combination has no dispersion. The simplest type, an *achromatic doublet*, is made of two lenses of flint and crown glass. The *power of the doublet is the sum of the powers of the lenses ($P = P_1 + P_2$). For the combination to be achromatic, the lenses must satisfy the relationship $P_1\omega_1 + P_2\omega_2 = 0$, where ω_1 and ω_2 are the dispersive powers of the glasses used. Achromatic lenses are called *achromats*.

acid. A substance that will react with a *base to form a salt and water. Acids turn litmus red and produce hydrogen ions if dissolved in water. They react with certain metals to give hydrogen and a metal salt. *Strong acids* are substances such as hydrochloric acid, in which the covalent molecule is fully dissociated into ions in solution: $HCl = H^+ + Cl^-$. *Weak acids* are compounds such as acetic acid, which are partially dissociated. In solution the hydrogen ion, H^+, is solvated by water and often considered to be a hydroxonium ion, H_3O^+. The idea of an acid in chemistry

has been extended to include *Lewis acids.

acid chloride (acyl chloride). Any of a class of organic compounds with the general formula RCOCl, in which R is a hydrocarbon group. They are derived by replacing the hydroxyl group of a carboxylic acid by a chlorine atom using a chlorinating agent such as phosphorus trichloride. Acid chlorides, such as acetyl chloride, CH_3COCl, are easily hydrolysed: $CH_3COCl + H_2O = CH_3COOH + HCl$. They similarly react with alcohols and other hydroxy compounds and are used as acylating agents (*see* acylation). Other *acid halides* (or *acyl halides*), such as RCOF, and RCOBr, and RCOI, show similar behaviour.

acid dye. Any of a class of dyes that consist of salts of alkali metals containing large coloured negative ions. Acid dyes can be used on wool and silk. *Azo dyes are examples of acid dyes.

acid halide. *See* acid chloride.

acidic. Denoting a substance that is an acid or a solution containing an excess of hydrogen ions.

acidic hydrogen. A hydrogen atom in an acid that can be lost to form a hydrogen ion. For example, of the four hydrogen atoms in the acetic acid molecule, CH_3COOH, only the atom joined to the oxygen atom is an acid hydrogen: $CH_3COOH = CH_3COO^- + H^+$.

acidimetry. Determination of the amounts of acids in solution by titration.

acidolysis. Hydrolysis of carboxylic *esters in acid solution to yield the parent carboxylic acid and the alcohol. The acid acts as a catalyst by protonating the carbonyl oxygen, thus facilitating attack by water.

acid radical. The group bound to the acidic hydrogen atom or atoms in an acid. For example, the acetate group, CH_3COO-, is the acid radical of acetic acid.

acid salt. *See* salt.

aclinic line. *See* magnetic equator.

acoustics. The scientific study of sound.

acre. An Imperial unit of area equal to 4840 sq. yards. It is equivalent to 4046.856 422 sq. metres.

acriflavine. A brown-orange granular solid, $C_{14}H_{14}N_3Cl$, used as an antiseptic and bacteriostat.

acrolein (propenal). A colourless or yellowish flammable liquid *aldehyde, CH_2:CHCHO, manufactured from propene and used for producing polyurethane and polyester resins. M.pt. -87 °C; b.pt. 53 °C; r.d. 0.84.

acrylic resin. Any of a class of synthetic resins obtained by polymerization of acrylic acid, methacrylic acid, or their esters. The acrylics are thermoplastic materials noted for their transparency. The commonest is *polymethylmethacrylate.

acrylonitrile (vinyl cyanide). A colourless liquid *nitrile, H_2C:CHCN, manufactured from propene, air, and ammonia. It is copolymerized with butadiene to make synthetic rubbers and is also used in the production of acrylic fibres. M.pt. -83.5 °C; r.d. 0.81.

actinic. Denoting radiation that causes chemical reaction, especially ultraviolet radiation.

actinide. Any of 15 elements from actinium (atomic number 89) to lawrencium (atomic number 103) inclusive. The actinides are similar to the *lanthanides in that they form a series in which the 5*f* shell is being filled. Chemically, the actinides are reactive metals forming compounds with a variety of valencies. All are radioactive and those with atomic numbers greater than 92—the *transuranic elements*—are artificial elements, made by bombardment of other nuclei with high-energy particles.

actinium. Symbol: Ac. An *actinide element found in uranium ores. Its most stable isotope, ^{227}Ac, has a half-life of 21.7 years. A.N. 89; m.pt. 1050°C; r.d. 10.07; valency 3.

actinometer. Any of various instruments for measuring the intensity of radiation.

actinon. The isotope of radon with mass number 219. Its half-life is 3.92 s.

action. The product of momentum and distance.

activate. 1. To heat a solid porous material in order to drive off absorbed water and other substances, thus producing an absorbent material. *Activated alumina*, made by heating aluminium oxide, is used for absorbing gases and for chromatography. *Activated charcoal* is also a highly effective absorbent. It is used for removing gas from vacuum systems, separating gases by selective absorption, purifying air in gas masks, decolorizing, deodorizing, and similar applications.
2. To supply sufficient energy to an atom or molecule to make it reactive.
3. To make a material radioactive, as by bombardment with neutrons or other particles.

activated complex. *See* transition state.

activation analysis. A technique for determining the amount of a particular element in a sample by bombarding the sample to produce a radioactive isotope, which is then identified by its gamma-ray emission spectrum. A common method of activating the sample is by placing it in a nuclear reactor, where radioisotopes are formed by neutron capture. The technique is extremely sensitive.

activation energy. The energy required to initiate a reaction. In a chemical reaction the activation energy is the energy that must be supplied in breaking and reforming chemical bonds: i.e. it is the energy required to form the *transition state. *See also* Arrhenius equation.

active mass. The effective concentration of a substance in a chemical reaction, as used in the law of *mass action.

activity. Symbol: *A*. A measure of the radioactivity of a radioactive substance, equal to the number of atoms disintegrating per unit time. It is measured in *curies.

acute. Denoting an angle that is between 0° and 90°.

acyclic. Denoting a chemical compound that is not cyclic, i.e. does not contain a ring of atoms in its molecular structure. Propane and acetic acid are common examples of acyclic compounds. *Compare* cyclic.

acylation. The introduction of an acyl group (RCO-) into an organic compound in a chemical reaction. The most important acylations are those in which an acyl group is attached to an aromatic ring by a *Friedel-Crafts reaction. *See also* acetylation.

acyl chloride. *See* acid chloride.

acyl group. Any organic group with the formula RCO-, where R is a hydrocarbon group. Examples are the acetyl group, CH_3CO- and the benzoyl group, C_6H_5CO-.

acyl halide. *See* acid chloride.

addend. One of a set of numbers to be added.

addition. A chemical reaction in which one molecule or atom combines with another to form a third molecule. In organic chemistry, addition is usually a reaction in which a molecule adds to an unsaturated molecule by breaking a double or triple bond. *Alkenes, *alkynes, and *aldehydes all undergo addition reactions.

addition polymerization. *See* polymerization.

additive process. The process in which a coloured light is produced by direct combination of lights of different colours. Most colours can be produced

by a suitable mixture of primary colours. *Compare* subtractive process.

adiabatic. Denoting a process in which no heat enters or leaves the system. In general, the temperature changes when an adiabatic change occurs: for example, in the adiabatic compression of a gas work is done on the system and the gas temperature rises. *Compare* isothermal.

adiabatic demagnetization. A technique for producing very low temperatures (close to absolute zero) by demagnetizing a paramagnetic salt. The magnetized material is first cooled to the temperature of liquid helium and isolated thermally from its surroundings. When the field is removed the sample is demagnetized and cools still further.

adiabatic equation. The equation $pV^{\gamma} = C$, describing the relation between the pressure and volume of a gas during an adiabatic change. C is a constant and γ is the ratio of the principal *specific heat capacities of the gas.

adipic acid (hexanedioic acid). A colourless crystalline carboxylic acid, $HOOC(CH_2)_4COOH$, manufactured by oxidation of cyclohexanol. It is used in the manufacture of synthetic polymers, particularly *nylon. M.pt. 153 °C; b.pt. 267 °C (750 mmHg); r.d. 1.4.

admittance. Symbol: Y. A measure of the ability of a circuit to pass electric current, equal to the reciprocal of its *impedance. It is a complex quantity: $Y = G + iB$, where G is the *conductance and B is the *susceptance. Admittance is measured in siemens.

adsorption. The process in which a compound, usually a gas, forms a layer on the surface of a solid: this process is distinguished from *absorption*, in which the gas permeates into the material. Two types of adsorption are distinguished: *chemisorption*, in which the gas molecules or atoms are held by covalent bonds, and *physisorption*, in which they are held by the weaker van der Waals forces. In chemisorption, a single layer of adsorbed molecules is formed: physisorption may involve the production of several layers.

aerial (antenna). A device for transmitting and receiving radio waves. A simple form is the *dipole aerial*—a long metal rod divided at the centre point with connections made at this point. The overall length of the dipole is about one half of the operating wavelength. In transmitting, the electromagnetic waves are produced by accelerating charges in the aerial. In receiving, the electromagnetic radiation induces small varying currents. Many different types of aerial exist suitable for use at various frequencies. Arrays of elements are used for reception and transmission in particular directions.

aerodynamics. The branch of science concerned with gases in motion, in particular the relative motion of solid objects and gases, as in the movement of bodies in air.

aerosol. A fine dispersion of liquid or solid particles in a gas.

aether. *See* ether.

afterdamp. Carbon dioxide produced in coal mines by an explosion of firedamp.

agate. A naturally occurring form of silica, used for ornaments and, because of its hardness, for mortars and for knife edges in chemical balances.

aggregation. A cluster or group of particles held together in a gas or liquid by *intermolecular forces.

agonic line. A line on the earth's surface joining points of zero magnetic declination: i.e. points at which a compass indicates true north. Two main agonic lines exist; one passing from north to south through America and the other having an irregular path through eastern Europe, Arabia, Asia, and Australia.

alabaster. A naturally occurring form of gypsum, $CaSO_4.2H_2O$, used for ornamental carvings.

alanine (2-aminopropanoic acid). A colourless crystalline nonessential *amino acid, $CH_3CH(NH_2)COOH$. M.pt. 295–297 °C (decomposes).

albedo. The ratio of the amount of light scattered from a surface to the amount of incident light.

alchemy. A philosophical system that was the forerunner of modern chemistry. It dated from early Christian times, lasted until the 17th century, and involved a mixture of astrology, mysticism, magic, and practical chemistry in attempts to demonstrate the unity of the universe with the world of man. In particular, many alchemists sought the *Philosopher's stone*—a substance that could transmute base metals into gold and produce an elixir of life.

alcohol. 1. *See* ethanol.
2. Any of a class of organic compounds with general formula ROH, where R is a hydrocarbon group or substituted hydrocarbon group. Alcohols are distinguished from *phenols, in which the hydroxyl group is attached to a carbon atom in an aromatic ring. Alcohols are classified into *primary alcohols*, with general formula RCH_2OH, *secondary alcohols*, with formula RR′CHOH, and *tertiary alcohols*, with formula RR′R″OH. They are also classified as monohydric, dihydric, trihydric, etc., according to the number of hydroxyl groups they contain.
Alcohols react with electropositive metals to form *alkoxides: $2ROH + 2M = 2MOR + H_2$. They also react with acids to yield *esters and water. With oxidizing agents, primary alcohols give aldehydes: $RCH_2OH + O = RCOH + H_2O$; secondary alcohols give ketones: $RCH(OH)R' + O = RCOR' + H_2O$. Concentrated sulphuric acid and other dehydrating agents produce alkenes: $RCH_2CH_2OH - H_2O = RCH{:}CH_2$.

alcohol thermometer. A type of *thermometer consisting of a small glass bulb containing alcohol, connected to a fine sealed capillary tube. The temperature is measured by the expansion of the alcohol, which is usually coloured with red dye. Alcohol has a lower freezing point than mercury and the instrument is useful at low temperatures.

aldehyde. Any of a class of organic compounds containing the group -CHO (the *aldehyde group*), consisting of a carbonyl group bound to a hydrogen atom. Aldehydes are produced by oxidizing alcohols and are further oxidized to carboxylic acids: RCO.H + O = RCO.OH. Aldehydes are reducing agents and give a positive reaction with *Schiff's reagent, *Tollen's reagent, and *Fehling's solution. They also have a variety of addition and condensation reactions.

aldol. 1. Any organic compound containing a hydroxyl group and an aldehyde group bound to adjacent carbon atoms, i.e. containing the *aldol group*, -CH(OH)CH(CHO)-.
2. *See* acetaldol.

aldose. A *sugar that is an aldehyde in its straight-chain form.

Alfvén waves. Magnetohydrodynamic waves propagated through a plasma under certain conditions. Alfvén waves travel in the direction of the magnetic field, and the particles of plasma oscillate in a plane perpendicular to this direction. The motion of particles is communicated both by collisions and by interaction with electric and magnetic fields. [After Hannes Alfvén (b. 1908), Swedish physicist.]

algebra. 1. The branch of mathematics concerned with the general properties of numbers. Algebra is a generalization of arithmetic, and achieves its generality by investigating relations between different representations of numbers treated abstractly. Letters are employed to represent unspecified numbers.
2. Any abstract mathematical system involving formal rules for operations on and relations between entities. The entities can be vectors, matrices, sets, logical propositions, etc.

algebraic. Of or relating to algebra or the rules of algebra. The *algebraic sum* of a set of numbers is the result of their addition with due regard to sign; for example the algebraic sum of 25 and -30 is -5 (not 55).

algin. *See* alginic acid.

alginate. *See* alginic acid.

alginic acid. A polymeric gelatinous substance extracted from certain seaweeds. Alginic acid has a chain similar to that in carbohydrates with carboxyl groups attached. Its salts, the *alginates*, form viscous gelatinous solutions. Sodium alginate (*algin*) is used as an emulsifier and as a thickener in some foods. Calcium alginate can be spun into fibres.

algorithm. A procedure or formula applied mechanically in order to carry out a computation. For example, *Euclid's algorithm* is a mechanical method for calculating the highest common factor of two large numbers, by dividing the larger by the smaller, then dividing the smaller by the remainder, then dividing the first remainder by the second, and repeating this procedure until one division is exact. When this occurs, the last divisor is the highest common factor.

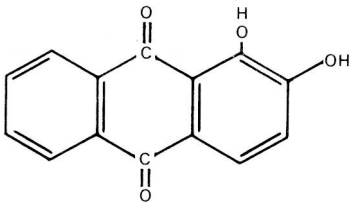
alicyclic. Denoting a chemical compound that is both *aliphatic and *cyclic. Cyclohexane is a common example.

alidade. *See* astrolabe.

aliphatic. Denoting an organic compound that is not *aromatic: i.e. does not have the characteristic chemical behaviour of benzene. Aliphatic compounds include the alkanes, alkenes, alkynes, cycloalkanes, and their derivatives.

alizarin (1,2-dihydroxyanthraquinone). An orange-red crystalline solid, $C_6H_4(CO)_2C_6H_2(OH)_2$, used as a dyestuff. It was formerly extracted from madder roots but is now synthesized. M.pt. 289 °C; b.pt. 430 °C.

Alizarin



alkali. A *base that is soluble in water, thus producing a solution of *hydroxide ions.

alkali metals. The metallic elements lithium, sodium, potassium, rubidium, caesium, and francium, belonging to group IA of the periodic table. They tend to be soft silvery metals, which are univalent, electropositive, and highly reactive. Their oxides and hydroxides are strongly alkaline and their salts are typical ionic crystalline solids containing M^+ ions.

alkalimetry. Determination of the amounts of alkalis in solution by titration.

alkaline-earth metals. The metallic elements beryllium, magnesium, calcium, strontium, and barium, belonging to group IIA of the periodic table. They are silvery-white metals, which are divalent and electropositive and are not quite as reactive as the alkali metals. Like the alkali metals they form basic oxides and hydroxides and crystalline ionic salts. Strictly speaking the **alkaline earths** are the oxides of these metals, although the term is often used for the metals themselves.

alkaloid. Any of a class of organic compounds found in plants, characterized by their physiological activity. Typically alkaloids are poisonous insoluble crystalline compounds containing oxygen and nitrogen. They are basic, forming soluble crystalline salts. Typical examples are quinine and strychnine.

alkane (paraffin). Any of the saturated hydrocarbons with general formula

C_nH_{2n+2}. The alkanes form a *homologous series starting with methane, CH_4. The first four alkanes are gases and higher members of the series are liquids or colourless waxes. Alkanes tend to be rather unreactive: they can be converted into alkyl halides by *substitution.

alkanization. Hydrogenation of an unsaturated hydrocarbon, such as an alkene, to produce an alkane.

alkene. Any one of a class of hydrocarbons characterized by the presence of double bonds between carbon atoms. The simplest example is *ethylene. Alkenes can be prepared by treatment of an alkyl halide with alcoholic potassium hydroxide: $C_2H_5Cl + KOH = CH_2{:}CH_2 + KCl + H_2O$. Other common methods are the dehydration of alcohols, dehalogenation of vicinal dihalides, and reduction of alkynes. The main type of reaction of alkenes are *addition reactions. For example, under acid conditions: $CH_2{:}CH_2 + H_2O = CH_3CH_2OH$. Under some conditions substitution can also occur: $CH_3CH_2{:}CH_2 + Cl_2 = CH_2ClCH_2{:}CH_2$. Alkenes also react with ozone to form an unstable intermediate which breaks down to give aldehydes or ketones: $RCH{:}CHR' + O_3 = RCOH + R'COH$. Alkenes with one double bond form a homologous series with general formula C_nH_{2n}, called the *ethylene series.*

alkyd resin. *See* polyester resin.

alkyl. An organometallic compound in which a metal atom is directly bound to an alkyl group. Tetraethyl lead, $Pb(C_2H_5)_4$, is a common example. The aluminium alkyls, with general formula $Al(C_nH_{2n+1})_3$, are also commercially important, being used in Ziegler-Natta catalysts. Alkyls can be made by direct reaction of a metal with an alkyl halide.

alkylation. The introduction of an alkyl group into an organic compound in a chemical reaction. Usually alkylations involve addition of an alkyl group to an alkene, or substitution of an alkyl group into an aromatic ring by a *Friedel-Crafts reaction.

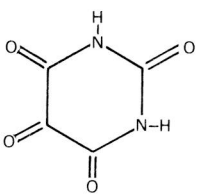
alkylbenzene. Any hydrocarbon containing an aromatic group bound to an alkyl group, and having the chemical properties of both.

alkyl group. A univalent organic group derived by removing one hydrogen atom from an aliphatic hydrocarbon, usually an alkane. An example is the methyl group, CH_3-.

alkyne. Any one of a class of hydrocarbons characterized by the presence of triple bonds between carbon atoms.

allene. A colourless gaseous hydrocarbon, $CH_2{:}C{:}CH_2$.

allotropy. The existence of a solid compound or element in more than one physical form *(allotropes).* Diamond and graphite, for example, are allotropes of carbon.



Alloxan

alloxan. A white crystalline heterocyclic compound, $C_4H_2O_4N_2$. M.pt. 170 °C (decomposes).

alloy. A metallic substance consisting of a mixture of two or more metals or of a metal with nonmetals. Alloys have properties that differ from those of their components. They may be solid solutions, in which the material is homogeneous, or may contain small inclusions of one phase in a matrix of another phase.

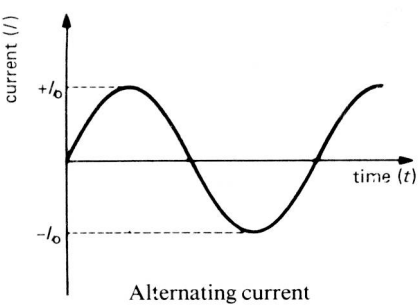
allyl alcohol (prop-2-en-1-ol). A colourless poisonous liquid, $CH_2{:}CHCH_2OH$, with a pungent mustard-like odour, used in the manufacture of plasticizers and synthetic resins. M.pt. -129 °C; b.pt. 97 °C; r.d. 0.85.

allyl group. The organic group CH_2:-$CHCH_2$-.

alpha decay. A type of radioactive decay in which an unstable nucleus ejects on alpha particle. The product has a mass number that has decreased by 4 and an atomic number that has decreased by 2. Radium-226, for example, with an atomic number of 88, decays to give radon-222, which has an atomic number of 86. The radiation emitted during alpha decay follows the *Geiger-Nuttall law. *See also* radioactivity.

alpha iron. The allotropic form of iron that is stable below 906°C. It has a body-centred cubic crystal structure and is ferromagnetic up to its Curie temperature (768°C). *See also* beta iron, ferrite.

alpha particle (α-particle). A helium-atom nucleus, containing two protons and two neutrons. Alpha particles are emitted in streams *(alpha rays)* by radioactive decay.



Alternating current

alternating current (a.c.). An electric current that varies in strength, periodically reversing its direction. The commonest practical form is a sinusoidal current, in which the value of the current follows the equation $I = I_0 \sin 2\pi ft$. I_0 is the peak value of the current, f is the *frequency, and t is the time.

alternating series. An infinite series whose elements are alternately positive and negative, e.g. 1 - ½ + ¼ - ⅛ + 1/12 -.....
Such a series converges if the moduli of the successive terms decrease and tend to zero.

alternator. A device for producing an alternating current. *See* generator.

altitude. 1. A celestial coordinate that determines the angular distance of a star, planet, etc., above the horizon.
2. The height of a geometric figure or solid measured perpendicular to the base.

alum. Any of a class of isomorphous hydrated crystalline double salts having the formula, $M_2SO_4.M'_2(SO_4)_3.24H_2O$, where M is a monovalent metal and M' a trivalent metal. The term is often applied to the double sulphate of potassium and aluminium, $K_2SO_4.Al_2(SO_4)_3.24H_2O$, known as *potash alum.* The potassium can be replaced by other monovalent ions as in *ammonium alum*, $(NH_4)_2SO_4.Al_2(SO_4)_3.24H_2O$. Similarly the term alum is used for double salts in which the aluminium has been replaced by a trivalent metal, as in *chrome alum*, $K_2SO_4.Cr_2(SO_4)_3.24H_2O$, or *ammonium ferric alum*, $(NH_4)_2SO_4.Fe_2(SO_4)_3.24H_2O$. Alums are prepared by crystallizing solutions of the sulphates mixed in the correct proportions. In strict chemical usage they are named according to the rules for double salts: aluminium potassium sulphate, etc.

alumina. *See* aluminium oxide.

aluminium. Symbol: Al. A silvery ductile metallic element obtained from *bauxite; the most abundant metal in the earth's crust. It is produced by converting the bauxite to aluminium oxide by addition of caustic soda and heating the precipitated aluminium hydroxide. A fused mixture of the oxide with cryolite is electrolysed to obtain the aluminium. It is extensively used in a wide range of light aluminium alloys, which also contain manganese, nickel, copper, zinc, and other metals and are used in aircraft, ships, machinery,