

Concise
Science
Dictionary

Concise Science Dictionary

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Preface

The *Concise Science Dictionary* aims to provide school and first-year university students with explanations of unfamiliar words they might come across in the course of their studies, in their own or adjacent disciplines. For example, chemistry students will find all they are likely to need to know about the life sciences, and vice versa. The dictionary will also provide a handy reference source for non-scientists who require accurate definitions of the scientific terms they are likely to encounter in their work or general reading.

At this level the dictionary provides full coverage of terms and concepts relating to physics, chemistry, biology, biochemistry, palaeontology, and the earth sciences. There is also coverage of key terms in astronomy, mathematics, and computer technology.

In compiling the dictionary, the contributors and editors have made every effort to make the entries as concise and comprehensible as possible, always bearing in mind the needs of the readers. Particular features of the book are its lack of unnecessary scientific jargon and its extensive network of cross references. An asterisk placed before a word used in an entry indicates that this word can be looked up in the dictionary and will provide further explanation or clarification. However, not every word that appears in the dictionary has an asterisk placed before it. Some entries simply refer the reader to another entry, indicating either that they are synonyms or abbreviations or that they are most conveniently discussed in one of the dictionary's longer articles. Synonyms and abbreviations are usually placed within brackets immediately after the headword.

Where appropriate, the entries have been supplemented by fully labelled line drawings or tables *in situ*. In addition, the Appendices at the end of the book include the periodic table, tables of SI units and conversion tables to and from

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other systems of units, and summary classifications of the plant and animal kingdoms.

AI

JD

EAM

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A

ab- A prefix attached to the name of a practical electrical unit to provide a name for a unit in the *electromagnetic system of units, e.g. abampere, abcoulomb, abvolt. The prefix is an abbreviation of the word 'absolute' as this system is also known as the *absolute system*. Compare *stat-*. In modern practice both absolute and electrostatic units have been replaced by *SI units.

abdomen The posterior region of the body trunk of animals. In vertebrates it contains the stomach and intestines and the organs of excretion and reproduction. It is particularly well defined in mammals, being separated from the *thorax by the *diaphragm. In many arthropods, such as insects and spiders, it may be segmented.

aberration 1. (in optics) A defect in the image formed by a lens or curved mirror. In *chromatic aberration* the image formed by a lens (but not a mirror) has coloured fringes as a result of the different extent to which light of different colours is refracted by glass. It is corrected by using an *achromatic lens. In *spherical aberration*, the rays from the object come to a focus in slightly different positions as a result of the curvature of the lens or mirror. For a mirror receiving light strictly parallel with its axis, this

can be corrected by using a *parabolic surface* rather than a *spherical surface*. Spherical aberration in *lenses* is minimized by making both *surfaces* contribute equally to the ray *deviations*, and can (though with *reduced image brightness*) be reduced by the use of *diaphragms* to let light pass only through the centre part of the lens. See also *astigmatism*; *coma*. 2. (in astronomy) The apparent displacement in the position of a star as a result of the earth's motion round the sun. Light appears to come from a point that is slightly displaced in the direction of the earth's motion. The angular displacement $\alpha = v/c$, where v is the earth's orbital velocity and c is the speed of light.

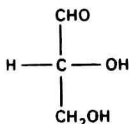
abiogenesis The origin of living from nonliving matter, as by *biopoiesis. See also *spontaneous generation*.

ABO system One of the most important human *blood group systems. The system is based on the presence or absence of *antigens A and B on the surface of red blood cells and *antibodies against these in blood serum. A person whose blood contains either or both these antibodies cannot receive a transfusion of blood containing the corresponding antigens as this would cause the red cells to clump (see *agglutination*). The

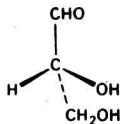
Group	Antigens on red cell surface	Antibodies in serum	Blood group of people donor can receive blood from	Blood group of people donor can give blood to
A	A	anti-B	A,O	A, AB
B	B	anti-A	B,O	B, AB
AB	A and B	none	A,B,AB,O	AB
O	neither A nor B	anti-A and anti-B	O	A, B, AB, O

The ABO blood group system

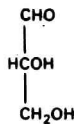
abscisic acid



planar formula

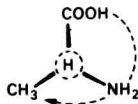
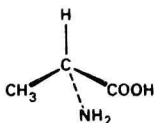


structure in 3 dimensions

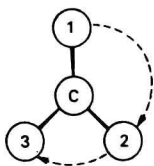


Fischer projection

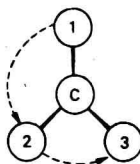
D-(+)-glyceraldehyde (2,3-dihydroxypropanal)



D-alanine (R is CH_3 in the CORN rule). The molecule is viewed with H on top



R-configuration



S-configuration

R-S system. The lowest priority group is behind the chiral carbon atom

table illustrates the basis of the system: people of blood group O are described as 'universal donors' as they can give blood to those of any of the other groups. See also immune response.

abscisic acid A naturally occurring plant *growth substance that promotes leaf ageing, leaf fall (see abscission), and *apical dominance and induces *dormancy in seeds and buds.

abscissa See Cartesian coordinates.

abscission The separation of a leaf, fruit, or other part from the body of a plant. The process is controlled by

growth substances, notably *abscisic acid; it involves the formation of an *abscission zone*, at the base of the part, within which a layer of cells (*abscission layer*) breaks down.

absolute 1. Not dependent on or relative to anything else, e.g. *absolute zero. 2. Denoting a temperature measured on an *absolute scale*, a scale of temperature based on absolute zero. The usual absolute scale now is that of thermodynamic *temperature; its unit, the kelvin, was formerly called the **degree absolute** ($^{\circ}\text{A}$) and is the **same size** as the degree Celsius. In **British engineering practice** an **absolute scale** with Fahrenheit-size degrees

absolute temperature

has been used: this is the **Rankine** scale.

absolute alcohol See ethanol.

absolute configuration A way of denoting the absolute structure of an optical isomer (see optical activity). Two conventions are in use: The D-L convention relates the structure of the molecule to some reference molecule. In the case of sugars and similar compounds, the dextrorotatory form of glyceraldehyde ($\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$), 2,3-dihydroxypropanal) was used. The rule is as follows. Write the structure of this molecule down with the asymmetric carbon in the centre, the $-\text{CHO}$ group at the top, the $-\text{OH}$ on the right, the $-\text{CH}_2\text{OH}$ at the bottom, and the $-\text{H}$ on the left. Now imagine that the central carbon atom is at the centre of a tetrahedron with the four groups at the corners and that the $-\text{H}$ and $-\text{OH}$ come out of the paper and the $-\text{CHO}$ and $-\text{CH}_2\text{OH}$ groups go into the paper. The resulting three-dimensional structure was taken to be that of *d*-glyceraldehyde and called D-glyceraldehyde. Any compound that contains an asymmetric carbon atom having this configuration belongs to the D-series. One having the opposite configuration belongs to the L-series. It is important to note that the prefixes D- and L- do not stand for dextrorotatory and laevorotatory (i.e. they are not the same as *d*- and *l*-). In fact the arbitrary configuration assigned to D-glyceraldehyde is now known to be the correct one for the dextrorotatory form, although this was not known at the time. However, all D-compounds are not dextrorotatory. For instance, the acid obtained by oxidizing the $-\text{CHO}$ group of glyceraldehyde is glyceric acid (1,2-dihydroxypropanoic acid). By convention, this belongs to the D-series, but it is in fact laevorotatory; i.e. its name can be written as D-glyceric

acid or *l*-glyceric acid. To avoid confusion it is better to use + (for dextrorotatory) and - (for laevorotatory), as in D-(+)-glyceraldehyde and D-(-)-glyceric acid.

The D-L convention can also be used with alpha amino acids (compounds with the $-\text{NH}_2$ group on the same carbon as the $-\text{COOH}$ group). In this case the molecule is imagined as being viewed along the H-C bond between the hydrogen and the asymmetric carbon atom. If the clockwise order of the other three groups is COOH , $-\text{R}$, $-\text{NH}_2$, the amino acid belongs to the D-series; otherwise it belongs to the L-series. This is known as the **CORN rule**.

The R-S convention is a convention based on priority of groups attached to the chiral carbon atom. The order of priority is I, Br, Cl, SO_3H , OCOCH_3 , OCH_3 , OH, NO_2 , NH_2 , COOCH_3 , CONH_2 , COCH_3 , CHO , CH_2OH , C_6H_5 , C_2H_5 , CH_3 , H, with hydrogen lowest. The molecule is viewed with the group of lowest priority behind the chiral atom. If the clockwise arrangement of the other three groups is in descending priority, the compound belongs to the R-series; if the descending order is anticlockwise it is in the S-series. D-(+)-glyceraldehyde is R-(+)-glyceraldehyde.

absolute expansivity See expansivity.

absolute humidity See humidity.

absolute permittivity See permittivity.

absolute pitch (perfect pitch) The ability of a person to identify and reproduce a note without reference to a tuned musical instrument.

absolute temperature See absolute; temperature.

absolute value

absolute value (modulus) The square root of the sum of the squares of the real numbers in a *complex number, i.e. in the complex number $x + iy$, the absolute value is $\sqrt{x^2 + y^2}$.

absolute zero Zero of thermodynamic *temperature (0 kelvin) and the lowest temperature theoretically attainable. It is the temperature at which the kinetic energy of atoms and molecules is minimal. It is equivalent to -273.15°C or -459.67°F . See also zero-point energy; cryogenics.

absorptance Symbol α . The ratio of the radiant or luminous flux absorbed by a body to the flux falling on it. Formerly called *absorptivity*, the absorptance of a *black body is by definition 1.

absorption 1. (in chemistry) The take up of a gas by a solid or liquid, or the take up of a liquid by a solid. Absorption differs from *adsorption in that the absorbed substance permeates the bulk of the absorbing substance. 2. (in physics) The conversion of the energy of electromagnetic radiation, sound, streams of particles, etc., into other forms of energy on passing through a medium. A beam of light, for instance, passing through a medium, may lose intensity because of two effects: *scattering of light out of the beam, and absorption of photons by atoms or molecules in the medium. When a photon is absorbed, there is a transition to an excited state. 3. (in biology) The movement of fluid or a dissolved substance across a cell membrane. In animals, for example, soluble food material is absorbed into the circulatory system through cells lining the alimentary canal. In plants, water and mineral salts are absorbed from the soil by the *roots. See osmosis.

absorption coefficient See Lambert's laws.

absorption indicator A type of indicator used in reactions that involve precipitation. The yellow dye fluorescein is a common example, used for the reaction



As silver nitrate solution is added to the sodium chloride, silver chloride precipitates. As long as Cl^- ions are in excess, they adsorb on the precipitate particles. At the end point, no Cl^- ions are left in solution and negative fluorescein ions are then adsorbed, giving a pink colour to the precipitate.

absorption spectrum See spectrum.

absorptivity See absorptance.

abundance 1. The ratio of the total mass of a specified element in the earth's crust to the total mass of the earth's crust, often expressed as a percentage. For example, the abundance of aluminium in the earth's crust is about 8%. 2. The ratio of the number of atoms of a particular isotope of an element to the total number of atoms of all the isotopes present, often expressed as a percentage. For example, the abundance of uranium-235 in natural uranium is 0.71%. This is the *natural abundance*, i.e. the abundance as found in nature before any enrichment has taken place.

abyssal zone The lower depths of the ocean (below approximately 2000 metres), where there is effectively no light penetration. Abyssal organisms are adapted for living under high pressures in cold dark conditions.

a.c. See alternating current.

acceleration Symbol a . The rate of increase of speed or velocity. It is measured in m s^{-2} . For a body moving linearly with constant acceleration a from a speed of u to a speed of v ,

$$a = (v - u)/t = (v^2 - u^2)/2s$$

where t is the time taken and s the distance covered.

If the acceleration is not constant it is given by $dv/dt = d^2s/dt^2$. If the motion is not linear the vector character of displacement, velocity, and acceleration must be considered.

acceleration of free fall Symbol g . The acceleration experienced by any massive object falling freely in the earth's gravitational field. Experimentally this is almost constant for all positions near the earth's surface, independent of the nature of the falling body (provided air resistance is eliminated). This is taken to indicate the strict proportionality of *weight (the force causing the acceleration) and *inertial mass, on the basis of *Newton's second law of motion. There is some variation of g with latitude, because of the earth's rotation and because the earth is not completely spherical. The standard value is taken as 9.80665 m s^{-2} . The acceleration of free fall is also called the *acceleration due to gravity*.

accelerator 1. (in physics) An apparatus for increasing the kinetic energies of charged particles, used for research in nuclear and particle physics. See cyclotron; synchrocyclotron; linear accelerator. 2. (in chemistry) A substance that increases the rate of a chemical reaction, i.e. a catalyst.

acceptor 1. (in chemistry) A compound, molecule, ion, etc., to which electrons are donated in the formation of a coordinate bond. 2. (in electronics) A substance that is added as an impurity to a *semiconductor because of its ability to accept electrons from the valence bands, causing

p -type conduction by the mobile positive holes left.

accommodation 1. (in animal physiology) The process by which the focal length of the *lens of the eye is changed so that clear images of objects at a range of distances are displayed on the retina. In man and some other mammals accommodation is achieved by reflex adjustments in the shape of the lens brought about by relaxation and contraction of muscles within the *ciliary body. 2. (in botany) The ability of a plant to adapt itself to gradually changing environmental conditions. 3. (in animal behaviour) The psychological adjustment made by an animal in response to continuously changing environmental conditions.

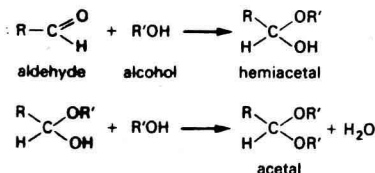
accumulator (secondary cell; storage battery) A type of *voltaic cell or battery that can be recharged by passing a current through it from an external d.c. supply. The charging current, which is passed in the opposite direction to that in which the cell supplies current, reverses the chemical reactions in the cell. The common types are the *lead-acid accumulator and the *nickel-iron accumulator.

acellular Describing tissues or organisms that are not made up of separate cells but often have more than one nucleus. Examples of acellular structures are muscle fibres. Compare unicellular.

acetaldehyde See ethanal.

acetals Organic compounds formed by addition of alcohol molecules to aldehyde molecules. If one molecule of aldehyde (RCHO) reacts with one molecule of alcohol (R'OH) a *hemiacetal* is formed (RCH(OH)OR'). The rings of aldose sugars are hemiacetals. Further reaction with a second alcohol molecule produces a

acetamide



Formation of acetals

full acetal ($\text{RCH}(\text{OR}')_2$). The formation of acetals is reversible; acetals can be hydrolysed back to aldehydes in acidic solutions. In synthetic organic chemistry aldehyde groups are often converted into acetal groups to protect them before performing other reactions on different groups in the molecule. See also ketals.

acetamide See ethanamide.

acetate See ethanoate.

acetic acid See ethanoic acid.

acetone See propanone.

acetylation See acylation.

acetyl chloride See ethanoyl chloride.

acetylcholine A substance that is released at some (*cholinergic*) nerve endings (see neurotransmitter). Its function is to pass on a nerve impulse to the next nerve (i.e. at a synapse) or to initiate muscular contraction. Once acetylcholine has been released it has only a transitory effect because it is rapidly broken down by the enzyme *acetylcholinesterase*.

acetylene See ethyne.

acetylenes See alkynes.

acetyl group See ethanoyl group.

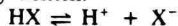
acetylide See carbide.

achene A dry indehiscent fruit formed from a single carpel and containing a single seed. An example is the feathery achene of *clematis*. Variants of the achene include the *caryopsis, *cypsela, *nut, and *samara. See also etaerio.

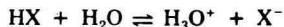
Acheson process An industrial process for the manufacture of graphite by heating coke mixed with clay. The reaction involves the production of silicon carbide, which loses silicon at 4150°C to leave graphite. The process was patented in 1896 by the US inventor Edward Goodrich Acheson (1856–1931).

achromatic lens A lens that corrects for chromatic aberration by using a combination of two lenses, made of different kinds of glass, such that their dispersions neutralize each other although their refractions do not. The aberration can be reduced further by using an *apochromatic lens*, which consists of three or more different kinds of glass.

acid 1. A type of compound that contains hydrogen and dissociates in water to produce positive hydrogen ions. The reaction, for an acid HX , is commonly written:



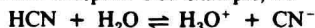
In fact, the hydrogen ion (the proton) is solvated, and the complete reaction is:



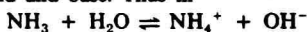
The ion H_3O^+ is the *oxonium ion* (or *hydroxonium ion* or *hydronium ion*). This definition of acids comes from the *Arrhenius theory*. Such acids tend to be corrosive substances with a sharp taste, which turn litmus red and give colour changes with other indicators. They are referred to as *protonic acids* and are classified into *strong acids*, which are almost completely dissociated in water (e.g. sulphuric acid and hydrochloric acid), and *weak acids*, which are only par-

tially dissociated (e.g. ~~ethanoic~~ acid and hydrogen sulphide). The strength of an acid depends on the extent to which it dissociates, and is measured by its *dissociation constant. See also base.

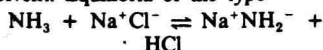
2. In the *Lowry-Bronsted theory* of acids and bases (1923), the definition was extended to one in which an acid is a proton donor, and a base is a proton acceptor. For example, in



the HCN is an acid, in that it donates a proton to H_2O . The H_2O is acting as a base in accepting a proton. Similarly, in the reverse reaction H_3O^+ is an acid and CN^- a base. In such reactions, two species related by loss or gain of a proton are said to be *conjugate*. Thus, in the reaction above HCN is the *conjugate acid* of the base CN^- , and CN^- is the *conjugate base* of the acid HCN. Similarly, H_3O^+ is the conjugate acid of the base H_2O . An equilibrium, such as that above, is a competition for protons between an acid and its conjugate base. A strong acid has a weak conjugate base, and vice versa. Under this definition water can act as both acid and base. Thus in



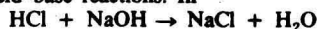
the H_2O is the conjugate acid of OH^- . The definition also extends the idea of acid-base reaction to solvents other than water. For instance, liquid ammonia, like water, has a high dielectric constant and is a good ionizing solvent. Equilibria of the type



can be studied, in which NH_3 and HCl are acids and NH_2^- and Cl^- are their conjugate bases.

3. A further extension of the idea of acids and bases was made in the *Lewis theory* (G. N. Lewis, 1923). In this, a *Lewis acid* is a compound or atom that can accept a pair of electrons and a *Lewis base* is one that can donate an electron pair. This def-

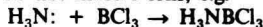
inition encompasses 'traditional' acid-base reactions. In



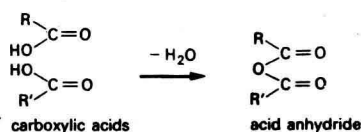
the reaction is essentially



i.e. donation of an electron pair by OH^- . But it also includes reactions that do not involve ions, e.g.



in which NH_3 is the base (donor) and BCl_3 the acid (acceptor). The Lewis theory establishes a relationship between acid-base reactions and *oxidation-reduction reactions.



Formation of a carboxylic acid anhydride

acid anhydrides (acyl anhydrides)

Compounds that react with water to form an acid. For example, carbon dioxide reacts with water to give carbonic acid:



A particular group of acid anhydrides are anhydrides of carboxylic acids. They have a general formula of the type $\text{R.CO.O.CO.R}'$, where R and R' are alkyl or aryl groups. For example, the compound ethanoic anhydride ($\text{CH}_3\text{CO.O.CO.CH}_3$) is the acid anhydride of ethanoic (acetic) acid. Organic acid anhydrides can be produced by dehydrating acids (or mixtures of acids). They are usually made by reacting an acyl halide with the sodium salt of the acid. They react readily with water, alcohols, phenols, and amines and are used in *acylation reactions.

acid-base balance The regulation of the concentrations of acids and bases in blood and other body fluids so that the *pH remains within a physiologically acceptable range. This is achieved by the presence of natural *buffer systems, such as the haemo-

acid dissociation constant

globin, bicarbonate ions, and carbonic acid in mammalian blood. By acting in conjunction, these effectively mop up excess acids and bases and therefore prevent any large shifts in blood pH. The acid-base balance is also influenced by the selective removal of certain ions by the kidneys and the rate of removal of carbon dioxide from the lungs.

acid dissociation constant See dissociation.

acid dye See dye.

acid halides See acyl halides.

acidic 1. Describing a compound that is an acid. 2. Describing a solution that has an excess of hydrogen ions. 3. Describing a compound that forms an acid when dissolved in water. Carbon dioxide, for example, is an acidic oxide.

acidic hydrogen (acid hydrogen) A hydrogen atom in an acid that forms a positive ion when the acid dissociates. For instance, in methanoic acid $\text{HCOOH} \rightleftharpoons \text{H}^+ + \text{HCOO}^-$ the hydrogen atom on the carboxylate group is the acidic hydrogen (the one bound directly to the carbon atom does not dissociate).

acidic stains See staining.

acidimetry Volumetric analysis using standard solutions of acids to determine the amount of base present.

acidity constant See dissociation.

acid rain See pollution.

acid salt A salt of a polybasic acid (i.e. an acid having two or more acidic hydrogens) in which not all the hydrogen atoms have been replaced by positive ions. For example, the dibasic acid carbonic acid (H_2CO_3)

forms acid salts (hydrogencarbonates) containing the ion HCO_3^- . Some salts of monobasic acids are also known as acid salts. For instance, the compound potassium hydrogendifluoride, KHF_2 , contains the ion $[\text{F} \cdots \text{H}-\text{F}]^-$, in which there is hydrogen bonding between the fluoride ion F^- and a hydrogen fluoride molecule.

acid value A measure of the amount of free acid present in a fat, equal to the number of milligrams of potassium hydroxide needed to neutralize this acid. Fresh fats contain glycerides of fatty acids and very little free acid, but the glycerides decompose slowly with time and the acid value increases.

acoustics 1. The study of sound and sound waves. 2. The characteristics of a building, especially an auditorium, with regard to its ability to enable speech and music to be heard clearly within it. For this purpose there should be no obtrusive echoes or resonances and the reverberation time should be near the optimum for the hall. Echoes are reduced by avoiding sweeping curved surfaces that could focus the sound and by breaking up large plane surfaces or covering them with sound-absorbing materials. Resonance is avoided by avoiding simple ratios for the main dimensions of the room, so that no one wavelength of sound is a factor of more than one of them. If the reverberation time is too long, speech will sound indistinct and music will be badly articulated, with one note persisting during the next. However, if it is too short, music sounds dead. It is long in a bare room with hard walls, and can be deliberately reduced by carpets, soft furnishings and sound-absorbent ('acoustic') felt. Reverberation times tend to be reduced by the presence of an audience and this must be taken into account in the design of the building.

acoustoelectronic devices (electroacoustic devices) Devices in which electronic signals are converted into acoustic waves. Acoustoelectronic devices are used in constructing *delay lines and also in converting digital data from computers for transmission by telephone lines.

acquired characteristics Features that are developed during the lifetime of an individual, e.g. the enlarged arm muscles of a tennis player. It is a basic tenet of current evolutionary thought that such characteristics are not genetically controlled and cannot be passed on to the next generation. See also Lamarckism; neo-Lamarckism.

Acrilan A tradename for a synthetic fibre. See acrylic resins.

acrosome See spermatozoon.

acrylate See propenoate.

acrylic acid See propenoic acid.

acrylic resins Synthetic resins made by polymerizing esters or other derivatives of acrylic acid (propenoic acid). Examples are poly(propenenitrile) (e.g. *Acrilan*), and poly(methyl 2-methylpropenoate) (polymethyl methacrylate, e.g. *Perspex*).

acrylonitrile See propenenitrile.

ACTH (adrenocorticotrophic hormone, corticotrophin) A hormone produced by the anterior *pituitary gland in response to stress that controls secretion of certain hormones (the *corticosteroids) by the adrenal glands. It can be administered by injection to treat such disorders as rheumatic diseases and asthma, but it only relieves symptoms and is not a cure.

actinic radiation Electromagnetic radiation that is capable of initiating a chemical reaction. The term is used especially of ultraviolet radiation and also to denote radiation that will affect a photographic emulsion.

actinides See actinoids.

actinium Symbol Ac. A silvery radioactive metallic element belonging to group IIIB of the periodic table; a.n. 89; mass number of most stable isotope 227 (half-life 21.7 years); m.p. $1050 \pm 50^\circ\text{C}$; b.p. 3300°C (estimated). Actinium-227 occurs in natural uranium to an extent of about 0.715%. Actinium-228 (half-life 6.13 hours) also occurs in nature. There are 22 other artificial isotopes, all radioactive and all with very short half-lives. Its chemistry is similar to that of lanthanum. It has no uses and was discovered by A. Debierne in 1899.

actinium series See radioactive series.

actinoid contraction A smooth decrease in atomic or ionic radius with increasing proton number found in the *actinoids.

actinoids (actinides) A series of elements in the *periodic table, generally considered to range in atomic number from thorium (90) to lawrencium (103) inclusive. The actinoids all have two outer *s*-electrons (a $7s^2$ configuration), follow actinium, and are classified together by the fact that increasing proton number corresponds to filling of the $5f$ level. In fact, because the $5f$ and $6d$ levels are close in energy the filling of the $5f$ orbitals is not smooth. The outer electron configurations are as follows:

89 actinium (Ac) $6d^1 7s^2$
 90 thorium (Th) $6d^2 7s^2$
 91 protactinium (Pa) $5f^2 6d^1 7s^2$
 92 uranium (U) $5f^3 6d^1 7s^2$

actinometer

- 93 neptunium (Np) $5f^5 7s^2$ (or $5f^4 6d^1 7s^2$)
94 plutonium (Pu) $5f^6 7s^2$
95 americium (Am) $5f^7 7s^2$
96 curium (Cm) $5f^7 6d^1 s^2$
97 berkelium (Bk) $5f^8 6d^1 s^2$ (or $5f^9 7s^2$)
98 californium (Cf) $5f^{10} 7s^2$
99 einsteinium (Es) $5f^{11} 7s^2$
100 fermium (Fm) $5f^{12} 7s^2$
101 mendelevium (Md) $5f^{13} 7s^2$
102 nobelium (Nb) $5f^{14} 7s^2$
103 lawrencium (Lw) $5f^{14} 6d^1 s^2$

The first four members (Ac to U) occur naturally. All are radioactive and this activity makes chemical study difficult because of self-heating, fogging of X-ray plates, short life-times, safety precautions, etc. Often, chemical studies have to be performed on tiny (nanogram) samples. Like the *lanthanoids, the actinoids show a smooth decrease in atomic and ionic radius with increasing proton number. The lighter members of the series (up to americium) have *f*-electrons that can participate in bonding, unlike the lanthanoids. Consequently, these elements resemble the transition metals in forming coordination complexes and displaying variable valency. As a result of increased nuclear charge, the heavier members (curium to lawrencium) tend not to use their inner *f*-electrons in forming bonds and resemble the lanthanoids in forming compounds containing the M^{3+} ion. The reason for this is pulling of these inner electrons towards the centre of the atom by the increased nuclear charge. Note that actinium itself does not have a *5f* electron, but it is usually classified with the actinoids because of its chemical similarities. See also transition elements.

actinometer Any of various instruments for measuring the intensity of electromagnetic radiation. Recent actinometers use the *photoelectric effect but earlier instruments depended

either on the fluorescence produced by the radiation on a screen or on the amount of chemical change induced in some suitable substance.

actinomorphism See radial symmetry.

actinomycetes A group of Gram-positive, mostly anaerobic nonmotile bacteria. All species are fungus-like, with filamentous cells producing reproductive spores on aerial branches similar to the spores of certain moulds. The group includes bacteria of the genera *Actinomyces*, some species of which cause disease in animals and man; and *Streptomyces*, which are a source of many important antibiotics (including streptomycin).

action potential The change in electrical potential that occurs across a cell membrane during the passage of a nerve *impulse. As an impulse travels in a wavelike manner along the *axon of a nerve, it causes a localized and transient switch in electrical potential across the cell membrane from -60 mV (millivolts) to +45 mV. Nervous stimulation of a muscle fibre has a similar effect.

action spectrum A graphical plot of the efficiency of electromagnetic radiation in producing a photochemical reaction against the wavelength of the radiation used. For example, the action spectrum for photosynthesis using light shows a peak in the region 670-700 nm. This corresponds to a maximum absorption in the absorption spectrum of chlorophylls in this region.

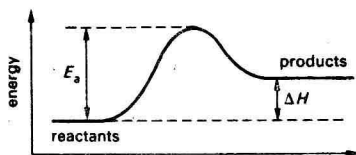
activated alumina See aluminium hydroxide.

activated charcoal See charcoal.

activated complex The association of atoms of highest energy formed in

the *transition state of a chemical reaction.

activation analysis An analytical technique that can be used to detect most elements when present in a sample in milligram quantities (or less). In *neutron activation analysis* the sample is exposed to a flux of thermal neutrons in a nuclear reactor. Some of these neutrons are captured by nuclides in the sample to form nuclides of the same atomic number but a higher mass number. These newly formed nuclides emit gamma radiation, which can be used to identify the element present by means of a gamma-ray spectrometer. Activation analysis has also been employed using charged particles, such as protons or alpha particles.



Reaction profile
(for an endothermic reaction)

activation energy The minimum energy required for a chemical reaction to take place. In a reaction, the reactant molecules come together and chemical bonds are stretched, broken, and formed in producing the products. During this process the energy of the system increases to a maximum, then decreases to the energy of the products. The activation energy is the difference between the maximum energy and the energy of the reactants; i.e. it is the energy barrier that has to be overcome for the reaction to proceed. The activation energy determines the way in which the rate of the reaction varies with temperature (see Arrhenius equation). It is usual to express activation energies in joules per mole of reactants.

active device 1. An electronic component, such as a transistor, that is capable of amplification. **2.** An artificial *satellite that receives information and retransmits it after amplification. **3.** A radar device that emits microwave radiation and provides information about a distant body by receiving a reflection of this radiation. *Compare* passive device.

active site 1. A site on the surface of a catalyst at which activity occurs. **2.** The site on the surface of an *enzyme molecule that binds the substrate molecule. The properties of an active site are determined by the three-dimensional arrangement of the polypeptide chains of the enzyme and their constituent amino acids. These govern the nature of the interaction that takes place and hence the degree of substrate specificity and susceptibility to *inhibition.

active transport The movement of substances through membranes in living cells, often against a concentration gradient: a process requiring metabolic energy. Organic molecules and inorganic ions are transported into and out of both cells and their organelles. It is thought that the substance binds to a carrier protein embedded in the membrane, which carries it through the membrane and releases it on the opposite side. Active transport serves chiefly to maintain the normal balance of ions in cells, especially the concentration gradients of sodium and potassium ions crucial to the activity of nerve and muscle cells. *Compare* facilitated diffusion.

activity 1. Symbol *a*. A thermodynamic function used in place of concentration in equilibrium constants for reactions involving nonideal gases and solutions. For example, in a reaction



acyclic

the true equilibrium constant is given by

$$K = a_B a_C / a_A$$

where a_A , a_B , and a_C are the activities of the components, which function as concentrations (or pressures) corrected for nonideal behaviour. *Activity coefficients* (symbol γ) are defined for gases by $\gamma = a/p$ (where p is pressure) and for solutions by $\gamma = aX$ (where X is the mole fraction). Thus, the equilibrium constant of a gas reaction has the form

$$K_p = \gamma_B \gamma_C p_C / \gamma_A p_A$$

The equilibrium constant of a reaction in solution is

$$K_c = \gamma_B \gamma_C X_C / \gamma_A X_A$$

The activity coefficients thus act as correction factors for the pressures or concentrations. See fugacity.

2. Symbol A . The number of atoms of a radioactive substance that disintegrate per unit time. The *specific activity* (a) is the activity per unit mass of a pure radioisotope. See radiation units.

acyclic Describing a compound that does not have a ring in its molecules.

acyl anhydrides See acid anhydrides.

acylation The process of introducing an acyl group ($\text{RCO}-$) into a compound. The usual method is to react an alcohol with an acyl halide or a carboxylic acid anhydride; e.g. $\text{RCOCl} + \text{R}'\text{OH} \rightarrow \text{RCOOR}' + \text{HCl}$. The introduction of an acetyl group ($\text{CH}_3\text{CO}-$) is *acetylation*, a process used for protecting $-\text{OH}$ groups in organic synthesis.

acyl group A group of the type $\text{RCO}-$, where R is an organic group. An example is the acetyl group $\text{CH}_3\text{CO}-$.



Acyl halide: X is a halogen atom

acyl halides (acid halides) Organic compounds containing the group $-\text{CO.X}$, where X is a halogen atom. Acyl chlorides, for instance, have the general formula RCOCl . The group $\text{RCO}-$ is the *acyl group*. In systematic chemical nomenclature acyl-halide names end in the suffix *-oyl*; for example, ethanoyl chloride, CH_3COCl . Acyl halides react readily with water, alcohols, phenols, and amines and are used in **acylation reactions*. They are made by replacing the $-\text{OH}$ group in a carboxylic acid by a halogen using a halogenating agent such as PCl_5 .

adaptation 1. (in evolution) Any change in the structure or functioning of an organism that makes it better suited to its environment. **Natural selection* of inheritable adaptations ultimately leads to the development of new species. Increasing adaptation of a species to a particular environment tends to diminish its ability to adapt to any sudden change in that environment. **2.** (in physiology) The alteration in the degree of sensitivity (either an increase or a decrease) of a sense organ to suit conditions more extreme than normally encountered. An example is the adjustment of the eye to vision in very bright or very dim light.

adaptive radiation (divergent evolution) The evolution from one species of animals or plants of a number of different forms. As the original population increases in size it spreads out from its centre of origin to exploit new habitats and food sources. In time this results in a number of populations each adapted to its particular habitat: eventually these populations will differ from each other sufficiently to become new species. A good example of this process is the evolution of the Australian marsupials into species adapted as carnivores, herbivores, burrowers, fli-