



AAR See AMINO ACID RACEMIZATION.

AAS See ATOMIC ABSORPTION SPECTROSCOPY.

abherent See RELEASE AGENT.

ab-initio calculation A method of calculating atomic and molecular structure directly from the first principles of quantum mechanics, without using quantities derived from experiment (such as ionization energies found by spectroscopy) as parameters. Ab-initio calculations require a large amount of numerical computation; the amount of computing time required increases rapidly as the size of the atom or molecule increases. The development of computing power has enabled the properties of both small and large molecules to be calculated accurately, so that this form of calculation can now replace *semi-empirical calculations. Ab-initio calculations can, for example, be used to determine the bond lengths and bond angles of molecules by calculating the total energy of the molecule for a variety of molecular geometries and finding which conformation has the lowest energy.

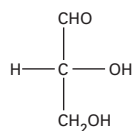
absolute 1. Not dependent on or relative to anything else, e.g. *absolute zero. **2.** Denoting a temperature measured on an **absolute scale**, a scale of temperature based on absolute zero. The usual absolute scale now is that of thermodynamic *temperature; its unit, the kelvin, was formerly called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

heit-size degrees has been used: this is the Rankine scale.

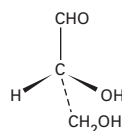
absolute alcohol See ETHANOL.

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 -CHO group at the top, the -OH on the right, the - CH_2OH at the bottom, and the -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 -H and -OH come out of the paper and the -CHO and - CH_2OH 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

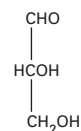
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planar formula

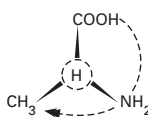
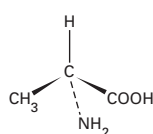
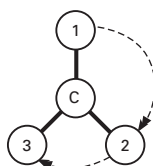


structure in 3 dimensions

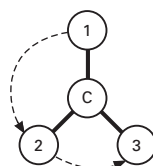


Fischer projection

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

D-alanine (R is CH₂ 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

Absolute configuration

time. However, all D-compounds are not dextrorotatory. For instance, the acid obtained by oxidizing the -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 -NH₂ group on the same carbon as the -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, -R, -NH₂, 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, SO₃H, OCOCH₃, OCH₃, OH, NO₂, NH₂, COOCH₃, CONH₂, COCH₃, CHO, CH₂OH, C₆H₅, C₂H₅, CH₃, H, with hydrogen lowest. The molecule is viewed with the group of lowest priority behind the chiral atom. If the clockwise arrange-

ment 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. See illustration.

absolute temperature See ABSOLUTE; TEMPERATURE.

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.

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.

absorption coefficient 1. (in spectroscopy) The **molar absorption coefficient** (symbol ϵ) is a quantity that characterizes the absorption of light (or any other type of electromagnetic radiation) as it passes through a sample of the absorbing material. It has the dimensions of $1/(\text{concentration} \times \text{length})$. ϵ is dependent on the frequency of the incident light; its highest value occurs where the absorption is most intense. Since absorption bands usually

spread over a range of values of the frequency ν it is useful to define a quantity called the **integrated absorption coefficient**, A , which is the integral of all the absorption coefficients in the band, i.e. $A = \int \epsilon(\nu) d\nu$. This quantity characterizes the intensity of a transition. It was formerly called the **extinction coefficient**. See also BEER-LAMBERT LAW. **2.** The volume of a given gas, measured at standard temperature and pressure, that will dissolve in unit volume of a given liquid.

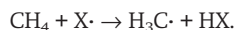
absorption indicator See ADSORPTION INDICATOR.

absorption spectrum See SPECTRUM.

absorption tower A long vertical column used in industry for absorbing gases. The gas is introduced at the bottom of the column and the absorbing liquid, often water, passes in at the top and falls down against the countercurrent of gas. The towers are also known as **scrubbers**.

ABS plastic Any of a class of plastics based on acrylonitrile-butadiene-styrene copolymers.

abstraction A chemical reaction that involves bimolecular removal of an atom or ion from a molecule. An example is the abstraction of hydrogen from methane by reaction with a radical:



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 percent-

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age. 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.

ac Anticlinal. See TORSION ANGLE.

acac The symbol for the *acetyl-acetonato ligand, used in formulae.

accelerant A flammable material used to start and spread a fire in cases of arson. Petrol and paraffin are the substances commonly used. Traces of accelerant are detectable by gas chromatography in forensic work.

accelerator A substance that increases the rate of a chemical reaction, i.e. a catalyst.

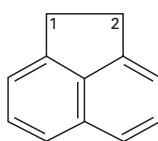
acceptor 1. (in chemistry and biochemistry) A compound, molecule, ion, etc., to which electrons are donated in the formation of a coordinate bond. **2.** (in physics) A substance that is added as an impurity to a *semiconductor because of its ability to accept electrons from the valence bands, causing *p*-type conduction by the mobile positive holes left. Compare DONOR.

accessory pigment A *photosynthetic pigment that traps light energy and channels it to chlorophyll *a*, the primary pigment, which initiates the reactions of photosynthesis. Accessory pigments include the carotenes and chlorophylls *b*, *c*, and *d*.

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 and nickel-cadmium accumulators. See also SODIUM-SULPHUR CELL.

acenaphthene A colourless crystalline aromatic compound, $C_{12}H_{10}$; m.p. $95^{\circ}C$; b.p. $278^{\circ}C$. It is an intermediate in the production of some dyes.

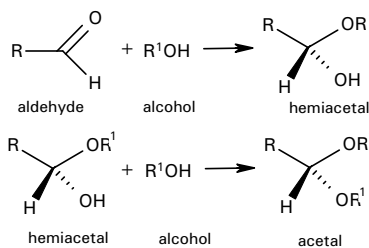


Acenaphthene

acetaldehyde See ETHANAL.

acetaldol See ALDOL REACTION.

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^1OH) a **hemiacetal** is formed ($RCH(OH)OR^1$). The rings of aldose sugars are hemiacetals. Further reaction with a second alcohol molecule produces a full acetal ($RCH(OR^1)_2$). It is common to refer to both types of compound simply as 'acetals'. The formation of acetals is reversible; acetals can be hydrolysed back to aldehydes in acidic solutions. In synthetic organic chemistry aldehyde groups are often



Acetals

converted into acetal groups to protect them before performing other reactions on different groups in the molecule. See also KETALS.

 SEE WEB LINKS

- Information about IUPAC nomenclature

acetamide See ETHANAMIDE.

acetanilide A white crystalline primary amide of ethanoic acid, $\text{CH}_3\text{CONHC}_6\text{H}_5$; r.d. 1.2; m.p. 114.3°C ; b.p. 304°C . It is made by reacting phenylamine (aniline) with excess ethanoic acid or ethanoic anhydride and is used in the manufacture of dyestuffs and rubber. The full systematic name is **N-phenylethanamide**.

acetate See ETHANOATE.

acetate process See RAYON.

acetic acid See ETHANOIC ACID.

acetic anhydride See ETHANOIC ANHYDRIDE.

acetoacetic acid See 3-OXOBUTANOIC ACID.

acetoacetic ester See ETHYL 3-OXOBUTANOATE.

acetone See PROPANONE.

acetone-chlor-haemin test (Wagenaar test) A *presumptive test for blood in which a small amount of acetone (propanal) is added to the bloodstain, followed by a drop of hydrochloric acid. Haemoglobin produces derivatives such as haematin and haemin, forming small characteristic crystals that can be identified under a microscope.

acetonitrile See ETHANENITRILE.

acetophenone See PHENYL METHYL KETONE.

acetylacetonato The ion $(\text{CH}_3\text{COCHCOCH}_3)^-$, functioning as a bidentate ligand coordinating

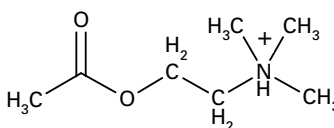
through the two oxygen atoms. In formulae, the symbol **acac** is used.

acetylating agent See ETHANOYLATING AGENT.

acetylation See ACYLATION.

acetyl chloride See ETHANOYL CHLORIDE.

acetylcholine A substance that is released at some (**cholinergic**) nerve endings. 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 **cholinesterase**.



Acetylcholine

acetyl coenzyme A (acetyl CoA) A compound formed in the mitochondria when an acetyl group ($\text{CH}_3\text{CO}-$), derived from the breakdown of fats, proteins, or carbohydrates (via *glycolysis), combines with the thiol group ($-\text{SH}$) of *coenzyme A. Acetyl CoA feeds into the energy generating *Kreb's cycle and also plays a role in the synthesis and oxidation of fatty acids.

acetylene See ETHYNE.

acetylenes See ALKYNES.

acetyl group See ETHANOYL GROUP.

acetylide See CARBIDE.

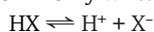
Acheson process An industrial process for the manufacture of graphite by heating coke mixed with clay. The reaction involves the production of silicon carbide, which loses silicon at 4150°C to leave

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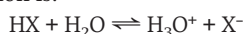
graphite. The process was patented in 1896 by the US inventor Edward Goodrich Acheson (1856–1931).

achiral Describing a molecule that does not contain a *chirality element.

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:

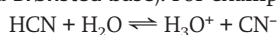


In fact, the hydrogen ion (the proton) is solvated, and the complete reaction is:



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 partially 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–Brønsted theory** of acids and bases (1923), the definition was extended to one in which an acid is a proton donor (a **Brønsted acid**), and a base is a proton acceptor (a **Brønsted base**). 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 reac-

tions, 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

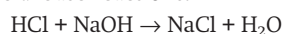


the H_2O is the conjugate acid of OH^- . The definition also extends the idea of acid–base reaction to solvents other than water. For instance, liquid ammonia, like water, has a high dielectric constant and is a good ionizing solvent. Equilibria of the type

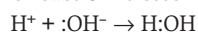


can be studied, in which NH_3 and HCl are acids and NH_2^- and Cl^- are their conjugate bases.

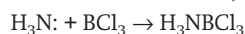
3. A further extension of the idea of acids and bases was made in the **Lewis theory** (G. N. Lewis, 1923). In this, a **Lewis acid** is a compound or atom that can accept a pair of electrons and a **Lewis base** is one that can donate an electron pair. This definition encompasses 'traditional' acid–base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



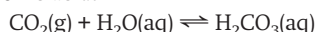
in which NH_3 is the base (donor) and BCl_3 the acid (acceptor). The Lewis theory establishes a relationship between acid–base reactions and *oxi-

dation–reduction reactions. *See* HSAB PRINCIPLE.

See also AQUA ACID; HYDROXOACID; OXOACID.

acid anhydrides (acyl anhydrides)

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

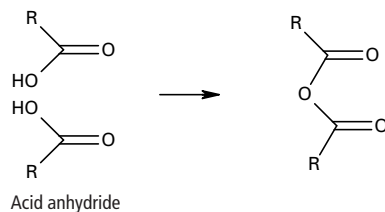


A particular group of acid anhydrides are anhydrides of carboxylic acids.

They have a general formula of the type R.CO.O.CO.R', where R and R' are alkyl or aryl groups. For example, the compound ethanoic anhydride (CH₃.CO.O.CO.CH₃) 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.

 **SEE WEB LINKS**

- Information about IUPAC nomenclature



acid–base indicator *See* INDICATOR.

acid dissociation constant *See* DISSOCIATION.

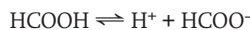
acid dye *See* DYES.

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



the hydrogen atom on the carboxylate group is the acidic hydrogen (the one bound directly to the carbon atom does not dissociate).

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

acidity constant *See* DISSOCIATION.

acid rain Precipitation having a pH value of less than about 5.0, which has adverse effects on the fauna and flora on which it falls. Rainwater typically has a pH value of 5.6, due to the presence of dissolved carbon dioxide (forming carbonic acid). Acid rain results from the emission into the atmosphere of various pollutant gases, in particular sulphur dioxide and various oxides of nitrogen, which originate from the burning of fossil fuels and from car exhaust fumes, respectively. These gases dissolve in atmospheric water to form sulphuric and nitric acids in rain, snow, or hail (**wet deposition**). Alternatively, the pollutants are deposited as gases or minute particles (**dry deposition**). Both types of acid deposition affect plant growth – by damaging the leaves and impairing photosynthesis and by increasing the acidity of the soil, which results in the leaching of essential nutrients. This acid pollution of the soil also

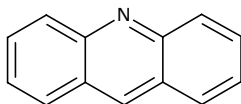
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leads to acidification of water draining from the soil into lakes and rivers, which become unable to support fish life. Lichens are particularly sensitive to changes in pH and can be used as indicators of acid pollution.

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 $[\text{F}\dots\text{H}-\text{F}]^-$, 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.

acridine A colourless crystalline heterocyclic compound, $\text{C}_{12}\text{H}_9\text{N}$; m.p. 110°C . The ring structure is similar to that of anthracene, with three fused rings, the centre ring containing a nitrogen heteroatom. Several derivatives of acridine (such as acridine orange) are used as dyes or biological stains.



Acridine

Acrilan A tradename for a synthetic fibre. See ACRYLIC RESINS.

acrolein See PROPENAL.

acrylamide An inert gel (polyacrylamide) employed as a medium in *electrophoresis. It is used particularly in the separation of macromolecules, such as nucleic acids and proteins.

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(propenonitrile) (e.g. **Acrilan**), and poly(methyl 2-methylpropenoate) (polymethyl methacrylate, e.g. **Perspex**).

acrylonitrile See PROPENONITRILE.

ACT See ACTIVATED-COMPLEX THEORY.

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 3 (formerly IIIA) 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. 3200°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. Its main use is as a source of alpha particles. The element was discovered by A. Debierne in 1899.

 SEE WEB LINKS

- Information from the WebElements site

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 (Ur) $5f^3 6d^1 7s^2$
 93 neptunium (Np) $5f^4 7s^2$ (or $5f^6 6d^1 7s^2$)
 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) $5f^8 6d^1 7s^2$ (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 Ur) occur naturally. All are radioactive and this makes investigation difficult because of self-heating, short lifetimes, safety precautions, etc. 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 See ACTINOMETRY.

actinometry The measurement of the intensity of electromagnetic radiation. An instrument that measures this quantity is called an **actinometer**. 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. Different types of actinometer have different names according to the type of radiation they measure. A **pyroheliometer** measures the intensity of radiation from the sun. A **pyranometer** measures the intensity of radiation that reaches the surface of the earth after being scattered by molecules or objects suspended in the atmosphere. A **pyrogeometer** measures the difference between the outgoing infrared radiation from the earth and the incoming radiation from the sun that penetrates the earth's atmosphere.

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

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the axon of a nerve, it causes a localized and transient switch in electric potential across the cell membrane from -60 mV (the resting potential) to $+45$ mV. The change in electric potential is caused by an influx of sodium ions. 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 adsorption *Adsorption that involves an activation energy. This occurs in certain cases of chemisorption.

activated alumina See ALUMINIUM HYDROXIDE.

activated charcoal See CHARCOAL.

activated complex See ACTIVATED-COMPLEX THEORY.

activated-complex theory (ACT)

A theory enabling the rate constants in chemical reactions to be calculated using statistical thermodynamics. The events assumed to be taking place can be shown in a diagram with the potential energy as the vertical axis, while the horizontal axis, called the **reaction coordinate**, represents the course of the reaction. As two reactants A and B approach each other, the potential energy rises to a maximum. The collection of atoms near the maximum is called the **activated complex**. After the atoms have rearranged in the chemical reaction, the value of the potential energy falls as the products of the reaction are formed. The point of maximum po-

tential energy is called the **transition state** of the reaction, as reactants passing through this state become products. In ACT, it is assumed that the reactants are in equilibrium with the activated complex, and that this decomposes along the reaction coordinate to give the products. ACT was developed by the US chemist Henry Eyring and colleagues in the 1930s. See also EYRING EQUATION.

activated sludge process A sewage and waste-water treatment. The sludge produced after primary treatment is pumped into aeration tanks, where it is continuously stirred and aerated, resulting in the formation of small aggregates of suspended colloidal organic matter called **floc**. Floc contains numerous slime-forming and nitrifying bacteria, as well as protozoans, which decompose organic substances in the sludge. Agitation or air injection maintains high levels of dissolved oxygen, which helps to reduce the *biochemical oxygen demand. Roughly half the sewage in Britain is treated using this method.

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.

activation energy Symbol E_a . The