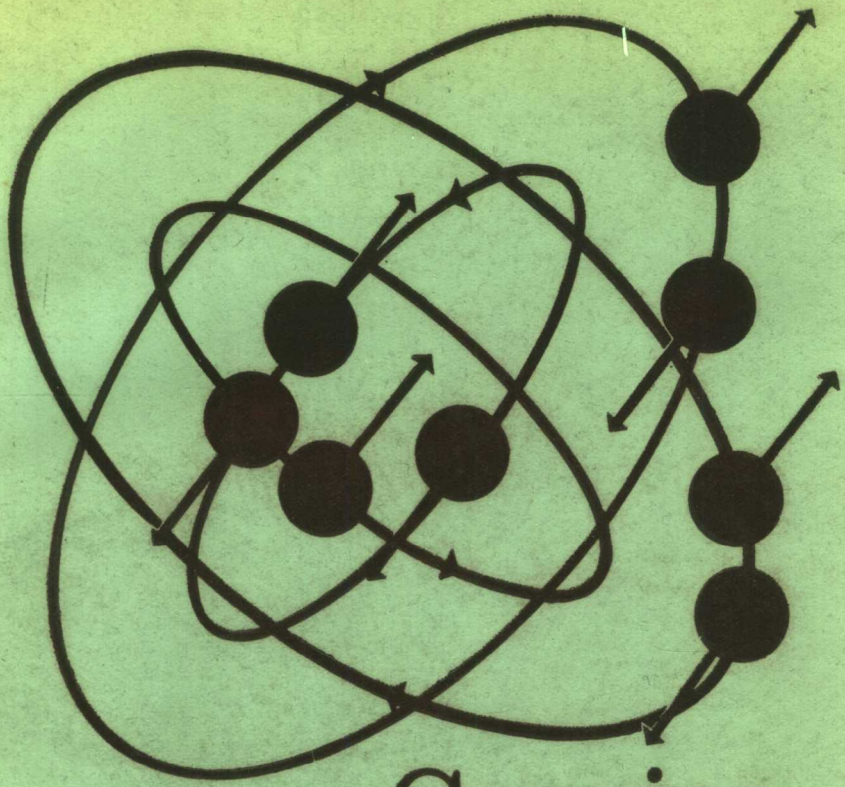

Concise Dictionary of Physics

and related subjects

Second Edition

Revised & Enlarged

J. Thewlis
D.Sc., F.Inst.P.

Pergamon Press

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Foreword to First Edition

In compiling this *Concise Dictionary of Physics* I have relied on the *Encyclopaedic Dictionary of Physics* to a considerable extent. However, since the new Dictionary consists of short definitions of terms which are each restricted (with some exceptions) to one concept, a new approach has had to be made to the choice and treatment of individual entries. The *Concise Dictionary* is, therefore, a new work in everything but scope, and even here there are noticeable differences between it and the *Encyclopaedic Dictionary*, if only because Physics does not stand still.

The scope of the work again covers not only Physics proper, but to a greater or lesser extent such related subjects as Astronomy, Astrophysics, Aerodynamics, Biophysics, Crystallography, Geophysics, Hydraulics, Mathematics, Medical Physics, Meteorology, Metrology, Photography, Physical Chemistry, Physical Metallurgy and so on.

It is hoped that a wide range of readers will find the Dictionary useful, from academic and industrial research physicists who may be interested in some branch of Physics removed from their own immediate specialities, through science teachers in Universities, Colleges or Schools, to students in Colleges and Universities and senior students in Schools, who may or may not be specializing in Physics, but who will find that the short summaries presented can save their consulting various dispersed sources for particular pieces of information.

Another kind of reader to whom the Dictionary should clearly be useful is the professional worker in some branch of science, such as one of those listed above, which is related to Physics. But there is also a large group of people with broader interests who will, I am sure, find the Dictionary a handy book of reference. I refer to managers and administrators in Government and Industry, who employ scientists and need to know the significance of what they read and hear; to politicians; to educationalists and teachers in general; to scientific editors; to writers and journalists; and of course to interested laymen of various kinds.

All this means naturally that not every entry in the Dictionary is suitable for every reader; but even the more specialized definitions will usually be found to contain an introductory sentence or so which serves to indicate the general nature of the term being defined.

To assist the reader cross-references have been given from individual terms to related terms; and the terms mentioned in the text are italicized where such cross-references have been made or where the reader might in any case be expected to look for them.

Terms which have their dictionary meaning or which are self-evident are not defined unless there is a special reason. The natural order of words in the terms has been adopted where possible, but there are many exceptions to this, for example, where groups of related terms are entered in close proximity. Thus *Emission spectrum* will be found under *Spectrum, emission*, with other related terms. One or two important terms are, however, entered in more than one place.

The order of the entries is strictly alphabetical and the use of apostrophes has been avoided for simplification, e.g. *Boyle law*, not *Boyle's law*. This strict alphabetical arrangement may occasionally lead to the inclusion of a term among a series of others to which it is not related (e.g. *Archimedes principle* and *Arctic air* come in the middle of terms dealing with *Arc*), but experience has shown that worse problems arise when one departs from the strict alphabetical order. The great advantage of the arrangement adopted is that there are no rules to remember, so that the reader knows precisely where to look for a given term.

This Dictionary is published at a time when a change to SI units is taking place in Schools, Colleges and Universities, and in Science and Technology in general. Even so, CGS units (and some units such as the electron volt, which are neither CGS nor SI) already form part of the literature and are likely to survive for some time to come. CGS and SI equivalents are, therefore, included in the definitions as appropriate. In addition, conversion tables are included in one of the Appendices, which give the values of CGS and related units, and of Imperial units, in terms of SI units.

The symbols are explained in each definition; but, apart from the general physical constants, are not necessarily the same in different definitions. Indeed a moment's reflection will show that this would be impossible. The usual convention has been adopted by which, in writing symbols for chemical elements or nuclides, the numerals attached have the following significance: upper left—mass number; lower left—

nuclear charge; lower right—number of atoms in the molecule. Thus $^{7}_{3}Li$ represents a lithium nucleus of mass 7, and $^{2}_{1}H_2$ or D_2 represents a molecule of deuterium. By extension $^{1}_{0}n$ represents a neutron. Where the state of ionization is needed it is given in the upper right-hand position.

In conclusion, I should like to acknowledge the help and encouragement given to me by the publishers, first by Mr. Robert Maxwell and later by Mr. Eric Buckley; and by the staff of Pergamon Press.

Finally I should like to say how much I owe to my wife, who has not only typed the script of the whole Dictionary (some parts more than once!) but has been of invaluable assistance in assembling and collating the individual entries.

Ardentinny,
Argyll

J. Thewlis

Introduction to Second Edition

The foreword to the original edition of the *Concise Dictionary of Physics* will serve the reader as a statement of the scope and plan of the present edition. In this edition an attempt has been made to fill gaps in the original edition, to modify or re-write entries in that edition which in the light of later work seemed incomplete or inaccurate, and to supply a number of new entries mostly dictated by recent discoveries.

Of the three original Appendices only the first, the Periodic Table and Symbols of the elements, remains untouched. The second, dealing with conversion tables, has been replaced by a fairly comprehensive table giving SI units, conversions and equivalents; and the third, giving values of some Fundamental Physical Constants, has been brought up to date by the inclusion of the latest recommended values.

Throughout the Dictionary the numerical values of physical quantities, ranging from the fundamental physical constants to experimentally determined values, have been examined and replaced by the latest values as necessary, having due regard to SI units.

I should again like to acknowledge the help and encouragement given to me by the publishers, notably Mr. Robert Maxwell and Mr. Alan Steel, and by members of the staff of Pergamon Press.

Finally I should once more like to thank my wife for typing and collating the revisions and additions, and for her invaluable assistance in general.

Ardentinny
Argyll

J. Thewlis

Contents

a

AB-. A prefix used to denote CGS electromagnetic units. See: *Units, CGS electromagnetic (e.m.u.).*

ABAMPERE. The absolute ampere, i.e. the CGS unit of current. One ampere is equal to 10^{-1} abamperes. See also: *Ampere, international. Biot.*

ABBE NUMBER. The reciprocal of the dispersive power for optical glass. See also: *Dispersive power, optical. Constringence.*

ABBÉ REFRACTOMETER. An instrument, employing the principle of total internal reflection, for the direct determination of the refractive index of a small quantity of liquid.

ABERRATION OF AN OPTICAL SYSTEM. Any failure of an optical system to form a point image of a point object. See also: *Astigmatism. Caustic. Coma (optics). Chromatic aberration. Spherical aberration.*

ABERRATION OF LIGHT. The alteration of the apparent position of a star or planet as a consequence of the Earth's motion and the finite velocity of light. See also: *Annual aberration. Diurnal aberration.*

ABLATION. A term originally describing the erosion and disintegration of meteors entering the Earth's atmosphere. Its meaning has now been extended to include the erosion of the outer surfaces of space vehicles, missiles, etc., on re-entering the Earth's atmosphere.

ABLATION MATERIALS. Protective materials, typically organic plastics, applied to the outer surfaces of space vehicles, missiles, etc., which are designed to undergo slow erosion on re-entering the Earth's atmosphere, thus affording protection from thermal damage to the space vehicle or missile itself.

ABNEY LAW. States that: if a spectral colour is desaturated by adding white light, its hue shifts towards the red end of the spectrum if the wavelength is below 5700 Å, and towards the blue if it is above. (*Note:* 1 Å is equal to 10^{-10} m.)

ABNEY MOUNTING. A modification of the Rowland mounting of a concave diffraction grating. See also: *Rowland circle. Rowland mounting.*

ABNORMAL SERIES. See: *Anomalous series.*

ABOHM. The absolute ohm, i.e. the CGS unit of resistance. One ohm is equal to 10^9 abohms. See also: *Ohm, international.*

ABSOLUTE PERMITTIVITY: PERMITTIVITY. Of a medium: the electric flux density or displacement produced in a medium by unit electric force. The term is often used to mean *relative permittivity.* See also: *Dielectric, refractive index of. Permittivity, relative.*

ABSOLUTE ZERO. The least possible temperature that could theoretically exist, according to the first and second laws of thermodynamics. At this temperature thermal energy is nil, but zero-point energy, attributed to the atoms by quantum mechanics, persists. See: *Temperature scale, international practical (IPTS).*

ABSORBANCE. The common logarithm of the absorptance. Also known as the optical extinction or optical density.

ABSORBED CHARGE. In a capacitor: the slow increase in charge which arises from the (slow) orientation of permanent dipolar molecules when the potential difference across a charged capacitor is maintained.

ABSORPTANCE. The ratio of the radiant flux absorbed by a body to the incident flux it receives. It is also known as the *absorptivity.*

ABSORPTION BAND. A band observed in an optical spectrum, arising from the excitation of the molecules of the absorbing medium to a number of excited states, with a consequent reduction of transmitted energy. See also: *X-ray absorption edge.*

ABSORPTION CELL. A vessel, usually with two transparent parallel walls, for containing a gas or liquid for which the absorption of radiation is to be measured. For the visible region glass walls are used, fused silica is commonly used for the ultraviolet region, and sodium chloride for the infrared. See also: *Beer law.*

ABSORPTION, CHEMICAL. The more or less uniform penetration of one substance into another across either a liquid or solid surface, involving a force of attraction analogous to valency. The process is not reversible. Alternative name: *Chemisorption.*

ABSORPTION COEFFICIENT FOR RADIATION. The quantity, α, in the expression $\alpha \Delta x$ for the fraction of a particular type of radiation absorbed in the passage of a parallel beam of the radiation through a thin layer of matter of thickness Δx. It is the absorption coefficient of that matter for that type of radiation. It is a function of the energy of the radiation and the nature of the matter, and, according as the thickness is expressed in terms of length, mass per unit area, moles per unit area, or atoms per unit area, the absorption coefficient is termed the *linear*, *mass*, *molar* or *atomic* absorption coefficient respectively. The absorption coefficient, α, occurs exponentially in the expression for the fraction of radiation transmitted $I = I_0 e^{-\alpha x}$ where I_0 refers to the incident and I to the transmitted radiation, and x is the thickness of matter traversed expressed in one of the above ways. See also: *Attenuation coefficient for radiation.*

ABSORPTION EDGE. See: *X-ray absorption edge.*

ABSORPTION INDEX. See: *Refractive index, complex.*

ABSORPTION LIMIT. See: *X-ray absorption edge.*

ABSORPTION OF RADIATION. (1) The transfer of energy to matter from radiation passing through the matter. (2) The disappearance in matter of an incident particle as a free particle, with or without the subsequent emission of other (possibly similar) particles. See also: *Absorption coefficient for radiation. Bouger–Lambert law of absorption. Photoelectric absorption.*

ABSORPTION, PHYSICAL. The more or less uniform penetration of one substance into another across either a liquid or solid surface, involving physical forces only. The process is reversible.

ABSORPTIVITY. See: *Absorptance.*

ABUNDANCE, CHEMICAL. Of an element: the fractional amount of that element (in terms of mass or number of atoms) present in a given environment, e.g. in the Earth (*terrestrial abundance*) or in the Universe (*cosmic abundance*).

ABUNDANCE, ISOTOPIC. Of a particular isotope in a mixture of isotopes of the same element: the fractional amount of that isotope. When expressed as a percentage it is known as the *relative abundance.*

ABUNDANCE, NATURAL. The isotopic abundance as found in nature. It is not necessarily constant.

ABUNDANCE RATIO. Of a particular isotope in a given material: the ratio of the number of atoms of that isotope to the number of atoms of another isotope of the same element present in the material.

ABUNDANT NUMBER. See: *Perfect number.*

ABVOLT. The absolute volt, i.e. the CGS unit of e.m.f. One volt is equal to 10^8 abvolts. See also: *Volt, international.*

ACCELERATING TUBE. The evacuated tube through which ions are accelerated in a Van de Graaff generator, Cockcroft–Walton apparatus, etc. It consists of a series of insulating rings sealed between conducting rings (the "electrodes") and is to be distinguished from the drift tubes or waveguide sections (a series of tuned radio-frequency cavities) used in a linear accelerator. See also: *Particle accelerator.*

ACCELERATION. The rate of change of velocity with time.

ACCELERATION DUE TO GRAVITY. See: *Gravitational acceleration.*

ACCELERATOR (PHOSPHOR). See: *Activator, optical.*

ACCEPTOR. An impurity or imperfection in a semiconductor which accepts electrons excited from the valence band, leading to hole conduction. The energy required to raise an electron from the valence band to the acceptor state is the ionization energy of the acceptor atom. See also: *Donor.*

ACCEPTOR LEVEL. An energy level associated with the acceptor state, commonly measured from the top of the uppermost filled energy band.

ACCIDENTAL COUNTS. In a coincidence counting system: the counts arising from effects unrelated to that under investigation.

ACCOMMODATION COEFFICIENT. A measure of the extent to which gas molecules leaving the surface of a solid in an atmosphere of the gas are in thermal equilibrium with it. It is defined as

$$a = \frac{T_i - T_r}{T_i - T_w}$$

where T_i is the temperature associated with the molecules incident on the surface, T_r is that associated with the molecules leaving the surface, and T_w is the temperature of the surface itself.

ACCOMMODATION TIME. Of an electrical discharge: the time that elapses from the production of the first electron to the establishment of the discharging condition (*ignition*).

ACCUMULATOR. An electrochemical cell in which storage is achieved and which is capable of being recharged when discharged, in contrast to a primary cell which has a limited life. The three main forms are the lead–acid, nickel–cadmium and nickel–iron cells. The accumulator is also known as a *storage cell* or *secondary cell*. See also: *Primary cell.*

ACCUMULATOR, EFFICIENCY OF. The ratio of the electrical energy obtained from the accumulator during its discharge to that supplied during charging. The energy is taken between specified limits of charge and discharge, and is usually expressed as a percentage.

ACCURACY. The reliability of a measurement, observation, etc., usually expressed as its error (i.e. its deviation from the "true" value). See also: Entries under *Error. Precision.*

ACHROMATIC COLOUR. One which has no hue, i.e. a grey.

ACHROMATIC SENSATION. One which gives merely a sensation of grey.

ACID. A substance having a tendency to lose a proton in a chemical reaction. See also: ***Base***.

ACKERET THEORY. States that the disturbance due to an aerofoil in a supersonic air stream consists of two plane waves, occurring at the leading and trailing edges respectively, which are propagated outwards like sound waves. The theory leads to expressions for the pressures on the upper and lower surfaces of the aerofoil and to values for the lift, drag and momentum coefficients.

ACOUSTIC. See also under *Sound.*

ACOUSTIC ARRAY, DIRECTIONAL. An arrangement of acoustic sources or receivers which is designed to have directional properties. The term may be extended to include electrical signal-processing operations which influence the directional properties, e.g. a multiplicative array. See also: *Array, scanning of.*

ACOUSTIC ARRAY, DIRECTIONAL FUNCTION OF. (1) For a transmitting array: a function relating the strength of the acoustic signal at a distant receiving point to the bearing angle, as the array is rotated. (2) For a receiving array: a function expressing the electrical output amplitude from a fixed distant source, as the array is rotated.

ACOUSTIC ARRAY, MULTIPLICATIVE. A receiving array which is split into two parts, the signal voltages obtained from them being multiplied together. Also known as a *correlation array.*

ACOUSTIC CAPACITANCE. The negative imaginary part of acoustic impedance.

ACOUSTIC EMISSION FROM MATERIALS. The generation of sound when certain materials are mechanically deformed. In most cases the amplitude of the sound is too low, or the frequency too high, for it to be heard without special apparatus. The main causes are twinning (as in the well-known *cry of tin*), the sudden reorientation of large grains in polycrystalline material, the martensitic transformation, and slip in general. The effect has been applied in a variety of ways, from the warning of rock bursts in mines to studying the behaviour of nuclear reactor pressure vessels. See also: *Singing sands.*

ACOUSTIC FILTER. A device which filters out or attenuates certain frequencies initially present in a sound wave. The filters may consist of tubes, ducts or acoustic diffraction gratings, but the term is usually restricted to tubes with expanded or contracted sections, branch pipes or cavities, or diaphragms.

ACOUSTIC GRATING. A diffraction grating for the production of sound spectra. Both transmission and reflection types, including concave gratings, are used. With a frequency of 5000 Hz the grating spacing is about 10 cm.

ACOUSTIC IMPEDANCE. At a surface: the complex ratio of sound pressure averaged over the surface to the flux, or volume velocity, through it. It may be written $Z_A = P/Sv$, where P is the complex pressure, S is the area in question and v is the volume velocity. The units are the *acoustic ohm* (dyne s cm^{-5}) or the *SI acoustic ohm* (N s m^{-5}). See also: *Impedance. Mechanical impedance.*

ACOUSTIC IMPEDANCE, CHARACTERISTIC. A special case of the specific acoustic impedance for a plane wave. It is equal to the product of the mean density of the medium and the velocity of sound in the medium. It is sometimes known as the *intrinsic resistance.*

ACOUSTIC IMPEDANCE, SPECIFIC. The ratio of the (complex) sound pressure to the particle velocity, i.e. to the velocity of an infinitesimal part of the medium.

ACOUSTIC MODEL OF PARTICLE SCATTERING. An early form of the optical model, involving sound instead of light. See also: *Optical model of particle scattering.*

ACOUSTIC NOISE IN THE SEA. Underwater acoustic noise. It may be due to thermal agitation,

breaking waves, fish and other marine animals, the rolling of shingle, ships' propellers, etc. Its importance falls off with the operational frequency of the detection system and is unimportant in sonar systems working at frequencies above 200 kHz.

ACOUSTICS. The science dealing with the production, behaviour and detection of sound.

ACOUSTO-ELECTRIC EFFECTS. Phenomena which arise from the interaction of free electrons and holes with acoustic waves.

ACTINIC LIGHT. Light of a wavelength capable of producing a photographic effect.

ACTINIC VALUE. Of light of a given wavelength: the density of the image produced in a photographic emulsion under specified conditions.

ACTINIDE ELEMENTS. Members of the second rare earth series, the actinide series, named by analogy with the lanthanide series. The actinide elements comprise elements with atomic numbers 90 to 103. See also: *Rare earths. Appendix I.*

ACTINIUM SERIES. The radioactive series of elements beginning with ^{235}U and ending with ^{207}Pb. It is one of the three naturally occurring radioactive series, the others being the thorium series and the uranium series, which are separately defined. The series is also known as the *actino-uranium series*, or the *4n + 3 series* (since the atomic number of each member of the series can be expressed in this way).

ACTINOMETER. A radiometer used mainly in meteorology to measure solar and terrestrial radiation. An instrument designed to measure the intensity of the direct solar beam is known as a *pyrheliometer*. One designed to measure the total radiation falling on a surface is known as a *pyranometer*.

ACTINOMETRY. (1) The measurement of the light absorbed by a system undergoing photochemical change. Often extended to include the measurement of radiant energy absorption in general. (2) The measurement of the energy of solar radiation.

ACTINON. See: *Radioactive emanation: Emanation.*

ACTINO-URANIUM SERIES. See: *Actinium series.*

ACTION. Of a conservative dynamical system: the space integral of the total momentum of the system, i.e.

$$\int_{P_1}^{P_2} \Sigma_i m_i \frac{d\mathbf{r}_i}{dt} \cdot d\mathbf{r}_i$$

where m_i is the mass and $\mathbf{r}_i$ the position vector of the ith particle, t is time, and the system is assumed to pass from configuration P_1 to P_2. This expression reduces to $2\int_{t_1}^{t_2} E\,dt$ where t_1 and t_2 are the times at which the system has the configuration P_1 and P_2 respectively, E being the total energy of the system. See also: *Least action.*

ACTION AT A DISTANCE. The problem of the influence of one body upon another, with which it is not in contact. Contiguous or contact forces, such as tensions and pressures in electric and magnetic fields, were invoked at one time to resolve this problem, but the concept of action at a distance has now been modified into an interaction through some intermediate field, such as the electromagnetic field of Maxwell or the gravitational field of Einstein. A similar attitude exists in the quantum treatment of interaction.

ACTION POTENTIAL. The wave of depolarization travelling down biological cells, which is associated with signals carried by nerves or with the contraction of muscles. Also known as a *spike*. After the passage of an action potential down a nerve, the nerve is for a short time quite unexcitable. This time is the *absolute refractory period* of the nerve. The nerve then shows a reduced excitability for a further period, the *relative refractory period*, before its initial excitability returns. See also: *Resting potential.*

ACTION SPECTRUM. A plot against wavelength of the ability of a given type of radiation to produce a particular biological effect. This ability is expressed as the reciprocal of the energy required to produce the effect in question and the action spectrum corresponds more or less closely to the relevant absorption spectrum.

ACTIVATED DIFFUSION. The migration of ions, atoms or lattice defects across a potential barrier in a solid.

ACTIVATION ANALYSIS. See: *Radioactivation analysis.*

ACTIVATION ENERGY. The energy that must be acquired by an atomic or molecular system, or part of such a system, to enable a particular process to occur. Examples are: the energy needed by a molecule to take part in a chemical reaction, the energy needed to produce annealing or creep in crystalline materials, the energy needed to excite an electron in the production of luminescence, the energy required to raise an electron to the conduction band, or the energy needed to allow a lattice defect to move to a neighbouring site.

ACTIVATION, RADIOACTIVE. The process of

inducing radioactivity by irradiation.

ACTIVATOR, OPTICAL. An activating agent which is added in minute quantities to a phosphor to produce luminescence of a required colour. Alternative name: *Accelerator.*

ACTIVE COMPONENT. In electrical engineering: that component of the vector representing an alternating quantity which is in phase with some reference vector, e.g. the active component of the current, or *active current* (the component in phase with the voltage), the *active voltage* (the component in phase with the current), the active *volt-amperes* (the product of the active voltage and the current, or of the active current and the voltage, equal to the power in the circuit).

ACTIVE CURRENT. See: *Active component.*

ACTIVE DAYS: DISTURBED DAYS. Five days selected each month as international magnetic "disturbed" or "active" days, on the basis of many magnetic observations. See also: *Quiet days: Calm days.*

ACTIVE NITROGEN. A modification of ordinary nitrogen produced by passing various types of discharge through N_2. It exhibits a wide range of interesting physical and chemical properties, including significant changes in the optical spectrum. Active nitrogen emits a golden yellow glow (the *Lewis–Rayleigh afterglow*), which is believed to be associated with the recombination of nitrogen atoms.

ACTIVE VOLTAGE. See: *Active component.*

ACTIVE VOLT-AMPERES. See: *Active component.*

ACTIVITY. (1) Of a radioactive substance: the number of nuclear disintegrations occurring in a given quantity of substance per unit time. See also: *Becquerel. Curie. Radioactive decay constant: Radioactive disintegration constant.* (2) In a chemical reaction: the ideal or thermodynamic concentration of a substance, the substitution of which for the true concentration permits the application of the law of mass action. (3) Optical: the property of rotating the plane of polarization of light. It may arise from the asymmetric arrangement of molecules in a crystal or from the asymmetric arrangement of atoms in a molecule.

ACTIVITY COEFFICIENT. The ratio of the chemical activity to the true concentration.

ACTIVITY, SPECIFIC. Of a specified radioactive material or nuclide: the activity per unit mass.

ACTUATOR DISK. A simplified concept of a propeller in which it is assumed that the number of blades is infinite and that the thrust is uniformly distributed over the disk.

ADAPTATION (VISION). The change in the sensitivity of the eye after prolonged exposure to light or dark. *Dark adaptation* occurs when the subject moves from a bright to a dark environment, and is measured in minutes. *Light adaptation* occurs when the subject moves in the opposite sense, and is measured in seconds.

ADAPTIVE CONTROL. The automatic control of a process (e.g. the flight of an aircraft) in such a way that the process responds to changes in the operating environment (e.g. the autopilot of an aircraft would take account of change in altitude and speed).

ADAPTOMETER. An instrument for measuring the course of adaptation of the eye.

ADDITIVE COLOUR PROCESS. See: *Photography, colour.*

ADHERENCE NUMBER. A measure of the adhesive properties of solid particles, based on the number of particles adhering to a plate under specified conditions.

ADHESION, WORK OF. The work required to pull apart unit area of the interface between two solids, two liquids, or a liquid and a solid.

ADIABATIC APPROXIMATION. An approximation used when the Hamiltonian of a quantum system varies slowly with time.

ADIABATIC CHANGE. (1) Any process taking place without gain or loss of heat. (2) A reversible thermodynamical change of a system carried out with no change of entropy, i.e. without any heat entering or leaving the system. See also: *Polytropic change or process.*

ADIABATIC CHART. A chart showing the variations of a pair of thermodynamic variables during an adiabatic change. Also called an *isentropic chart.*

ADIABATIC DEMAGNETIZATION, COOLING BY. (1) Of a paramagnetic salt: the most common method of producing temperatures below 1 K. It involves the isothermal magnetization of the salt, followed by adiabatic demagnetization, and temperatures as low as about 10^{-3} K may be obtained in this way. (2) Of a substance with nuclear moments: a method involving the isothermal magnetic alignment of the nuclear spins at temperatures of about 10^{-2} K, followed by adiabatic

demagnetization. The production of temperatures as low as about 10^{-6} K should be feasible.

ADIABATIC LAPSE RATE. See: *Lapse rate.*

ADIABATIC SATURATION TEMPERATURE. Of a gas under specified initial conditions of temperature and humidity: the temperature that the gas would attain if it were saturated with vapour under adiabatic conditions. For the special case of the air–water system this temperature is equal to the wet-bulb temperature.

ADMITTANCE. The reciprocal of impedance. The real part is called the *conductance* and the imaginary part the *susceptance.*

ADMITTANCE, IMAGE. The reciprocal of the image impedance.

ADSORBATE. The film of adsorbed material present on an adsorbing surface, i.e. on the *adsorbent.* See also: *Adsorption.*

ADSORPTION. Absorption when only the surface functions as the absorbing medium. The material adsorbed (the *adsorbate*) is present as a film, which may be only one molecule thick, on the surface of the adsorbent.

ADSORPTION INDICATOR. A compound capable of revealing the end-point in a precipitation titration by changing the colour of the precipitate.

ADSORPTION ISOBAR. The relation between the quantity of gas adsorbed at a solid surface to the temperature, at constant pressure.

ADSORPTION ISOTHERM. The relation between the quantity of gas adsorbed at a solid surface to the pressure of the gas, at constant temperature.

ADVANTAGE FACTOR. In a nuclear reactor: the ratio of a specified radiation quantity at a position where an enhanced effect is produced to the value of the same radiation quantity at some reference position.

ADVECTION. Refers (mainly in meteorology) to the change in any property (e.g. temperature) of a given element of air which is brought about by the motion of the air in a gradient of the property concerned. It is usually limited to the change arising from the horizontal component of the motion only.

AEOLIAN TONE. A musical note set up when air flows past a fixed thin wire. It arises from the vortices formed in the wake of the air stream. See also: *Noise, aerodynamic.*

AELOTROPIC. Having different properties in different directions. The term usually refers to a crystal and is applied even if only one anisotropic property is exhibited.

AERIAL. A conductor or series of conductors, usually in the form of a wire or wires, erected in an elevated position and used for the transmission or reception of radio waves. Also known as *antenna.*

AERIAL, ADCOCK. A directional receiving aerial consisting of two spaced vertical dipoles connected to respond only to vertically polarized waves.

AERIAL ARRAY. A system of two or more spatially arranged, coupled aerials, which is designed to have particular directional radiating or receiving properties. See also: *Array, scanning of.*

AERIAL ARRAY, LINEAR. An aerial array in which the constituent elements, generally identical, are arranged along a straight line and separated by equal distances of a given fraction of a wavelength. It is designed to have highly directional properties.

AERIAL ARRAY, NULL DIRECTION OF. That direction in which the power radiated or received in unit solid angle is zero.

AERIAL, BEVERAGE. An aerial consisting of a long conductor mounted horizontally above the earth and running in the direction of arrival of the incoming waves. Also called *wave aerial.*

AERIAL, BICONICAL. An aerial formed by two conical conductors, having a common axis and vertex, and excited at the vertex.

AERIAL, DIPOLE. Usually refers to a straight conductor, of overall length one half-wavelength, and fed in the centre. Other lengths may, however, be used and a *full-wave* dipole is not uncommon.

AERIAL, DIRECTIVE PATTERN OF. See: *Aerial, polar diagram of.*

AERIAL, DIRECTIVITY OF. The ratio of the radiation intensity of an aerial, measured in the peak direction, to the radiation intensity of a standard uniform radiator, when both are subject to the same input power.

AERIAL, EFFECTIVE HEIGHT OF. Of a receiving aerial: the ratio of the total voltage induced at the terminals to the field strength (in volts per unit length) incident on the aerial.

AERIAL, FOLDED-DIPOLE. A dipole antenna folded back on itself to form a narrow rectangular loop one half-wavelength long.

AERIAL, FRAME. See: *Aerial, loop or frame.*

AERIAL GAIN. Of a directional aerial: the ratio, usually expressed in decibels, of the power supplied to the aerial for the production of a given field strength to that required for the production of the same field strength in the same direction by a non-directional comparison aerial.

AERIAL, HELICAL. An aerial in the form of a loosely wound helix in which the circumference of one turn is approximately equal to the wavelength. It has appreciable gain with the main lobe directed along the axis of the helix.

AERIAL, HORN. An open extension of a waveguide in which some degree of matching between the waves in the guide and those in space is obtained by suitably shaping the region of transition between the guide and the aerial aperture.

AERIAL IMPEDANCE. (1) Between two points in an aerial system: the self-impédance that would be offered to the voltage supply feeding the system if that supply were to be fed at the two points in question. (2) Of one point in an aerial system: the self-impedance that would be offered if the system were to be open-circuited at that point and the voltage source inserted. At the resonant frequency of the system the aerial impedance is purely resistive.

AERIAL, INDUCTION FIELD OF. The electromagnetic field distribution which is localized round an aerial, and which makes no contribution to the average power flowing into or out of the aerial. The magnetic induction field varies as the inverse square and the electric induction field as the inverse cube of the distance from the aerial.

AERIAL, LOOP OR FRAME. An aerial consisting of one or more rings, squares or rectangles of wire, the plane of the loops being in the direction of maximum transmission or reception. Of main interest are electrically small loops operated at high frequency.

AERIAL NOISE. A noise component (analogous to thermal noise) of the output from an aerial or aerial system which is directed at the open sky or at objects which absorb radio waves. Its magnitude is given by the *aerial temperature*, defined as the temperature of a black-body enclosure which, if it completely surrounded the aerial system and were in thermodynamic equilibrium with it, would produce the same amount of noise.

AERIAL, PARABOLIC. A directional aerial employing a reflecting parabolic mirror. It is fed (by means of dipoles, waveguide feed systems, or horns) at a point approximately at the focus of the reflector for a paraboloid of rotation, or on the focal line of the reflector for a parabolic cylinder.

AERIAL, PARASITIC. An element of an aerial array excited not by the primary source but by the field produced by other "driven" elements of the array.

AERIAL, POLAR DIAGRAM OF. The plot of the radiation intensity received or transmitted by an aerial as a function of direction in a given plane. Where the mapping is carried out in three dimensions the diagram is known as the *radiation pattern* or *directive pattern* of the aerial.

AERIAL, RADIATION PATTERN OF. See: *Aerial, polar diagram of.*

AERIAL, RHOMBIC. An aerial which has four wire elements arranged along the sides of a rhombus. The aerial is fed at one corner and the opposite corner is terminated in the resistance required to prevent reflections travelling back towards the feed.

AERIAL, SLOT. A radiating element formed by cutting a hole or slot in the wall of a waveguide or cavity resonator.

AERIAL TEMPERATURE. See: *Aerial noise.*

AERIAL, TURNSTILE. (1) An aerial comprising four vertical radiators arranged to intersect a horizontal plane at the four corners of a square. (2) An aerial consisting of two horizontal half-wave dipoles arranged at right angles and fed in phase quadrature.

AERIAL, VEE. An aerial consisting of a pair of equal straight conductors set at an angle to each other and fed at the junction between them.

AERIAL, WAVE. See: *Aerial, Beverage.*

AERIAL, YAGI. An aerial array containing one radiating element and a number of parasitic ones.

AERODYNAMIC CENTRE. The position within an aircraft or missile at which a change in the angle of incidence produces no change in the aerodynamical pitching moment. It is the point at which the additional forces induced by a change of incidence may be considered to be located. From the position of the vehicle's centre of gravity with respect to this point, the longitudinal stability or *static margin* of the vehicle, may be assessed.

AERODYNAMIC HEATING. The transfer of heat to a solid body immersed within, and moving relative to, a fluid, often air.

AERODYNAMIC NOISE. See: *Turbulence, sound from.*

AERODYNAMIC RANGE. An arrangement for observing the motion of a projectile, aircraft model or missile model in free flight. It is complementary to a wind tunnel.

AERODYNAMICS. The study of air in motion; by generalization, the science of the dynamics of gases. It deals largely with the disturbance produced by the relative motion between a solid and air or other gas in contact with it, and with the reactions experienced by the solid.

AERODYNAMICS, INTERNAL. The study of the flow of air or gas through compressors, ducts, fans, orifices, turbines, valves, etc.

AERODYNAMIC TIME. A unit of time, known as the *airsec*, formerly used in aerodynamic investigations of stability, and defined as $\frac{W/S}{\varrho g V}$ where W is the all-up weight of an aircraft, S the gross wing area, ϱ the density of the air, V the air speed and g the gravitational acceleration.

AERODYNE. See: *Aircraft.*

AEROELASTICITY. The science concerned with the dynamics of a system governed by inertial (and to some extent gravitational), aerodynamic and elastic forces. Its principal application lies in the field of aeronautics, but it is also of considerable significance in other fields, e.g. the stability of suspension bridges, the oscillation of towers and high buildings.

AEROFOIL. In aeronautics: a lifting wing or, more specifically, the shape of an appropriate section through such a wing.

AEROFOIL, INCIDENCE OF. The angle between the chord line of an aerofoil and the relative airflow.

AEROFOILS, CASCADE OF. A set (finite or infinite) of aerofoils arranged in rows or tiers, usually of constant chord, with constant *pitch* (distance between neighbouring members), whose purpose is to deflect a uniform airstream through a constant angle. By extension, sections of a set of turbine blades, taken at constant radius, can be developed into sections of an infinite cascade.

AEROFOIL, SPAN OF. The length along a specified line measured normal to the main air flow. See also: *Span.*

AEROFOILS, STAGGER OF. Of two or more aerofoils arranged in cascade (e.g. in a biplane system): the angle (in a section normal to the span) between a line joining the leading edges and the normal to a chord line. It is positive if the upper aerofoil ("up" being taken as the direction of lift) leads the lower.

AEROFOIL, WEDGE. A supersonic aerofoil section of small thickness ratio (5% or less) with plane surfaces instead of curved. It is usually wedge-shaped at both leading and trailing edges, sometimes with a parallel mid-portion, and is then known as a *double-wedge aerofoil.*

AEROGEL. A gel in which the dispersing medium is a gas.

AEROLITE. See: *Meteorite.*

AEROLOGY. The study of the atmosphere in three dimensions as contrasted with the study of the atmosphere from observations made only at the Earth's surface.

AERONOMY. The study of the physics of upper atmospheric phenomena, including the effects of solar radiation.

AEROPHYSICS. The study of the properties of gases at very high Mach numbers.

AEROSOL. A relatively stable suspension of solid particles or liquid droplets dispersed in a gas.

AEROSOL, RADIOACTIVE. A suspension in air of liquid or solid particles containing radioactive substances. The particle size may vary from 10^{-3} to 50 μm.

AEROSTAT. See: *Aircraft.*

AEROSTATICS. The study of gases at rest in equilibrium. An important application is to the equilibrium of balloons and airships.

AFFINE FIELD THEORIES, RELATIVISTIC. Theories which attempt to extend the general theory of relativity to explain the origin of the electromagnetic field and the meson field.

AFFINE SPACE. An n-dimensional space with particular properties associated with the transformation of coordinates. It finds a particular application in the general theory of relativity.

AFFINITY, CHEMICAL. Of a chemical or electrochemical reaction: the decrease in free energy accompanying the reaction.

AFTER-GLOW. The light emitted by a phosphor after the excitation is removed. See also: *Phosphorescence.*

AFTER-GLOW, LEWIS–RAYLEIGH. See: *Active nitrogen.*

AFTER-IMAGE. The image seen after the retina, or a portion of it, has been fatigued by exposure to intense light or to a continued fixed light stimulus. It may be positive or negative and sometimes exhibits colours complementary to the original.

AGE DETERMINATION BY RADIOACTIVITY. The determination of the time since a given radioactive nuclide was first formed, usually estimated from the ratio of the amounts of parent and daughter products, as in the case of potassium-argon dating and uranium series dating. In carbon dating the actual amount of ^{14}C present is determined, on the assumption that the decay rate has remained constant under terrestrial conditions during geological time. The technique has been applied to estimate the age of minerals, geological formations, meteorites, archaeological objects, etc., and has been extended to include the examination of fission tracks in minerals, which have resulted from spontaneous fission of uranium. See also: *Archaeomagnetism. Thermoluminescent dating.*

AGE HARDENING: PRECIPITATION HARDENING. Of an alloy: the hardening, by ageing at room temperature or above, of a supersaturated alloy quenched from a high temperature. The effect is due to the precipitation of new phases from the supersaturated matrix, usually in the form of platelets, known as *Guinier–Preston zones.*

AGEING OF MAGNETIC MATERIALS. The change of magnetic properties of a metastable alloy with time. Artificial ageing may be induced by heating at an elevated temperature.

AGE OF NEUTRONS. See: *Fermi age.*

AGGLUTINATION. The coalescing of small suspended particles into large masses which will form a precipitate.

AGGREGATE RECOIL. The ejection of radioactive atoms from the surface of a radioactive material. It occurs principally in α-particle disintegration where kinetic energy is transferred from the α-particle and the recoiling daughter nucleus to the parent atom, which may occasionally be ejected from the surface. It is observed as a migration of a fraction of the radioactivity on to nearby surfaces.

AGGREGATION. The gathering of particles, especially in the sense of their formation into larger entities or aggregates.

AGGREGATION, STATE OF. Formerly used to denote a separate physical condition with the classification into solids, liquids and gases. This is no longer sufficient and it can be considered that any discontinuity in a normally well-defined physical property marks some change in the state of aggregation. For example, solids may be divided into crystalline and amorphous; and superfluids and plasmas may be regarded as new states of aggregation.

AGREEMENT RESIDUAL. In crystal structure determination: a quantity expressing the extent to which the calculated structure amplitudes for a proposed structure disagree with those observed. It is given by the sum of the differences between the observed and calculated structure amplitudes, for all observed reflections, expressed as a fraction of the sum of the observed amplitudes. It is sometimes known as the *reliability factor.*

AIR COIL. A self-supporting coil of wire in which the core is free of any other material. It may be used, for example, as an impedance.

AIR-CONDITIONING. The control of the temperature, moisture content and purity of the air by ventilation, heating and cooling and adjustment of humidity.

AIRCRAFT. Any form of flying machine or vehicle supported by air. An *aerostat* is supported by its own buoyancy; an *aerodyne* by wings.

AIR ENGINE. A heat engine depending for its operation on the alternate expansion and contraction of a given mass of air.

AIR-EQUIVALENT MATERIAL. A material suitable for the walls of ionization chambers, particularly for standardizing measurements, having substantially the same effective atomic number as air. A suitable material is impregnated paper or light plastic, with graphite as the conducting material. Also known as *air-wall material.* See also: *Ionization chamber.*

AIRGLOW. An emission from the upper terrestrial atmosphere which, together with diffused light from the Sun and stars, contributes to the light of the night sky. It exhibits diurnal, annual and solar variations. The airglow emitted at twilight arises from the illumination of the upper layers of the atmosphere by the Sun and is known as the *twilight airglow.* See also: *Twilight phenomena.*

AIR MASS (METEOROLOGY). A volume of the atmosphere, usually extending over hundreds of thousands of square kilometres, within which the mean temperature of a vertical column of given height (some hundreds of metres) is not very different from place to place.

AIRSEC. See: *Aerodynamic time.*

AIRSHIP. A power-driven aircraft which is lighter than air.

AIR SHOWER. See: *Cosmic ray shower.*

AIRSPEED, EQUIVALENT. The indicated airspeed, corrected for the density of the air, i.e. for the altitude. It is equal to $V/\sqrt{\sigma}$, where V is the speed of the aircraft relative to the surrounding air and σ the factor by which the air density at the relevant altitude differs from the standard density at sea level.

AIRSPEED, INDICATED. The speed of an aircraft as displayed on an instrument actuated by the difference between two pressures dependent on the speed.

AIRSPEED, TRUE. The actual speed of an aircraft through the air, computed by correcting the indicated airspeed for altitude, temperature, position error (i.e. the error associated with the location of the pressure-measuring devices) and compressibility effect.

AIR STREAMLINE. A line along which the direction of motion of the air at any instant is tangential.

AIR TRAJECTORY. The path followed by an element of air, as given, for example, by the path followed by a small inert marker. For steady motion the air trajectories are identical with the streamlines in the field of flow.

AIR-WALL MATERIAL. See: *Air equivalent material.*

AIRY DISK: AIRY PATTERN. The Fraunhofer diffraction pattern due to a circular aperture uniformly illuminated; thus, the form of the image of a point source of light which would be produced by an aberration-free optical system. The variation of light intensity across the disk is given by

$$\left(\frac{2J_1(z)}{z}\right)^2,$$

where $z = \frac{2\pi r}{\lambda} \sin \alpha$, r is the distance from the centre of the image, α the semi-angle of the cone of rays forming the image and λ the wavelength.

AIRY POINTS. In metrology: two points on a standard bar which, if the bar is supported at them, result in the least effect on the horizontally projected length of the bar arising from the varying flexure of the bar due to changes in gravity or small errors in the exact point of support. Each point is distant from the centre point by $1/(2\sqrt{3})$ of the length of the bar. More generally, for n points of support the distance apart of the points is $l/\sqrt{(n^2-1)}$, where l is the length of the bar.

AIRY SPIRALS. Spiral interference patterns produced when quartz cut perpendicularly to the axis is examined in convergent circularly polarized light.

ALBEDO. (1) For radiant energy: the coefficient of diffuse reflection, i.e. the ratio of the total scattered energy to the incident energy. (2) For light: the ratio of the amount of light reflected in all directions by an element of a diffusely reflecting surface to the amount of light incident on that element. It is not necessarily a constant for any particular surface. In astrophysics the *Bond albedo* is used for determining the mean albedo. This is the ratio of the total light reflected in all directions from a sphere illuminated by parallel rays, to the light incident upon that sphere. (3) For cosmic rays: that fraction of the radiation outside the atmosphere which has its origin in interactions within the atmosphere. The *splash albedo* refers to all the outgoing radiation. The *geomagnetic albedo* is the fraction of the splash albedo which is returned to the atmosphere by the Earth's magnetic field. (4) For neutrons: the probability under specified conditions that a neutron entering into a region through a surface will return through that surface.

ALCOHOL. The hydroxyl derivative of a hydrocarbon. Of primary industrial importance are the primary alcohols, general formula R · OH, where R represents the hydrocarbon group.

ALFVÉN WAVE. A magnetohydrodynamic wave which is propagated in the direction of the magnetic field. The mass displacement is perpendicular to the direction of propagation.

ALGEBRAIC EQUATION. In the widest sense, an equation $F(z) = 0$ not involving the operations of differentiation or integration. Its solution is a number or set of numbers. A more restrictive definition is to a polynomial equation

$$P(z) \equiv a_0 z^n + a_1 z^{n-1} + \ldots + a_{n-1} z + a_n = 0,$$

the coefficients $a_0 \ldots a_n$ normally being real.

ALGEBRAIC NUMBER. Any number that can be expressed as the root of an algebraic equation. Algebraic numbers include all integers and rational fractions, and also those irrational numbers that satisfy the above definition. See also: *Transcendental number.*

ALGORITHM. A specific sequence of operations which, in principle at least, can give the solution to a given problem. The sequence can be of either finite or infinite length.