FOURTH EDITION

A Dictionary of Named Effects and Laws in Chemistry, Physics and Mathematics

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Science Paperbacks

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Named Effects and Laws
in Chemistry, Physics and Mathematics

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1980

LONDON NEW YORK

CHAPMAN AND HALL

150TH ANNIVERSARY

First published 1958
by Chapman and Hall Ltd
11 New Fetter Lane, London EC4P 4EE
Second edition 1961
Third edition 1970
First issued as a Science Paperback 1972
Fourth edition 1980

Published in the USA by
Chapman and Hall
in association with Methuen Inc.
733 Third Avenue, New York, NY 10017

Printed in the United States of America

ISBN 0 412 22380 5 (cased)
ISBN 0 412 22390 2 (Science Paperback)

British Library Cataloguing in Publication Data

Ballentyne, Denis William George
A dictionary of named effects and laws. – 4th ed.
1. Science – Dictionaries
I. Title II. Lovett, D R
500.2 Q123 79-41716

ISBN 0-412-22380-5
ISBN 0-412-22390-2 Pbk

A Dictionary of Named Effects and Laws

Preface to the fourth edition

The format of this edition remains unchanged from previous editions but the majority of entries have received some revision. In particular, units are now in SI units wherever possible, although with certain of the classical entries this is not possible. Chemical terminology has proved a particular problem. We have kept the common names for organic compounds because of the wide readership of this book but we have added an extra table giving the equivalent systematic names and the formulae.

We have tried to avoid omission of any *named* effects and laws that have wide usage. Nevertheless, in order to keep the book to a manageable length, it has been necessary to make a selection among the less commonly used terms and it is inevitable that some arbitrary choices and omissions must be made. Some entries from earlier editions have been left out to make room for other entries which we feel have become more important. We are especially grateful to those readers who have pointed out previous omissions.

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Preface to the first edition

Every science has its own vocabulary. It is impossible to read many pages of any scientific book without encountering words which possess a specific and unique meaning to the particular scientific subject with which the book deals. Some of these words are proper nouns, either used substantively or, more rarely, adjectivally. These are the names of scientists who have investigated a particular phenomenon or who have discovered some scientific law or relation or who have worked in some field with which their name has become historically connected.

It is with such names that this book is concerned. It is by no means intended to be read as a text-book but rather to be consulted as a dictionary whenever the reader, possibly an expert in one branch of science, is confronted by a mention of a relation or rule or law of someone or other who worked, maybe, in quite another field. He may not feel inclined to delve very deeply into the origins of the phrase. He may, in fact, wish to obtain such information as may enable him to proceed, as quickly as possible, with his reading. It is partly in an endeavour to help him that this glossary has been compiled.

Classification by subject matter has not been attempted and entries appear in alphabetical order.

Symbols

(Unless otherwise stated, further symbols are defined within the entries.)

c	velocity of light
e	electron charge
F	Faraday constant
g	acceleration due to gravity
h	Planck's constant
$\hbar =$	$h/2\pi$
k_B	Boltzmann's constant
m	electron mass
N	number of molecules
p	pressure
R	gas constant (per mole)
t	time
T	temperature (absolute scale)
V	volume
ε_0	permittivity of free space
μ_0	permeability of free space
exp	exponential
j =	$\sqrt{-1}$
ln	logarithm to base e
log	logarithm to base 10
O . . .	term of order . . .

Contents

A

Abbe Number
This is a measure of reciprocal dispersion for optical materials and is defined by

$$\nu = \frac{n_D - 1}{n_C - n_F}$$

where n is refractive index and subscripts D, C and F refer to **Fraunhofer Lines** (with wavelengths 589·3 nm, 656·3 nm and 486·1 nm respectively).

Abbe's Sine Condition
When the pencil of rays forming an optical image is of finite aperture, the condition that a magnification of the image can be obtained which is independent of the zone of the lens traversed is given by

$$\frac{n \sin \alpha}{n' \sin \alpha'} = \text{constant} = m$$

where n and n' are the refractive indices of object and image space, α and α' are the angles with which a ray leaves and (after refraction) reaches the axis again respectively and m is the lateral magnification.

Abbe's Theory (of the Diffraction of Microscopic Vision)
For the production of a truthful image of an illuminated structure by a lens it is necessary that the aperture be wide enough to transmit the whole of the diffraction pattern produced by the structure. If only a portion of the diffraction pattern is transmitted, the image will correspond to an object whose diffraction pattern is identical with the portion passed by the lens. If the structure is so fine or the lens aperture so narrow that none of the diffraction pattern is transmitted, the structure will be invisible regardless of the magnification.

Abegg's Rule
The sum of the maximum positive valency exhibited by an element

and its maximum negative valency equals 8. This rule is true generally for the elements of the 4th, 5th, 6th and 7th groups of the Periodic Table.

Abelian Group
If a group of elements A, B, C, . . . finite or infinite in number has the property that AB = BA (commutative property) for every element, then the group is known as an Abelian Group.

Abel's Identities
(1) If $A_s = a_n + a_{n+1} + \ldots a_s$ then

$$\sum_{s=p}^{m} a_s b_s = \sum_{s=p}^{m} (b_s - b_{s+1}) A_s - b_p A_{p-1} + b_{m+1} A_m$$

(2) If $A'_s = a_s + a_{s+1} + a_{s+2} + \ldots$ then

$$\sum_{s=p}^{m} a_s b_s = \sum_{s-p}^{m-1} (b_{s+1} - b_s) A'_{s+1} + b_p A'_p - b_m A'_{m+1}.$$

Abel's Inequality
If $u_n \to 0$ monotonically for integer values of n, then $\left|\sum_{n=1}^{m} a_n u_n\right| \leqslant A u_1$ where A is the greatest of the sums $|a_1|$, $|a_1 + a_2|$, $|a_1 + a_2 + a_3|, \ldots$ $|a_1 + a_2 + \ldots a_m|$.

Abel's Integral Equation
A particular type of **Volterra Equation** of the form

$$\mathrm{f}(t) = \int_0^t (t-s)^{-\alpha} \phi(s) \, \mathrm{d}s \qquad (0 < \alpha < 1).$$

The solution of the equation is

$$\phi(t) = \frac{\sin \pi\alpha}{\alpha} \frac{\mathrm{d}}{\mathrm{d}t} \int_0^t (t-s)^{\alpha-1} \, \mathrm{f}(s) \, \mathrm{d}s.$$

The equation, with $\alpha = 0{\cdot}5$, has particular application to the time of fall of a particle along a smooth curve in the vertical plane.

Abel's Test (for Convergence)
If Σu_n converges and $a_1, a_2, a_3, \ldots$ is a decreasing sequence of positive terms, then $\Sigma a_n u_n$ is convergent.

Abel's Test (for Infinite Integrals)
If $\int_a^\infty \mathrm{f}(x)\mathrm{d}x$ converges, and if for every value of y such that $b \leqslant y \leqslant c$ the function $\mathrm{g}(x, y)$ is neither negative nor increasing with x, then $\int_0^\infty \mathrm{f}(x)\mathrm{g}(x, y)\mathrm{d}x$ is uniformly convergent with respect to y in the range $b \leqslant y \leqslant c$.

Abel's Theorem (on Multiplication of Series)
If $c_n = a_0 b_n + a_1 b_{n-1} + \ldots + a_n b_0$, then the convergence of $\sum_{n=0}^{\infty} a_n$, $\sum_{n=0}^{\infty} b_n$ and $\sum_{n=0}^{\infty} c_n$ is a sufficient condition that $\left(\sum_{n=0}^{\infty} a_n\right)\left(\sum_{n=0}^{\infty} b_n\right) = \sum_{n=0}^{\infty} c_n$.

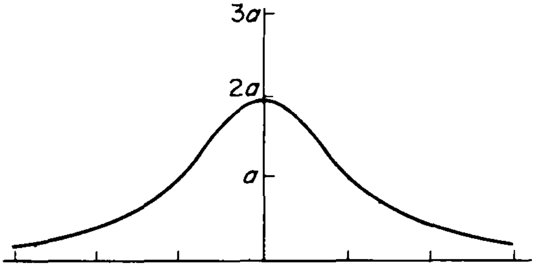
Abney Law
If the colour of a spectral line is desaturated by the addition of white light, its colour to the eye shifts towards the red if its wavelength is less than 570 nm and to the blue if its wavelength is greater than this value.

Adams–Bashforth Process
A method of numerically integrating ordinary differential equations. Starting with Gregory's backwards formula (*see* **Gregory's Interpolation Formulae**), $\mathrm{f}(x)$ is expanded and integrated to give

$$\frac{1}{h}\int_{x_0}^{x_0+h} \mathrm{f}(x)\mathrm{d}x = \mathrm{f}(x_0) + \left(\frac{1}{2}\nabla + \frac{5}{12}\nabla^2 + \frac{3}{8}\nabla^3 + \frac{251}{720}\nabla^4 + \frac{95}{288}\nabla^5 + \ldots\right)\mathrm{f}(x)$$

Hence, if $\mathrm{d}y/\mathrm{d}x = \mathrm{f}(x, y)$ and y and f are known for values of x up to $x = x_0$, a value for y corresponding to $x = x_0 + h$ can be obtained from f at x_0 and the backwards differences.

Agnesi, Witch of



Witch of Agnesi

A curve whose equation $x^2y = 4a^2(2a - y)$.

Airy's Disc
The diffraction pattern formed by plane light waves from a point source passing through a circular aperture consists of a bright central disc, known as Airy's disc, surrounded by further rings. Airy in 1934 obtained the intensity distribution across the pattern in terms of **Bessel Functions** of order unity. The radius of the central disc is given by

$$\frac{0{\cdot}61\,\lambda}{n \sin U}$$

where λ is the wavelength *in vacuo*, U is the semi-angle of the emergent cone of light from the aperture and n is the refractive index on the image side of the aperture. The form of the diffraction pattern has particular application to the calculation of the resolving power of telescopes and other optical instruments.

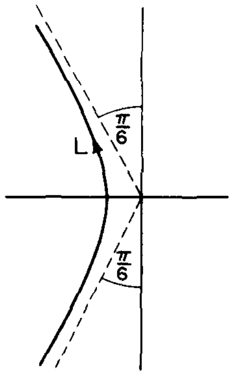
Airy's Equation
An equation for multiple-beam interference for light transmitted through a plane parallel plate. The intensity of the transmitted light is given by

$$I = \frac{I_0 T^2}{(1-R)^2\left[1 + \dfrac{4R\sin^2\delta/2}{(1-R)^2}\right]}$$

where I_0 is the intensity of the incident beam, R is the reflectivity of the surfaces of the plate and T their transmissivity, and δ is the phase difference between the directly transmitted light and light which is once reflected from the two internal surfaces of the plate. (*See also* **Fabry–Pérot Fringes.**)

Airy's Integral
This is defined as

$$\mathrm{Ai}(z) = \frac{1}{2\pi \mathrm{j}} \int_{\mathrm{L}} \exp(tz - t^3/3)\,\mathrm{d}t = \frac{1}{\pi} \int_0^{\infty} \cos(sz + s^3/3)\mathrm{d}s$$



Airy's Integral

where L is a contour as shown in the diagram. It is the integral solution of the differential equation

$$\frac{\mathrm{d}^2 y}{\mathrm{d}z^2} - zy = 0$$

Airy's Points
The optimum points at which a bar must be suspended horizontally to make bending a minimum. The distance apart of the points is

$$\frac{l}{\sqrt{(n^2 - 1)}}$$

where l is the length of the bar and n the number of supports.

Airy's Spirals
The spirals of light which can be produced when convergent polarized light is passed through two plates cut from right-handed and left-handed quartz (enantiomorphic forms of the crystal) and observed with crossed Nicol prisms (i.e. prisms to separate the ordinary and extraordinary rays). The spirals arise from the rotation of the plane of polarization of the light and the direction of spiralling depends on which quartz plate is positioned first.

Aitken's Formula
If a series of numbers $u_1, u_2, \ldots u_n, u_{n+1}, u_{n+2}, \ldots,$ is expected to converge slowly to an unknown limit u, then u can be estimated by assuming

$$u_n = u = e; \quad u_{n+1} = u - ke; \quad u_{n+2} = u - k^2 e \quad (k < 1)$$

whence, by eliminating k and e:

$$u = \frac{u_{n+2}u_n - u_{n+1}^2}{u_{n+2} - 2u_{n+1} + u_n} = u_{n+2} - \frac{(u_{n+2} - u_{n+1})^2}{u_{n+2} - 2u_{n+1} + u_n}$$

Alfvén Waves
In 1942 Alfvén predicted the possible existence of magnetohydrodynamic waves – in the simplest case transverse oscillations of magnetic field lines carrying with them a surrounding non-viscous perfectly conducting fluid. The velocity of propagation usually approximates (in SI) to

$$v^2 = \frac{B^2}{\mu\rho}$$

where B is the magnetic induction, ρ the density of the fluid and μ the magnetic permeability.

Amagat *See* **Appendix**

Amagat–Leduc Rule
According to E. H. Amagat and A. Leduc the volume occupied by a mixture of gases is equal to the sum of the volumes that the constituent gases would individually occupy at the temperature and pressure of the mixture. The Amagat–Leduc rule and **Dalton's Law of Partial Pressures** are identical for the perfect gas.

Amonton's Law
In any gas whose volume and mass are kept constant, the same rise in temperature produces the same increase of pressure.

Ampere; Ampere, Thermal; Ampere-turn *See* **Appendix**

Ampère's Law
The magnetic induction B produced at a point P in free space by a current flowing in a conductor is given using SI units by

$$B = \int \frac{\mu_0 I \, \mathrm{d}s \sin\theta}{4\pi r^2}$$

where μ_0 is the permeability of free space, I is the current flowing in an element of the circuit ds, r is the length of the line joining ds and the point P, and θ is the angle between ds and r. The law is also called **Laplace's Law** or the **Biot–Savart Relation.**

Alternatively, Ampère's Law is sometimes stated as

$$\oint B \cos\theta \, \mathrm{d}\ell = \mu_0 I$$

where the integral is over a closed path enclosing a current I which sets up magnetic induction B. θ is here the angle between B and the incremental path length dℓ.

Anderson Localization
For understanding the theory of electrons in certain non-crystalline media, P. W. Anderson has proposed the use of a potential-energy function which is non-periodic by the addition of a random potential energy to the periodic function used for crystalline solids. If the ratio of this random potential energy to the energy bandwidth associated with the original periodic function is higher than approximately 5 (the ratio depends slightly on the coordination number associated with the material), the wave-functions for the electrons decay exponentially with distance, thus giving rise to electron localization.

Andrade's Creep Law
Andrade showed that when a load is applied at the beginning of a creep test, the instantaneous elastic elongation is followed by a transient state in which strain varies as $t^{1/3}$ and, finally, a steady state is reached in which there is a constant rate of creep under constant effective stress.

Ångström *See* **Appendix**

Ångström's Formula
For the scattering effect of dust in the atmosphere

$$S = A\lambda^{-B}$$

where λ is the wavelength, B depends on the particle size and A is a constant.

Angus–Smith Process
When iron is heated to about 370°C and then immersed in a solution of coal-tar in oil and paranaphthalene, an anti-corrosive layer is formed. *See* **Bower–Barff Process.**

Antoine Equation
An expression for the vapour pressure p of a condensed solid or liquid as a function of absolute temperature T:

$$\ln p = A - \frac{B}{C+T}$$

where A, B and C are constants obtained experimentally.

Antonoff's Rule
The interfacial surface tension γ_{AB} between two saturated liquid layers A and B, in equilibrium, is equal to the difference between the surface tensions against vapour or air of the two mutually saturated solutions, i.e.

$$\gamma_{AB} = \gamma_A - \gamma_B$$

Apollonius' Circle
The locus of the vertex, A, of a triangle of given base BC such that the sides AB and AC are in a given ratio λ:1 is a circle with, as diameter, the line joining the points which divide the base BC internally and externally in the ratio λ:1.

Apollonius' Conic Sections
The curves obtained by cutting through a cone at particular angles. The ellipse, parabola and hyperbola were named by Apollonius.

Apollonius' Theorem
In any triangle, the sum of the squares on two sides is equal to twice the square on half the base together with twice the square on the median drawn to the base.

Appleton Layer *See* **Heaviside Layer**

Arbusov Reaction (or **Rearrangement**)
In the Arbusov rearrangement, an alkyl phosphite is heated with a small amount of the corresponding alkyl halide. Initially a phosphonium salt is formed which decomposes to give a dialkyl alkyl phosphonate. The formation of the phosphonium salt is so fast that, if an equivalent amount of a different alkyl halide is used, up to 95 per cent yield of a product having the new alkyl group attached to the phosphorus can be obtained.

Archimedean Polyhedra
These are semi-regular polyhedra, also called Archimedean solids, for which every face is a regular polygon, although the faces are not all of the same kind. The faces must be arranged in the same order around each vertex. There are 13 Archimedean solids although two of these 13 can exist in enantiomorphic forms: i.e. in right-handed and left-handed forms. They can all be described in a sphere. Additionally there are 13 Archimedean duals in which all the faces are congruent and their polyhedral angles regular but not identical. Such solids are referred to as vertically-regular and have an inscribed sphere. Each Archimedean dual can be obtained from a corresponding Archimedean solid by replacing every vertex of the latter by the tangent plane to the sphere in which it can be described. *See also* **Platonic Polyhedra**.

Archimedes' Axiom
If a and b are any two positive rationals, an integer n exists, such that $nb > a$. Alternatively, it is called **Eudoxus' Theorem**.

Archimedes' Principle
When a body is immersed in a fluid, it experiences a buoyant force which manifests itself as an apparent loss of weight equal to the weight of fluid displaced.