

VAN NOSTRAND'S
SCIENTIFIC
ENCYCLOPEDIA

65-17

VAN NOSTRAND'S SCIENTIFIC ENCYCLOPEDIA

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GEOLOGY · MATHEMATICS · MECHANICAL ENGINEERING

MEDICINE · METALLURGY · METEOROLOGY

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PREFACE

The second edition of "Van Nostrand's Scientific Encyclopedia," follows generally the premise of the original volume. The book encompasses the basic sciences and the applied fields of science and engineering. There have been added to this edition new sections on Electronics and Radio, Metallurgy, Meteorology, Photography and Statistics. The sections on Aeronautics, Engineering—Chemical, Civil, Mechanical, and Electrical—and Navigation have been expanded considerably. The entire book now takes into account the broad advances of science that have occurred in Aeronautics, Astronomy, Botany, Chemical Engineering, Chemistry, Civil Engineering, Electrical Engineering, Electronics and Radio, Geology, Mathematics, Mechanical Engineering, Medicine, Metallurgy, Meteorology, Mineralogy, Navigation, Photography, Physics, Statistics, and Zoology—twenty sections.

The responsibility for each science has been left largely in the hands of a single author in order to attain a unity impossible when many men contribute. However, although the responsibility rested largely in the one scientist of note, a number of men in each field have worked with the author, and a still larger group have consulted in an advisory capacity with the authors and publishers.

In this Encyclopedia over eleven thousand terms of scientific interest are arranged alphabetically, and an extensive system of cross-indexing has been developed to enable the reader to find all the facts that bear directly on each included topic. By this system, terms explained in this book are printed in bold face (black face) type wherever they are used significantly in the course of the articles on other terms. This practice makes it possible to turn readily to every article that has a bearing on the particular topic in which the reader is interested, as well as to obtain all supplementary information relative to any particular subject. Wherever bold face type appears within an article, the word or term appearing in this type is described in its alphabetical position. The user can gain a very comprehensive knowledge of each term if these references are consulted.

Naturally there are limits in the compiling of any one-volume book. These limits necessarily restrict the length of the article and the size of the illustration. However, the comprehensiveness of the book is noteworthy both in the scope of the terms covered and the breadth of the treatment in the individual article. The meticulous care of the authors, their advisers and their helpers, together with their systematic cross-referencing, have contributed in great measure to the inclusion of so much material within the covers of one book.

A feature of this Encyclopedia is the progressive development of the discussion of each topic, beginning with a simple definition expressed in the plainest terms and progressing to a final reflection of the more detailed scientific aspects of the topic treated. Articles dealing with simple concepts are, of course, treated in simple terms throughout the Encyclopedia, but those of a highly technical nature may be of value both to the inquiring layman and to the trained technician by a selection of their reading from the earlier or later portions of such an article.

The authors and the publishers will appreciate the indulgence of the reader for omissions. The exercise of judgment in the selection of material was unavoidable, and it was necessary to maintain a limit of difficulty beyond which it was impractical to go in attempting to cover so broad a field within the physical confines of one useful volume.

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Van Nostrand's Scientific Encyclopedia

A

A SUPPLY. The source of the heating current for the cathode of an electronic tube. In the early days of radio the various voltages needed to operate a receiver were obtained from batteries, called A, B and C batteries, supplying the filament, plate and grid voltages respectively. These letter designations have carried over to the present-day sources, although the voltages are usually obtained now from an a-c source, either directly as in the case of the A supply or indirectly for B and C voltages. (See **Amplifiers and Radio Receivers.**) (L.R.Q.)

AA. An Hawaiian term introduced into geological nomenclature by C. E. Dutton, in 1883, and signifying the jagged, scoriaceous, blocky and exceedingly rough surface of some basic lava flows. (R.M.F.)

AARD-VARK. Mammalia, Tubulidentata. *Orycteropus*. African animals of peculiar form, including an Ethiopian and a South-African species. All are ant-eaters, feeding exclusively on ants and termites. The southern species has been called the ant-bear. (A.W.L.)

AARITE. Niccolite.

AARD WOLF. Mammalia, Carnivora. An African species, *Proteles cristatus*, superficially like the striped hyena. (A.W.L.)

AASVOGEL. South-African vultures. The name was applied by the Dutch colonists and means carrion-bird. (A.W.L.)

ABACA. The sclerenchyma bundles from the sheathing leaf bases of *Musa textilis* (Manila hemp), a plant closely resembling the edible banana plant. These bundles are stripped by hand, after which they are cleaned by drawing over a rough knife. The fiber bundles are now whitish and lustrous, and from six to twelve feet long. Being coarse, extremely strong and capable of resisting tension, they are much used in the manufacture of ropes and cables. Since the fibers swell only slightly when wet, they are particularly suited for rope which will be used in water. Waste manila fibers from rope manufacture and other sources are used in the making of a very tough grade of paper, known as manila paper. The fibers may be obtained from both wild and cultivated plants, the latter yielding a product of better grade. The cultivated plants, propagated by seeds, by cuttings of the thick *rhizomes* or by suckers, are ready for harvest at the end of three years, after which a crop may be expected approximately every three years. (R.M.W.)

ABALONE. Mollusca, Gasteropoda. *Haliotis*. Marine species, mostly of the Pacific and Indian Oceans. The single broad shallow shell has a richly colored iridescent inner surface and is an important source of mother-of-pearl and blister pearls for costume jewelry. The flesh is palatable. It is eaten on our west coast, but much larger quantities are dried in California for shipment to the Orient. (A.W.L.)

ABAMPERE. The abampere, formerly called the "electromagnetic unit current," is the fundamental unit of the c.g.s. (centimeter-gram-second) electromagnetic system of electrical units. If a current of this magni-

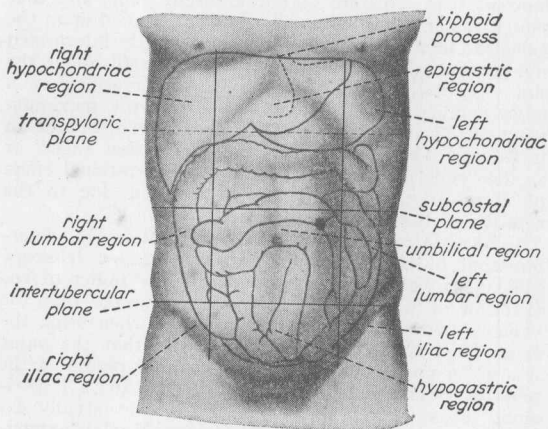
tude flows in a circular loop of 1 cm. radius in a vacuum, the resulting magnetic field has an intensity, at the center of the circle, of 2π oersteds; which is the same as 1 oersted per unit length of wire. An equivalent statement is that if a current of 1 abampere flows in a straight wire across a magnetic field of 1 oersted intensity, at right angles to the magnetic intensity, the resulting lateral thrust, or "electric motor effect," is equal to 1 dyne for each centimeter of length of the wire. The (absolute) ampere is defined as $\frac{1}{10}$ of the abampere. (L.D.W.)

ABCOULOMB. Electric and Magnetic Units.

ABDOMEN. The abdomen is the posterior division of the body in many arthropods. It is the posterior portion of the trunk in vertebrates. In the vertebrates this region of the body contains most of the alimentary tract, the excretory system, and the reproductive organs. It contains part of the coelom and in mammals is separated from the thorax by the diaphragm.

The abdominal cavity of the human body is subdivided into the abdomen proper and the pelvic cavity.

The walls of the abdominal cavity are lined with a smooth membrane called the peritoneum, which also provides partial or complete covering for the organs within the cavity.



Planes of subdivision of the abdominal cavity and outline tracing of the liver, stomach, and intestine in relation to the anterior abdominal wall.

The oblique position of the stomach and the high position of the transverse colon are largely due to the fact that the subject was fixed in the horizontal position.

(Cunningham, *Textbook of Anatomy*, Oxford Press.)

The abdomen proper is bounded above by the diaphragm; below it is continuous with the pelvic cavity; posteriorly it is bounded by the spinal column, and the back muscles; and on each side by muscles and the lower portion of the ribs. In front, the abdominal wall is made up of layers of fascia and muscles. The surface of the abdomen is divided into sections. The mid-section above the navel between the angle of the ribs is known as the epigastric region; that portion around the navel, as the umbilical; below the navel and above the pubic bone, as the hypogastric region. It is further divided

into right and left upper quadrants on each side above the navel, and right and left lower quadrants on each side below the navel. The lumbar region extends on either side of the navel posteriorly and laterally.

The principal organs of the abdominal cavity are the stomach, duodenum, jejunum, ileum, and colon or large intestine, the liver, gall bladder and biliary system, the spleen, pancreas and their blood and lymphatic vessels, lymph glands, and nerves.

The pelvic portion of the abdomen contains the urinary bladder, uterus, Fallopian tubes, and ovaries in the female, the sigmoid colon and rectum, and a portion of the small intestine. (A.W.L., R.S.M.)

ABERRATION OF LENSES. Chromatic Aberration; Spherical Aberration.

ABERRATION OF LIGHT. The apparent change of position of an object, due to the speed of motion of the observer, is known as the aberration of light. Care must be taken not to confuse this effect with that of parallax.

If a telescope, assumed to be stationary, is pointed at a source of light, the light which enters the object glass centrally and in the direction of the optic axis will pass through the telescope along that axis and emerge through the center of the eyepiece. If the telescope is in motion relative to the source, in any direction other than parallel to the optic axis, the light which enters centrally will emerge off the center of the eyepiece. If this light is to emerge centrally the telescope must be tilted forward in the plane containing the direction of motion of the instrument and the source. The amount of tilt will depend on the direction of the source and the ratio of the speed of the telescope to the speed of light.

This aberrational effect was first announced by Bradley in 1726. He noticed that stars had apparent periodic motions with a period of one sidereal year, and that the character of the apparent motion depended upon the celestial latitude of the star. He correctly interpreted the effect as due to the motion of the earth about the sun. Statistical discussions of the observations of a large number of stars have shown that the maximum value of this aberration due to the earth's orbital motion is $20''.47$. This is known as the "aberration angle" or as the "constant of aberration." An aberrational effect of about $0''.3$, at maximum, is observed due to the rotation of the earth on its axis.

In 1871, Airy made a series of observations for determination of the aberration constant using a telescope filled with water. Since the value of the index of refraction of water is about $\frac{4}{3}$, Airy expected that the value of the aberration would be $27''.3$ when using the water-filled tube. He found, however, that the value was $20''.5$ no matter what substance was placed in the telescope. The result of this so-called "Airy's Experiment" caused much discussion, but was eventually explained on the basis of the Michelson-Morley experiment and the theory of relativity.

All observations, in which the positions of the stars are involved, must be corrected for aberration of light if the results are to be accurate to within $20''$. Both the motion of the earth about the sun and the rotation of the earth must be considered. The magnitude of the correction depends upon the celestial coordinates of the star, the position of the observer on the earth, and the date and time of observation. (W.K.G.)

ABFARAD. Electric and Magnetic Units.

ABHENRY. Electric and Magnetic Units.

ABIOTENESIS. The origin of living matter or living organisms from non-living material.

The ancients believed that living things, such as insects and mice, sprang from decaying organic matter or even

from mud in situations where they were sometimes seen in large numbers. Careful experiments finally showed that such highly organized creatures were produced only by others like themselves but the discovery of micro-organisms again raised the question. In the experiments conducted by Pasteur and other scientists, it was at last proved that thoroughly sterilized materials gave rise to no living things unless they were later contaminated. Modern biology admits the possibility that an exceedingly simple type of living substance may arise from non-living materials but recognizes that living things as we know them are too complex to develop abruptly in this way. Even the origin of simple living substance has not actually been demonstrated. (A.W.L.)

ABLATION. From the Latin *ab* and *latio*, carried from, refers to the wasting away of the surfaces of rocks or glaciers, but principally used in the latter connection. Ablation deposits are the masses of detritus left after surface melting of glacial ice. (E.S.C.S., R.M.F.)

ABOHM. Electric and Magnetic Units; Ohm.

ABORAL OR APICAL SYSTEM. Part of the nervous system of the echinoderms. Unlike most nervous tissue it is developed from the middle germ layer. (A.W.L.)

ABORT. This term has two common meanings in medicine: 1. To check a disease or a condition during its early stages. 2. To expel the fetus during the first 4 or 5 months of pregnancy. (D.M.H.)

ABORTION. The expulsion of the fetus during the first half of pregnancy, which is always incompatible with the life of the fetus. Various descriptive terms are used to indicate the type of abortion as (1) accidental, (2) artificial or induced, i.e., intentional, (3) criminal, that is, induced illegally, (4) habitual, or where it occurs repeatedly with successive pregnancies in the same person, (5) incomplete, or where only a portion of the products of conception are expelled, (6) therapeutic, an abortion induced by a doctor as a protection to the life or health of the mother. Therapeutic abortions are commonly done when the mother has advanced tuberculosis, kidney or heart disease. (7) Threatened abortion, that is, the appearance of hemorrhage or labor pains early in pregnancy, may or may not develop into an actual abortion. (R.S.M.)

ABRASION. All metallic and non-metallic surfaces, no matter how smooth, consist of minute serrations and ridges which induce a cutting or tearing action when two surfaces in contact move with respect to each other. This wearing of the surfaces is termed abrasion. Undesirable abrasion may occur in bearings and other machine elements, but abrasion is also adapted to surface finishing and machining, where the material is too hard to be cut by other means, or where precision is a primary requisite. (H.C.H.)

ABRASIVES. Grinding, cutting, drilling, and polishing of various materials are often done with a wheel, sheet, or blast of abrasive, so-called, somewhat harder than the material treated. Accordingly, in the selection of an abrasive, the size of the individual grains and their specific hardnesses become important factors which determine the appearance of the finished surface or edge. The selected grains are bonded to a surface, such as sandpaper or emery paper, or formed into special shapes, especially wheels of various widths and diameters, or spotted on the face of drills as in sinking oilwells.

Many naturally occurring materials are used for this purpose, and for the harder abrasives specially manufactured materials are commonly utilized. The natural abrasives most used are sand, quartz, emery, diatomite, tripoli, pumice, and diamonds.

Sand, sandstone, quartzite and quartz, flint, and garnet are most used in sand-blasting of metals, in sawing-stones, grindstones, pulpstones, whetstones, in the grinding of ores in mills, and as sheets on paper or cloth. Emery and corundum are similarly used, practically all being imported as crude material and processed in this country.

Diatomite is used principally in polishes, but also as filter aid due to its high porosity, and as filler in special cases such as in plastics. It is highly resistant to heat, has low absorptive power for moisture, is chemically inert, has excellent electrical properties, and produces a good surface finish. It is stated that four leading brands of silver polishes contain 15 to 19% of diatomite as the sole abrasive. The principal states producing diatomite are California and Oregon. Tripoli is used for abrasive purposes, as an oilwell drilling mud, and also for foundry facing, and for filler in concrete. The production is centered around Newton County, Missouri, and adjacent Ottawa County, Oklahoma, and in Alexander County, southern Illinois. Pumice is used in cleansing and scouring mixtures and in hand soaps, and also for acoustic plaster and as an admixture for concrete.

Diamonds for abrasive purposes come from Brazil—these are called carbonados or black diamonds—and from the Union of South Africa—these are called bort. A beryllium-copper alloy is used successfully for cast-setting diamond core bits and reaming shells. These drilling bits are tough, strong, and hard, and the bond between the alloy and the diamonds is very close. Many small stones can be spaced over a comparatively small drill face.

Manufactured or "artificial" abrasives have made possible rapid working of very hard materials. Aluminum oxide glass ("Alundum") and silicon carbide crystals ("Carborundum") have proved outstandingly important. The total production manufactured for all uses, in 1941, in the United States, was aluminum oxide 150,000 short tons, and silicon carbide 45,000 short tons, with additional 85,000 short tons of metallic abrasives. Tungsten carbide has attracted much attention as a very hard abrasive. It is typical of several metallic carbides, nitrides, and borides that have been suggested as abrasives. Some information on this point is contained in the following table:

HARDNESS AND MELTING POINT OF VARIOUS CARBIDES, NITRIDES, AND BORIDES

> Greater than. Mohs' Values: Diamond 10, Corundum 9, Topaz 8, Quartz 7.

METAL	CARBIDES		NITRIDES		BORIDES	
	Hardness (Mohs' value)	Melting Point (°C.)	Hardness (Mohs' value)	Melting Point (°C.)	Hardness (Mohs' value)	Melting Point (°C.)
Chromium.....	> 7	1800				
Columbium.....		3500			8	
Molybdenum.....	7-9	2700	> 8		> 9	
Tantalum.....	> 9	3875	> 8		> 9	
Titanium.....	> 8	3150		3100	> 9	
Tungsten.....	> 9	2850	> 8	2950	> 9	
Vanadium.....	> 9	2830			> 9	
Zirconium.....	> 8	3530	> 8	2050 2980	> 9	
						3000

(R.K.S.)

ABSAROKITE. A geologic term proposed by Iddings in 1805 for a porphyritic basalt containing phenocrysts of olivine and augite in a ground mass of smaller labradorite crystals. Type locality, Absaroka Rane, Yellowstone Park. (R.M.F.)

ABSCISS. A localized collection of pus usually formed in response to an infectious agent. *Staphylococci* and

streptococci are the common bacteria producing abscesses, although any organism may do so.

Abscesses may be single or multiple, primary or metastatic (see *Metastasis*), and may involve any organ or tissue in the body. The wall of an abscess is made up of inflammatory tissue which acts as a barrier to the spread of infection; the abscess cavity contains pus which consists of white blood cells, debris of tissue destruction, and bacteria, living and dead.

The physical signs associated with a superficially situated abscess are those of inflammation, swelling, increased heat, redness and tenderness over the involved area. Treatment in uncomplicated cases is usually surgical incision and drainage at the proper time. Chemotherapy with sulfonamides and penicillin may be necessary. (D.M.H.)

ABSCISSION OF A POINT. Rectangular Coordinates in a Plane.

ABSCISSION. This term is applied to the process whereby leaves, leaflets, fruits or other plant parts become detached from the plant. Leaf abscission is a characteristic phenomenon of many species of woody dicots and is especially conspicuous during the autumn period of leaf fall. Three main stages can be distinguished in the usual process of leaf abscission. The first is the formation of an abscission layer which is typically a transverse zone of parenchymatous cells located at the base of the petiole. The cells of this layer may become differentiated weeks or even months before abscission actually occurs. The second step is the abscission process proper which occurs as a result of a dissolution of the middle lamellae of the cells of the abscission layer. This results in the leaf remaining attached to the stem only by the vascular elements which are soon broken by the pressure of wind or the pull of gravity and the leaf falls from the plant. In the final stage of the process the exposed cells of the leaf scar are rendered impervious to water by lignification and suberization of the walls (see *Lignin*; *Suberin*). Subsequently other layers of corky cells develop beneath the outer layer. These layers eventually become a part of the periderm of the stem. The broken xylem elements of the leaf scar become plugged with gums or tyloses and the phloem elements become compressed and sealed off.

In some kinds of plants an abscission layer is only imperfectly formed and in many others, especially herbaceous species, no abscission layer develops at the base of the petiole. In a few herbaceous species, of which coleus, begonia, and fuchsia are examples, an abscission layer develops. In the majority of herbaceous species, however, and in some woody species, there is no true abscission process. In such herbaceous plants most or

all of the leaves are retained until the death of the plant. In the woody plants falling in this category (example: shingle oak, *Quercus imbricaria*) the leaves are shed only by mechanical disruption from the plant. Abscission of the fruits of apple and doubtless of many other species occurs in much the same manner as abscission of leaves. The abscission of apple fruits can be artificially retarded by spraying with certain auxins. (B.S.M.)

ABSINTHE. *Artemisia*.

ABSOLUTE HUMIDITY. The mass of water vapor in a specified volume. It can be expressed in any convenient units: ounces per cu. yd., grams per cu. meter. Example: 22 grams per cu. meter. (See Humidity.) (P.E.K.)

ABSOLUTE MAGNITUDE. The apparent brightness of a star, or any other luminous object, depends both upon the intrinsic brightness of the object and also upon its distance from the observer. In the case of the stars the apparent brightness, expressed as **stellar magnitude**, may be determined by any one of the standard methods of stellar **photometry**. In case the distance of the star is known the intrinsic brightness may be immediately calculated. Conversely, if we have any method available for determining the intrinsic brightness of a star independently of a knowledge of the distance, this distance may be computed from the ratio between the apparent and intrinsic brightness.

The absolute magnitude of a star is the apparent brightness, expressed on the magnitude scale, that a star would have if it were situated at a distance of ten parsecs from the sun or, in other words, if the stellar parallax of the star were $\frac{1}{10}$ of a second. Analytically, the absolute magnitude, M , of a star is connected with the apparent magnitude, mg , and the stellar parallax, π'' , by:

$$M = mg + 5 + 5 \log \pi''.$$

On this scale we find the sun, with apparent magnitude -26.72 and parallax $206265''$, to have an absolute magnitude of 4.85 . **Antares** with parallax $0''.009$ and apparent magnitude 1.22 is found to have an absolute magnitude of -4.0 . On the basis of these absolute magnitudes and the defining relation of the magnitude scale, we find the brightness ratio of Antares to the sun to be 3470 or the star Antares is actually 3470 times as bright as the sun. (W.K.G.)

ABSOLUTE TEMPERATURE. Absolute Zero; Temperature Scales.

ABSOLUTE VALUE OF A REAL NUMBER. Number.

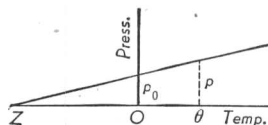
ABSOLUTE VARIABILITY. A measure of variability that is expressed in the unit of the variable. A measure of relative variability relates the absolute variability to an average, generally to the mean. (L.A.A.)

ABSOLUTE ZERO. A temperature at which bodies would possess no heat whatever. Prior to the discovery of the dynamic character of heat, no significance could be attached to a zero of temperature save that of a point arbitrarily chosen, such as the melting point of ice, from which temperatures might be reckoned both ways. But when it became known that heat is the kinetic energy of random molecular motion, it was at once possible to visualize, if not to realize, a condition of "absolute cold," merely by supposing the molecules of a substance to have come to rest relative to each other.

It was formerly customary to define the measure of temperature in such a way that a linear relation exists between the temperature θ and the pressure p of a gas (hydrogen) kept at constant volume; thus:

$$p = p_0 + a\theta \quad (1)$$

in which p_0 is the pressure at the arbitrary zero of temperature. This relation is represented by the straight line in the accompanying figure. The slope of this line,



Relation between temperature and pressure of a gas at constant volume.

expressed by the constant a , corresponds to the change in pressure for each unit of temperature change (degree). Experiment shows that when the centigrade scale is used, this change is 0.0036626 of the pressure of the gas at the zero of that scale, viz., the melting point of ice; so that $a = 0.0036626$. (This is on condition that the pressure p_0 is 1000 mm.) Equation (1) accordingly may be written

$$p = p_0 + 0.0036626p_0\theta = p_0(1 + 0.0036626\theta). \quad (2)$$

Equation (2) now implies the possibility of causing the pressure to vanish altogether by reducing the temperature until the factor $1 + 0.0036626\theta = 0$; that is, until $\theta = -273.03^\circ \text{C.} = -459.45^\circ \text{F.}$ (corresponding to Z in the figure). Since gas pressure depends upon the motion of molecules, it follows that, for the pressure to vanish, all such motion must cease. Hence we may suppose that the centigrade temperature -273.03°C. is the absolute zero, so far as translational thermal energy is concerned. More recent studies employing the Kelvin scale of temperature give -273.16°C. as absolute zero. There is reason to believe that a pressure would still exist in hydrogen even under these conditions. The lowest temperature so far experimentally attained is calculated to be within 0.005° of absolute zero. (See Thermometry.) (L.D.W.)

ABSORBENT COTTON. Absorbent cotton is prepared from the fibers of the cotton plant. These fibers are treated in such a way as to remove the natural waxy substances and the small amount of mineral matter present. Subsequent washing yields the product known commercially as absorbent cotton, which can absorb as much as eighteen times its own weight of water, and which has many commercial and medical uses. (R.M.W.)

ABSORPTION. This term has the widest significance in science and technology. In the organic world it denotes the process by which materials enter the living substance of which the organism is composed. Substances including food and oxygen are taken into special organs by ingestion and respiration but they must pass through the outer surface of the cells to become an integral part of the organism by absorption. The nature of the process is considered under osmosis.

The absorption of gases plays an important part in engineering. It is the frequent cause of corrosion by condensate (due to the high content of dissolved oxygen). Gaseous absorption is the basis of the absorption system of refrigeration. In this system a gas (or vapor) is absorbed in a suitable medium and is then separated by distillation, followed in some cases by liquefaction under pressure. The principles involved in the absorption of gases in liquids are treated in the article on **Solutions and Solubility**, and in the article on **Dissolving**. The adsorption of gases (as well as liquids and solids) is a related phenomenon that is treated in the article on **Adsorption**.

The quantity of heat absorbed by a substance is calculated from **specific heat** and **temperature**. The capacity of surface to absorb radiant heat is measured by its absorptivity (**Thermal Radiation**).

The absorption of mechanical energy by **dynamometers**, which convert the mechanical energy to heat or electrical forms, has lead to the use of the term "absorp-

tion dynamometers" to distinguish these machines. For the absorption of radiation see **Absorption Coefficient**. (F.T.M., A.W.L.)

ABSORPTION COEFFICIENT. A quantity used to express the rate at which a substance absorbs radiation passing through it. When light, x-rays, or other electromagnetic radiation enters a body of matter, it experiences in general two types of attenuation. Part of it is subjected to scattering, being reflected in all directions without essential change of character, while another portion is absorbed by being converted into other forms of energy. The scattered radiation may still be effective in the same ways as the original, but the absorbed portion ceases to exist as radiation or is re-emitted as secondary radiation. Strictly therefore we have to distinguish the true absorption coefficient from the scattering coefficient; but for practical purposes it is sometimes convenient to add them together as the total attenuation or extinction coefficient.

Accurate measurements upon radiation which has traversed various thicknesses of matter has established that any infinitely thin layer perpendicular to the direction of propagation cuts down the flux density by a fraction of its value proportional to the thickness of the layer, and that the flux density after having penetrated the medium to a distance x is

$$I = I_0 e^{-ax};$$

in which I_0 is the flux density just after entrance into the medium (i.e., for $x = 0$). For true absorption, the constant a is the absorption coefficient (commonly designated by μ). For scattering, which obeys the same law, a is the scattering coefficient. And for the total attenuation, including both, it is the extinction coefficient, which is the sum of the absorption and the scattering coefficients.

Another way of expressing the absorbing effect of a substance is to specify the "half-value layer," which is that thickness of the substance which will reduce the flux density to $\frac{1}{2}$ its original value, so that $I = \frac{1}{2}I_0$. This thickness is equal to $0.6931/a$. Thus if the absorption coefficient of copper for certain x-rays is 13.5 cm^{-1} , the half-value layer for these rays is 0.0513 cm . thick. For many purposes it is convenient to use the mass absorption coefficient, which is the absorption coefficient of the substance divided by its density.

In general the absorption coefficient of a medium varies characteristically with the wavelength of the radiation, as illustrated by the absorption of x-rays in aluminum, tabulated below.

WAVE-LENGTH (X-units) *	ABSORPTION COEFFICIENT (Cm^{-1})
100	0.45
200	0.72
300	1.45
400	2.95
500	5.30
600	8.70
700	13.50
800	20.40
900	28.10
1000	38.00
	(L.D.W.)

* An X-unit is 10^{-11} cm . (See X-Rays; Gas Absorption.)

ABSORPTION SPECTRUM. The spectrum of radiation which has been filtered through a material medium. When white light traverses a transparent medium, a certain portion of it is absorbed, the amount varying, in general, progressively with the frequency, of which the absorption coefficient is a function. Analysis of the transmitted light may, however, reveal that certain frequency ranges are absorbed to a degree out of all proportion to the adjacent regions; that is, with a distinct

selectivity. These abnormally absorbed frequencies constitute, collectively, the "absorption spectrum" of the medium, and appear as dark lines or bands in the otherwise continuous spectrum of the transmitted light. The phenomenon is not confined to the visible range, but may be found to extend throughout the spectrum from the far infra-red to the extreme ultra-violet and into the x-ray region.

A study of such spectra shows that the lines or bands therein accurately coincide in frequency with certain lines or bands of the emission spectra of the same substances. This was formerly attributed to resonance of electronic vibrations, but is now more satisfactorily explained by quantum theory on the assumption that those quanta of the incident radiation which are absorbed are able to excite atoms or molecules of the medium to some (but not all) of the energy levels involved in the production of the complete emission spectrum.

A very familiar example is the spectrum of sunlight, which is crossed by innumerable dark lines—the Fraunhofer lines—from which so much has been learned about the constitution of the sun.

A noteworthy characteristic of selective absorption is found in the existence of certain anomalies in the refractive index in the neighborhood of absorption frequencies; discussed under Dispersion. (L.D.W.)

ABSORPTION TOWER. Gas Absorption.

ABSORPTIVITY. Thermal Radiation.

ABUTMENT. A bridge abutment is a masonry or concrete structure which functions both as a pier and as a retaining wall. It must support the end of the bridge and hold the abutting earth in position. The simple abutment consists of a footing, a breast or cross wall, a bridge seat, a back wall, and usually companion wing walls. The footing transfers the loads to the supporting soil, consequently the area in contact with the soil must be large enough to insure a safe bearing pressure. The breast wall must be large enough to withstand safely the combined effects of the bridge loads, its own weight and the pressure of the soil back of the abutment. The bridge seat is the surface which supports the end bearings of the bridge. The back wall supports the earth above the bridge seat. The wing walls are usually attached to both ends of the breast wall and are used to retain the side slopes of the fill at the end of the abutment. (c.w.c.)

ABVOLT. Electric and Magnetic Units.

ABYSSAL FAUNA. The animals found in the depths of the ocean below 600 fathoms. The abysses are characterized by darkness, low temperature, great pressure, and the absence of plant life due to the lack of light. Grotesque form and the extensive development of light-producing organs are frequent among abyssal animals. (A.W.L.)

ABYSSAL ROCKS. Proposed by Brögger as a general term for deep-seated igneous rocks, or those which have crystallized from magmas far below the surface of the earth, very slowly and under great pressure. Granite is a typical abyssal rock. The term Plutonic is synonymous. (R.M.F.)

ACACIA. Leguminosae: tribe Mimosae. A very large genus of trees and shrubs, particularly abundant in Africa and Australia. The small flowers are aggregated into ball-like or elongate clusters, which are quite conspicuous. The leaves are rather diverse in shape; quite commonly they are dissected into compound pinnate forms; in other instances, especially in Australian species, they are reduced even to a point where only the flattened petiole (see Leaf), called a phyllode, remains. This petiole grows with the edges vertical, a fact which some have

been led to construe as a protective adaptation against too intense sunlight on the surface. Several species, particularly those growing in Africa and tropical Asia, yield products of commercial value. For example, from *Acacia Senegal* gum arabic is obtained; and from *A. Catechu*, a brown or black dye called cutch. Many species are valuable timber trees. Certain tropical American species are of particular interest because of the curious pairs of thorns, which are united at their base. These thorns are often hollowed out and used as nests by species of stinging ants. (R.M.W.)

ACANTHITE. Argentite.

ACANTHOCEPHALA. Worms with recurved spines at the anterior end, parasitic in the intestines of vertebrates. They are usually regarded as a class of roundworms (*Nemathelminthes*). (A.W.L.)

ACANTHUS. Acanthaceae. *Acanthus* is a small genus of Mediterranean plants largely grown for ornamental purposes. The flowers are white or various shades of red. The leaves of these plants are the source of the more or less conventionalized architectural design called the acanthus. (R.M.W.)

ACARINA. The order of *Arachnida* which includes the mites and ticks. (A.W.L.)

ACCELERATED FLIGHT. When the velocity of an airplane along its flight path contains elements of acceleration, the structure receives increments of inertia loading which may prove to be far more severe upon the structure than the loading imposed by the static weight of the airplane and its contents. Consequently, accelerated flight has been the subject of extensive analytical and experimental investigation. Acceleration of rectilinear velocity, as by increasing engine power in straight level flight, is of small import, since radial accelerations resulting from curvilinear flight at constant speed are so large as to be the critical influence. Cases of curved flight paths capable of accelerations of several g (acceleration of gravity, i.e., 32.2 ft. per sec.²) are quick pull-ups (or "zooms") from high-speed rectilinear flight, spins, steeply banked turns, loops. The magnitude of the effect of accelerated flight is well illustrated by the case of a flight path curved in a vertical plane. With a constant tangential speed of 120 m.p.h., our airplane will experience a radial acceleration of $4g$, even though the radius of curvature be as great as $250'$. (See *Load Factor*.) (F.T.M.)

ACCELERATION. The rate of change of the velocity with respect to the time is called acceleration. It is expressed mathematically by $\frac{dv}{dt}$, the vector derivative of the velocity, v with respect to the time, t . If the motion is in a straight line whose position is clearly understood, it is convenient to treat the velocity v and the acceleration $\frac{dv}{dt}$ as scalars with appropriate algebraic signs; otherwise they must be treated by vector methods.

Acceleration may be rectilinear or curvilinear, depending upon whether the path of motion is a straight line or a curved line. A body which moves along a curved path has acceleration components at every point. One component is in the direction of the tangent to the curve and is equal to the rate of change of the speed at the point. For uniform circular motion this component is zero. The second component is normal to the tangent and is equal to the square of the tangential speed divided by the radius of curvature at the point. This normal component which is directed toward the center of curvature also equals the square of the angular velocity multiplied by the radius of curvature. The acceleration due to gravity is equal to an increase in the

velocity of about 32.2 ft. per sec. per sec. at the earth's surface and is of prime importance since it is the ratio of the weight to the mass of a body. For examples of acceleration in both curved and linear motion, see *Kinematics*. (L.D.W.)

ACCELERATORS, RUBBER. Rubber and Accelerators.

ACCELEROMETER. The accelerometer is an instrument for determining the acceleration of the system with which it moves. Work in accelerometry is becoming increasingly important as means of transport continue to provide higher motive speeds for the use of mankind. The principal instrument in this field of work is the accelerometer. It has been used in airplane work to study the stresses that the airplane structure undergoes, and to determine how long these stresses last. The records can also be used to study pilots' ability, especially in landings and acrobatic maneuvers. Other uses for this instrument are the study of the oscillations of automobile springs, the pickup and braking power of automobiles, the side load on tires or rails when rounding curves, and study of vibrations of various sorts. The accelerometer should have a natural period of vibration which is considerably higher than that of any shocks it may experience. In addition, it should give a graphic, easily interpreted record, and it should be rugged, strong, and accurate. Not all these characteristics can be met by one design, and accelerometers suitable for measuring the accelerations produced in certain flight maneuvers are unsatisfactory for measuring landing shock accelerations. One style of the accelerometer is the seismograph type. Unfortunately, this instrument records displacements against an axis of time sequence, and accelerations are not read directly. The slope of the displaced curve is the rate of change of displacement with time; in other words, the velocity. If the velocity is determined and plotted, a similar measurement of slope gives the rate of change of velocity with time, and this is the acceleration. Thus the record of a seismograph type of accelerometer must be differentiated twice in order to obtain accelerations, for:

$$v = \frac{ds}{dt}$$

$$a = \frac{dv}{dt}$$

$$\text{Hence: } a = \frac{d^2s}{dt^2}$$

While this type of instrument has its certain uses, it has been superseded for most accelerometry work by more practical designs. (F.T.M.)

ACCESSORY NIDAMENTAL GLAND. A gland of the female reproductive system in the squids and allied species. (A.W.L.)

ACCOMMODATION. The power of altering the focus of the eye so that divergent light rays may be brought to a point on the retina. (See *Vision*.) (R.S.M.)

ACCOUCHEMENT. Confinement, or delivery of a baby, by an obstetrician or midwife. (R.S.M.)

ACCOUCHEUR. An obstetrician or midwife. (R.S.M.)

ACCRETION. Used in mineralogy and geology to define the process by which inorganic bodies grow larger by the addition of material onto the external surface. (R.M.F.)

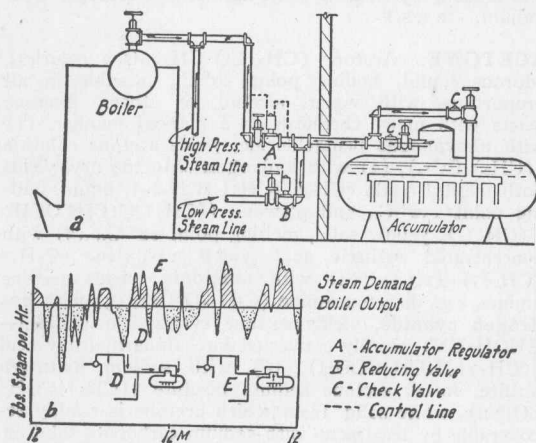
ACCUMULATOR, HYDRAULIC. The hydraulic accumulator is a hydraulic machine consisting of verti-

cal cylinders with weighted pistons or plungers under which a certain amount of water can be stored, and is, consequently, available for doing work at the pressure yielded by the weighted piston. The accumulator feature is obtained by virtue of the fact that while the water may be discharged rapidly, giving large hydraulic power for short periods of time, it may be refilled by a comparatively small and low-powered pump working a much longer time.

Another type of hydraulic accumulator is the pumped storage plant, now being looked on with considerable favor by electric power systems for the economic carrying of variable load. As employed in conjunction with steam generating stations, steam turbine-driven centrifugal pumps raise water from a lower to an upper pool with off-peak power. During the peak-load periods this water is released to the lower pool through a hydraulic turbo-generator as rapidly as is needed to give the required power. The hydraulic storage of power of this nature is essentially a high head development, low head equipment and hydraulic losses being too expensive. In favorable locations the over-all efficiency of conversion and storage may not need to be greater than 50% in order to justify the project. (F.T.M.)

ACCUMULATOR, STEAM. The steam accumulator is an effective means for smoothing out irregular steam demand into a uniform boiler output. Its operation is based upon the fact that the heat contained in water in a liquid form varies with the pressure of the water. Thus in a tank of water under pressure with the water at the saturation temperature, a decrease of pressure on the tank will be accompanied by a release of some of the heat energy held by the water, and a consequent flashing of a portion of the water into steam. This process can be continued with the production of steam at ever decreasing pressures until the lower pressure limit is reached. Since the heat required to evaporate a pound of water is much more than the heat of the liquid at the commonly used pressures, only 20-40% of the weight of water in a charged accumulator tank can be converted into steam.

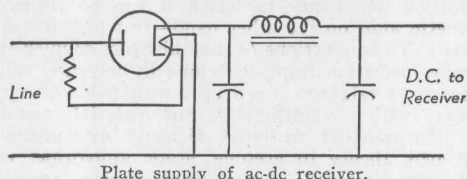
An accumulator installation is shown by diagram in the accompanying figure. The irregular steam demand



The Ruths steam accumulator.

is assumed to be that of an industrial process using considerable quantities of low-pressure steam, while the desired boiler output is shown as the straight line. The accumulator must absorb steam during the valleys which occur below the steady boiler output line and supply steam during the peaks. The direction of steam flow when charging the accumulator is shown at D, while at E is the flow diagram for accumulator discharging. (F.T.M.)

AC-DC RECEIVERS. These are radio receivers designed without transformers in the power supply so they may be connected to either alternating-current or direct-current circuits. The heaters or filaments of the



various tubes are connected in series with the proper series or parallel resistors to adjust the current to the correct value. The d-c voltage for the plates is obtained from a rectifier-filter circuit connected directly to the line. A simple half-wave type is shown. Such supplies prevent the use of a direct ground since the 110-volt line has one side grounded and there is always the possibility of connecting the receiver plug so it would short the line if the receiver were grounded. (L.R.Q.)

ACERDISE. See boehmite under Lepidocrocite.

ACETALDEHYDE. Acetaldehyde ($\text{CH}_3 \cdot \text{CHO}$) is a colorless, odorous liquid, boiling point 20°C ., miscible with water, alcohol, or ether in all proportions. Acetaldehyde reacts with many chemicals in a marked manner, (1) with ammonio-silver nitrate ("Tollen's solution"), to form metallic silver, either as a black precipitate or as an adherent mirror film on glass, (2) with alkaline cupric solution ("Fehling's solution") to form cuprous oxide, red to yellow precipitate, (3) with rosaniline (fuchsine, magenta), which has been decolorized by sulfurous acid ("Schiff's solution"), the pink color of rosaniline is restored, (4) with sodium hydroxide, upon warming, a yellow to brown resin of unpleasant odor separates (this reaction is given by aldehydes immediately following acetaldehyde in the series, but not by formaldehyde, furfuraldehyde or benzaldehyde), (5) with anhydrous ammonia, to form aldehyde-ammonia ($\text{CH}_3 \cdot \text{CHOH} \cdot \text{NH}_2$), white solid, melting point 97°C ., boiling point 111°C ., with decomposition, (6) with concentrated sulfuric acid, heat is evolved, and with rise of temperature, paraldehyde ($(\text{C}_2\text{H}_4\text{O})_3$ or $\text{CH}_3 \cdot \text{CH} < \begin{smallmatrix} \text{OCH}(\text{CH}_3) \\ \text{OCH}(\text{CH}_3) \end{smallmatrix} > \text{O}$), colorless liquid, boiling point 124°C ., slightly soluble in water, is formed, (7) with acids, below 0°C ., forms metaldehyde ($\text{C}_2\text{H}_4\text{O}$) $_x$ white solid, sublimes at about 115°C . without melting but with partial conversion to acetaldehyde, (8) with dilute hydrochloric acid or dilute sodium hydroxide, aldol ($\text{CH}_3 \cdot \text{CHOH} \cdot \text{CH}_2 \cdot \text{CHO}$) slowly forms, (9) with phosphorus pentachloride, forms ethylidene chloride ($\text{CH}_3 \cdot \text{CHCl}_2$), colorless liquid, boiling point 58°C ., (10) with ethyl alcohol and dry hydrogen chloride, forms acetal, 1,1-diethoxyethane ($\text{CH}_3 \cdot \text{CH}(\text{OC}_2\text{H}_5)_2$), colorless liquid, boiling point 104°C ., (11) with hydrocyanic acid, forms acetaldehyde cyanhydrin ($\text{CH}_3 \cdot \text{CHOH} \cdot \text{CN}$), readily converted into alpha-hydroxypropionic acid ($\text{CH}_3 \cdot \text{CHOH} \cdot \text{COOH}$), (12) with sodium hydrogen sulfite, forms acetaldehyde sodium bisulfite ($\text{CH}_3 \cdot \text{CHOH} \cdot \text{SO}_3\text{Na}$), white solid, from which acetaldehyde is readily recoverable by treatment with sodium carbonate solution, (13) with hydroxylamine hydrochloride forms acetaldoxime ($\text{CH}_3\text{CH}:\text{NOH}$), white solid, melting point 47°C ., (14) with phenylhydrazine, forms acetaldehyde phenylhydrazone ($\text{CH}_3 \cdot \text{CH}:\text{N} \cdot \text{NH} \cdot \text{C}_6\text{H}_5$), white solid, melting point 98°C ., (15) with magnesium methyl iodide in anhydrous ether ("Grignard's solution"), yields, after reaction with water, isopropyl alcohol ($(\text{CH}_3)_2\text{CHOH}$), a secondary alcohol, (16) with semicarbazide, forms acetaldehyde semicarbazone ($\text{CH}_3 \cdot \text{CH}:\text{N} \cdot \text{NH} \cdot \text{CO} \cdot \text{NH}_2$), white solid, melting

point 162° C., (17) with **chlorine**, forms trichloroacetaldehyde ("chloral") ($\text{CCl}_3 \cdot \text{CHO}$), (18) with **hydrogen sulfide**, forms thio-acetaldehyde ($\text{CH}_3 \cdot \text{CHS}$ or $(\text{CH}_3 \cdot \text{CHS})_2$). Acetaldehyde stands chemically between **ethyl alcohol** on one hand—to which it can be reduced—and **acetic acid** on the other hand—to which it can be oxidized. These reactions of acetaldehyde, coupled with its ready formation from **acetylene** by mercuric sulfate solution as a catalyzer, open up a vast field of organic chemistry with acetaldehyde as raw material: acetaldehyde hydrogenated to ethyl alcohol; oxygenated to acetic acid, thence to acetone, acetic anhydride, vinyl acetate, vinyl alcohol. Acetaldehyde is also formed by the regulated oxidation of ethyl alcohol by such a reagent as sodium dichromate in sulfuric acid (chromic sulfate also produced). Reactions (1), (3), (14) and (16) above are most commonly used in the detection of acetaldehyde. (R.K.S.)

ACETALS. Organic compounds of the general formula $\text{RCH}(\text{OR}')(\text{OR}'')$. They are formed by the reaction of **aldehydes** with **alcohols** in the presence of small amounts of acids or certain inorganic salts. They are stable toward alkali, are volatile and insoluble in water but are decomposed into aldehyde by the action of acids. The last reaction is often used as a source of aldehydes. (R.K.S.)

ACETANILIDE. Aniline.

ACETIC ACID AND ACETATES. Acetic acid ($\text{H} \cdot \text{C}_2\text{H}_3\text{O}_2$ or $\text{CH}_3 \cdot \text{COOH}$) is a colorless liquid, melting point 16.6° C., boiling point 118° C., miscible with water, alcohol, or ether in all proportions. Acetic acid solution reacts with alkalis to form acetates, e.g., **sodium acetate**, **calcium acetate**; similarly, with some oxides, e.g., **lead acetate**; with carbonates, e.g., **sodium acetate**, **calcium acetate**, **magnesium acetate**; with some sulfides, e.g., **zinc acetate**, **manganese acetate**. Ferric acetate solution, upon boiling, yields red precipitate of basic ferric acetate. Acetic acid solution attacks many metals, liberating hydrogen and forming acetate, e.g., **magnesium**, **zinc**, **iron**. Acetic acid is an important organic substance, with alcohols forming **esters** (acetates); with **phosphorus trichloride** forming acetyl chloride ($\text{CH}_3 \cdot \text{CO} \cdot \text{Cl}$), which is an important reagent for transfer of the acetyl ($\text{CH}_3\text{CO}-$) group; forming **acetic anhydride**, also an acetyl reagent; forming **acetone** and **calcium carbonate** when passed over a suitable catalyzer (**barium carbonate**) or when calcium acetate is heated; forming **methane** (and sodium carbonate) when sodium acetate is heated with sodium hydroxide; forming mono-, di-, tri-chloroacetic (or bromoacetic) acids by reaction with chlorine (or bromine) from which **hydroxy-** and **amino-**, **aldehydic-**, **dicarboxylic acids**, respectively, may be made; forming **acetamide** when ammonium acetate is distilled. Acetic acid dissolves sulfur and phosphorus, is an important solvent for organic substances, and causes painful wounds when it comes in contact with the skin. Normal acetates are soluble, basic acetates insoluble. The latter are important in their compounds with lead, copper ("verdigris"). Acetic acid is made (1) by destructive distillation of wood. Dilute acid is obtained in the aqueous distillate, recovered by neutralization with calcium hydroxide, and then evaporation and recovery of calcium acetate; (2) from calcium or sodium acetate, acetic acid of high strength is made by distillation with concentrated sulfuric acid; (3) by the action of bacteria on dilute ethyl alcohol, containing the proper food materials for the bacteria, dilute acetic acid (vinegar) is produced. The vinegar contains, besides acetic acid and water, the materials characteristic of the alcohol and the process used; (4) by the reaction of acetaldehyde and air over a suitable catalyzer. Acetic acid is used as has been suggested by its reactions, (1) in the preparation of many organic substances, notably,

cellulose acetate, as a non-inflammable photographic film and also as a textile fiber; (2) in the preparation of many acetates and basic acetates and carbonates (white lead in conjunction with carbon dioxide); (3) as a weak, moderately cheap acid; (4) as a solvent when concentrated, for organic chemicals; (5) in pharmaceutical preparations, dyeing, rubber, artificial leather.

Esters (acetates of various alcohols) of note are:

Methyl acetate ($\text{CH}_3\text{COOCH}_3$), boiling point 57° C.
Ethyl acetate ($\text{CH}_3\text{COOC}_2\text{H}_5$), boiling point 77° C.
Propyl acetate ($\text{CH}_3\text{COOC}_3\text{H}_7$), boiling point 102° C.
Butyl acetate ($\text{CH}_3\text{COOC}_4\text{H}_9$), boiling point 125° C.
Amyl acetate ($\text{CH}_3\text{COOC}_5\text{H}_{11}$), boiling point 149° C.
Glycol monoacetate ($\text{CH}_3\text{COOCH}_2 \cdot \text{CH}_2\text{OH}$), boiling point 182° C.

Glycol diacetate ($\text{CH}_3\text{COOCH}_2 \cdot \text{CH}_2\text{COOCH}_3$), boiling point 190° C.

Glycerol monoacetate (monoacetin) ($\text{CH}_2\text{OH} \cdot \text{CHOH} \cdot \text{CH}_2\text{OOCCH}_3$) decomposes upon heating.

Glycerol diacetate (diacetin) ($\text{CH}_2\text{OH} \cdot \text{CHOOCCH}_3 \cdot \text{CH}_2\text{OOCCH}_3$), melting point 40° C., boiling point 176° C. at 40 mm. pressure.

Glycerol triacetate (triacetin) ($\text{CH}_2\text{OOCCH}_3 \cdot \text{CHOOCCH}_3 \cdot \text{CH}_2\text{OOCCH}_3$), melting point -78° C., boiling point 259° C.

Glucose pentacetate ($\text{C}_6\text{H}_6(\text{OH})(\text{COOCH}_3)_5$), melting point 113° C., sublimes.

Cellulose triacetate ($\text{C}_6\text{H}_5(\text{OH})_2(\text{COOCH}_3)_3$).

Cellulose tetracetate ($\text{C}_6\text{H}_5(\text{OH})(\text{COOCH}_3)_4$), softens at about 150° C.

Cellulose pentacetate ($\text{C}_6\text{H}_5(\text{COOCH}_3)_5$).

Cetyl acetate ($\text{CH}_3\text{COOC}_{16}\text{H}_{33}$), melting point 22° C., boiling point 200° C. at 15 mm. pressure.

Phenyl acetate ($\text{CH}_3\text{COOC}_6\text{H}_5$), boiling point 195° C.

Acetates may be detected by formation of foul-smelling cacodyl (poisonous) on heating with dry arsenic trioxide. (R.K.S.)

ACETOACETIC ACID ESTER. This is an important organic liquid of the formula $\text{CH}_3(\text{CO})\text{CH}_2 \cdot \text{COOC}_2\text{H}_5$, which is used as a starting point for the synthesis of **ketones** of the type $\text{CH}_3(\text{CO})\text{CHR}'\text{R}''$ and acids of the type $\text{R}'\text{R}''\text{CHCOOH}$ where R' and R'' are hydrocarbon radicals. The ethyl ester of acetoacetic acid is made by treating ethyl acetate (see **Esters**) with sodium. (R.K.S.)

ACETONE. Acetone ($\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_3$) is a colorless, odorless liquid, boiling point 56° C., miscible in all proportions with water, alcohol, or ether. Acetone reacts with many chemicals in a marked manner, (1) with **phosphorus pentachloride**, yields acetone chloride ($(\text{CH}_3)_2\text{CCl}_2$), (2) with **hydrogen chloride** dry, yields both mesityl oxide ($\text{CH}_3\text{COCH}:\text{C}(\text{CH}_3)_2$), liquid, boiling point 132° C., and phorone ($(\text{CH}_3)_2\text{C}:\text{CHCOCH}:\text{C}(\text{CH}_3)_2$), yellow solid, melting point 28° C., (3) with concentrated **sulfuric acid**, yields mesitylene (C_6H_6), (4) with **ammonia**, yields acetone amines, e.g., diacetoneamine ($\text{C}_6\text{H}_{12}\text{ONH}$), (5) with **hydrogen cyanide**, yields acetone cyanhydrin ($(\text{CH}_3)_2\text{CHOH} \cdot \text{CN}$), readily converted into alpha-hydroxy acid ($(\text{CH}_3)_2\text{CHOH} \cdot \text{COOH}$), (6) with **sodium hydrogen sulfite**, forms acetone sodium bisulfite ($(\text{CH}_3)_2\text{COH} \cdot \text{SO}_3\text{Na}$), white solid, from which acetone is readily recoverable by treatment with sodium carbonate solution, (7) with **hydroxylamine** hydrochloride, forms acetoxime ($(\text{CH}_3)_2\text{C}:\text{NOH}$), solid, melting point 60° C., (8) with **phenylhydrazine**, yields acetonephenylhydrazone ($(\text{CH}_3)_2\text{C}:\text{NNHC}_6\text{H}_5 \cdot \text{H}_2\text{O}$), solid, melting point 16° C., anhydrous compound, melting point 42° C., (9) with **semicarbazide**, forms acetonesemicarbazone ($(\text{CH}_3)_2\text{C}:\text{NNHCONH}_2$), solid, melting point 189° C., (10) with **magnesium methyl iodide** in anhydrous ether ("Grignard's solution"), yields, after reaction with water, trimethylcarbinol ($(\text{CH}_3)_3\text{COH}$), a tertiary alcohol, (11) with ethyl thioalcohol and hydrogen chloride

dry, yields mercaptol $((\text{CH}_3)_2\text{C}(\text{SC}_2\text{H}_5)_2)$, (12) with hypochlorite, hypobromite, or hyposulfite solution, yields chloroform (CHCl_3), bromoform (CHBr_3) or iodoform (CHI_3), respectively, (13) with most reducing agents, forms isopropyl alcohol $((\text{CH}_3)_2\text{CHOH})$, a secondary alcohol, but with sodium amalgam forms pinacolone $((\text{CH}_3)_2\text{COH}\cdot\text{COH}(\text{CH}_3)_2)$, (14) with sodium dichromate and sulfuric acid, forms acetic acid (CH_3COOH) plus carbon dioxide (CO_2). When acetone vapor is passed through a tube at a dull red heat, ketene ($\text{CH}_2\text{:CO}$) and methane (CH_4) are formed. Acetone is made (1) by heating calcium acetate at 400°C ., calcium carbonate being simultaneously formed, (2) by passing acetic acid vapor over a heated catalyzer, e.g., barium carbonate, manganese carbonate, (3) by fermentation of starch by specific bacteria, normal-butyl alcohol being simultaneously produced, (4) in the water condensate (approximately 0.5% acetone) in the destructive distillation of wood, and, (5) in the urine of persons having diabetes. Acetone may be detected by the addition of acetic acid and sodium nitroprusside (trace). The appearance of a violet color in the interface between this solution and a layer of ammonium hydroxide indicates acetone. Acetone is used (1) as a solvent, e.g., for acetylene, (2) as a solvent for cellulose and glyceryl esters in the manufacture of celluloid, smokeless powders, airplane dopes, varnishes, (3) in the preparation of chloroform, iodoform, sulfonal. (R.K.S.)

ACETOPHENONE. Aldehydes, Ketones and Related Compounds.

ACETYL CHLORIDE. Chlorine.

ACETYLENE. Acetylene, ethyne (C_2H_2 or CH:CH) is a colorless gas, of characteristic odor, moderately poisonous, boiling point -84°C ., density, 1.17 grams per liter at 0°C . and 760 mm. (specific gravity 0.91, air equal to 1.00), slightly soluble in water or alcohol, very soluble in acetone (300 volumes of acetylene in 1 volume acetone at 12 atmospheres pressure), burns when ignited in air with a luminous sooty flame, requiring a specially devised burner for illumination purposes, forms an explosive mixture with air over a wide range (about 3% to 80% acetylene), explosive when compressed to 2 or more atmospheres, but safe when dissolved in acetone, of high fuel value (1455 B.T.U. per cubic foot). Acetylene reacts (1) with chlorine, to form acetylene tetrachloride ($\text{C}_2\text{H}_2\text{Cl}_4$ or $\text{CHCl}_2\cdot\text{CHCl}_2$) or acetylene dichloride ($\text{C}_2\text{H}_2\text{Cl}_2$ or CHCl:CHCl), (2) with bromine, to form acetylene tetrabromide ($\text{C}_2\text{H}_2\text{Br}_4$ or $\text{CHBr}_2\cdot\text{CHBr}_2$) or acetylene dibromide ($\text{C}_2\text{H}_2\text{Br}_2$ or CHBr:CHBr), (3) with hydrogen chloride (bromide, iodide), to form ethylene monochloride ($\text{CH}_2\text{:CHCl}$) (monobromide, monoiodide), and 1,1-dichloroethane, ethylidene chloride ($\text{CH}_2\cdot\text{CHCl}_2$) (dibromide, diiodide), (4) with water in the presence of a catalyzer, e.g., mercuric sulfate, to form acetaldehyde ($\text{CH}_3\cdot\text{CHO}$), (5) with hydrogen, in the presence of a catalyzer, e.g., finely divided nickel heated, to form ethylene (C_2H_4) or ethane (C_2H_6), (6) with metals, such as copper or nickel, when moist, also lead or zinc, when moist and unpurified. Tin is not attacked. Sodium yields, upon heating, the compounds C_2HNa and C_2Na_2 . (7) With ammoniacuprous (or silver) salt solution, to form cuprous (or silver) acetylide (C_2Cu_2), dark red precipitate, explosive when dry, and yielding acetylene upon treatment with acid, (8) with mercuric chloride solution, to form trichloromercuric acetaldehyde ($\text{C}(\text{HgCl})_3\cdot\text{CHO}$), precipitate, which yields with hydrochloric acid acetaldehyde plus mercuric chloride. Acetylene is made by reaction of calcium carbide and water, calcium hydroxide being simultaneously formed, and is formed when the gas in a Bunsen burner burns at the base of the burner; and when hydrogen is passed through a carbon arc (about 7% acetylene in the exit gas). Acetylene may be de-

tected by the formation of explosive copper acetylide. Acetylene is used (1) as a fuel with oxygen for high temperature flames, (2) as an illuminant, (3) in the manufacture of acetaldehyde, from which a variety of chemicals is prepared, (4) in the manufacture of chloro-derivatives, thus:

Acetylene \rightarrow vinyl chloride by HCl , Cu_2Cl_2 , NH_4Cl
vinyl acetylene by same, which yields chloroprene
 \rightarrow tetrachloroethane by Cl_2 , which yields trichloroethylene (CHCl:CCl_2), pentachloroethane ($\text{CHCl}_2\cdot\text{CCl}_3$), perchloroethylene ($\text{CCl}_2\cdot\text{CCl}_2$), hexachloroethane ($\text{CCl}_3\cdot\text{CCl}_3$). (R.K.S.)

ACETYLSALICYLIC ACID. A drug commonly known as "aspirin." (See Salicylic Acid.) It is used for relief of milder forms of pain, especially joint and muscle pain. It also tends to reduce fever. It does not harm the heart, contrary to popular opinion. This drug is used in massive doses in acute rheumatic fever. (R.S.M.)

ACHENE. An achene is a single-seeded fruit, which does not split when mature, and which has the seed free from the ovary wall except at the point of attachment. (R.M.W.)

ACHEULEAN. Paleontology of Man.

ACHILLES, TENDON OF. In man the prominent tendon at the back of the ankle, extending from the muscle of the calf to the heel. Technically it is the tendon which attaches the gastrocnemius and soleus muscles to the calcaneum or heel bone. The name derived from human anatomy is used in relation to other vertebrates. (A.W.L.)

ACHLORHYDRIA. Absence of hydrochloric acid in the stomach. This may occur normally in older people, and in certain diseases, such as cancer of the stomach, and pernicious anemia. (D.M.H.)

ACHOLIA. Absence or lack of secretion of bile. (R.S.M.)

ACHONDRITES. A form of stony meteorites without chondri, and having textures similar to those of some terrestrial rocks. (R.M.F.)

ACHRAS SAPOTA. Sapodilla. Sapotaceae. A large tree native to the forests of Central and tropical South America, the fruit of which is an edible berry. Its greatest value is in its latex product, which yields chicle. The chicle-gathering industry is centered in Yucatan and Central America. The tapping is done in the rainy season. The tapper climbs to a height of 30-50', and with a machete cuts a series of connecting zig-zag diagonal gashes in the bark as he descends. At the bottom of this series of cuts he attaches a cup, into which the latex flows. The crude substance is collected, boiled down to eliminate much of its water and the coagulated product pressed into 20-25 lb. blocks. This substance, chicle, varies in quality from the best grade, which is milk-white in color, to pinkish or darker grades, which have received less care in preparation. Each tree yields about $2\frac{1}{2}$ lbs. of chicle during one season and may be tapped every 6 years. The blocks of chicle are shipped largely to the United States, where they are melted and cleaned, flavored and sweetened, and then marketed as the familiar chewing gum. This use of the latex of the



Tendon of Achilles.

Sapodilla is not new, since the Aztecs and their predecessors knew of it and used it. When first introduced into the United States it was tried as a rubber substitute, but proved unsuitable. (R.M.W.)

ACHROIT. Tourmaline.

ACHROMATISM. Chromatic Aberration.

ACICULITE. Aikinite.

ACICULUM. A strong internal seta found in the parapodia of annelid worms. (A.W.L.)

ACID ANHYDRIDES. Acids, Carboxylic.

ACID ROCK. According to A. Holmes an igneous rock which contains 66% silica is said to be acidic. The term is gradually going out of use. Since the geologist uses acid in a different sense from the chemist, Clarke has proposed persilic for igneous rocks which are relatively rich in silica. (R.M.F.)

ACIDOSIS. A condition occurring in the body in which acids are absorbed or form in excess of their elimination or neutralization. The alkali reserve of the body is disturbed, the first step being a decrease in amount of bicarbonate (see **Carbon**) in the blood. The opposite condition results from excess formation or ingestion of alkalis, or from prolonged loss of acid from the stomach. The resulting condition is known as alkalosis. In this condition the alkali reserve is increased over the normal limit.

Ordinarily, excess acid or alkali formed or taken into the body does not cause either of these conditions. This is due to the ability of the body to protect itself automatically by preserving the acid-base equilibrium. This is accomplished by several mechanisms. In general, the balance is maintained by elimination, oxidation, excretion and neutralization. The buffer substances in the blood—the salts, haemoglobin and protein—act to lessen the change toward increased acid or alkali concentration. Further, there is a reserve of alkali to take care of any excess acid. This reserve of alkali consists of sodium bicarbonate, di-potassium phosphate and protein salts. Acidosis only occurs when the buffer substances and alkali reserve are depleted.

Excess acid or alkali can be eliminated by the kidneys and by the respiratory mechanism through its power to throw off greater or lesser concentrations of carbon dioxide. Neutralization of acid occurs with ammonia formed by the body metabolism. These are all normal bodily processes and the mechanism of equilibrium can still be maintained in abnormal conditions without producing an acidosis or alkalosis unless certain adverse factors enter into the picture.

Acidosis may occur in many conditions, usually those of serious nature. They are (1) starvation or inadequate intake of water or food (especially carbohydrates), or during acute infections, (2) after prolonged anaesthesia, (3) in diseases accompanied by severe diarrhea and vomiting, (4) in severe untreated diabetes, (5) in advanced kidney and heart disease.

Alkalosis may result from (1) prolonged vomiting with excess loss of hydrochloric acid from the stomach, (2) prolonged increase in the respiratory rate as is seen in certain disorders and in higher altitudes, (3) excess ingestion of alkalis by mouth as might occur in the treatment of peptic ulcer and in other conditions. This may also occur through prolonged use of alkali products by the laity due to the pernicious advertising of these products on the radio and in advertisements for treatment of imaginary and non-existent "acid conditions" and indigestion. (D.M.H.)

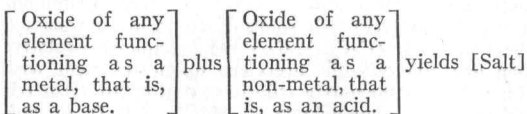
ACIDS, BASES AND SALTS. These are chemical compounds classified as electrolytes. Acids are electrolytes which furnish hydrogen ions, e.g., $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$. Bases are electrolytes which furnish hydroxyl ions, e.g., $\text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^-$. Salts are electrolytes which furnish neither hydrogen nor hydroxyl ions, e.g., $\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$. Salts are formed by the combination of equivalent weights of an acid and a base, a process called neutralization. The result is the formation of a salt and the combination of the hydrogen and hydroxyl ions to form water. $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$.

Water as an electrolyte occupies a unique position in that it furnishes both hydrogen ions and hydroxyl ions in equal amounts. In pure water the concentration of each of these ions is 10^{-7} moles per liter. The product of the hydrogen times the hydroxyl concentration is always constant and equal to 10^{-14} . When the hydrogen ion concentration is greater than 10^{-7} due to the presence of an acid, the hydroxyl ion concentration becomes less than 10^{-7} and the solution is said to be acidic. When the hydroxyl ion concentration is greater than 10^{-7} due to the presence of a base the hydrogen ion concentration adjusts itself to a value less than 10^{-7} . Thus the hydrogen ion concentration is a measure of the acidity or basicity of a solution. It is usually defined by stating the pH which is the negative logarithm of the hydrogen ion concentration (in moles per liter). The process of neutralization, whereby an acid and a base in solution react to form a salt—actually hydrogen ion of the acid and hydroxyl ion of the base react to form water leaving the cation of the base and the anion of the salt by recombination—is discussed elsewhere. (See **Reactions Involving Recombination of Ions.**)

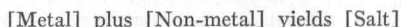
Upon evaporation of the solvent, the salt is obtained as such, frequently as crystals, sometimes with, sometimes without water of crystallization. (See **Reactions Involving Water.**)

A salt can be defined as "a system built from oppositely charged ions which do not neutralize each other" (Kilpatrick, 1935). In this sense hydrochloric acid (H^+Cl^-) and sodium hydroxide (Na^+OH^-) are salts. Acids are those salts whose cation is hydrogen ion, H^+ (probably acid (H_3O^+) dissociating to proton (H^+) plus base (H_2O)), and bases those whose anion is hydroxyl, OH^- (probably acid (water) dissociating to proton (H^+) plus base (OH^-)). A salt (1) when dissolved in an ionizing solvent, e.g., sodium chloride in water, is a good conductor of electricity, and (2) when in the solid state forms a crystal lattice, e.g., sodium chloride crystals possess a definite lattice structure for both sodium cations (Na^+) and chloride anions (Cl^-), determinable by examination with x-rays.

A broader definition than that confined to solutions is demanded in some fields of chemistry, for example, in high temperature reactions of acids, bases, salts. In the formation of metallurgical slags, at furnace temperatures, calcium oxide is used as base and silicon oxide and aluminum oxide, as acids, and calcium aluminosilicate is produced as a fused salt. Sodium carbonate and silicon oxide when fused react to form the salt sodium silicate with the evolution of carbon dioxide. In this sense:



Iron and sulfur when heated react to form the salt ferrous sulfide. In this sense:



Salts are, therefore, prepared (1) from solutions of acids and bases by neutralization, and separation by

evaporation and crystallization, (2) from solutions of two salts by precipitation where the solubility of the salt formed is slight, e.g., silver nitrate solution plus sodium chloride solution yields silver chloride precipitate (almost all as solid) and sodium nitrate as sodium cations and nitrate anions in solution (recoverable as sodium nitrate solid by separation of silver chloride and subsequent evaporation of the solution), (3) from fusion of a basic oxide (or its suitable compound—sodium carbonate above) and an acidic oxide or its suitable compound—ammonium phosphate since ammonium and hydroxyl are volatilized as ammonia and water, thus:

ammonium sodium hydrogen phosphate $\begin{array}{c} \text{NH}_4 \\ \text{Na} \diagup \text{P}^{5+} \text{O}_4 \\ \text{H} \diagdown \end{array}$ yields sodium metaphosphate $\text{Na}-\text{P}^{5+}\text{O}_3$ upon heating), (4) from reaction of a metal and a non-metal.

Reactions of acids as such in solution without decomposition of anion, are dependent upon the presence of hydrogen cation (H^+) and the anion of the acid.

Reactions of bases as such in solution without decomposition of cation, are dependent upon the presence of the cation of the base and hydroxyl anion (OH^-).

Reactions of salts as such in solution, without decomposition of cation or anion, are dependent upon the presence of the cation and the anion of the salt.

Acids in general (exceptions are common) attack metals, oxides, carbonates, sulfides, sulfitcs, with the formation of a salt and, in the respective instances, hydrogen, water, carbon dioxide, hydrogen sulfide, sulfur dioxide. For Ionization Constants of Acids, see Carboxylic Acids, Amines and Amides (for Nitrogen acids); of Bases, see Amines and Amides (for Nitrogen bases). (R.K.S.)

ACIDS, CARBOXYLIC, AND RELATED COMPOUNDS (Acid Anhydrides, Lactones, Lactides). Carboxylic acids (containing carboxyl group— COOH) are of wide variety as to constitution, physical properties, methods of preparation, and uses, well illustrated by reference to some of the particular acids, such as formic, acetic, stearic, oleic, benzoic. Several hydroxy acids (containing hydroxyl group, $-\text{OH}$, and carboxyl group, $-\text{COOH}$) are found in important natural materials. Such acids are tartaric, citric, malic, lactic. The ionization constants of some organic acids and of phenol, which constants indicate the relative strength

of these acids, are as follows, arranged in decreasing acidic strength:

ACID	IONATION CONSTANT OF ACID
Trichloroacetic	2×10^{-1}
Dichloroacetic	5×10^{-2}
Oxalic	4×10^{-2}
Malonic	2×10^{-3}
Chloroacetic	2×10^{-3}
Phthalic	1×10^{-3}
Tartaric	1×10^{-3}
Salicylic	1×10^{-3}
Citric	8×10^{-4}
Malic	4×10^{-4}
Formic	2×10^{-4}
Lactic	1×10^{-4}
Benzoic	7×10^{-5}
Succinic	7×10^{-5}
Acetic	2×10^{-5}
Carbonic	3×10^{-7}
Hydrocyanic	7×10^{-10}
Phenol	1×10^{-10}

Acids that are insoluble or slightly soluble in water may usually be titrated after dissolving in alcohol, and the amount of sodium hydroxide standard solution required to neutralize a given weight of the acid is characteristic, and an indication of the particular acid involved.

Substituted chloro-, bromo-, iodo-, amino- and cyano-, thio-, phospho-, acids will be found under the elements chlorine, bromine, iodine, nitrogen, sulfur, phosphorus, respectively.

Primary alcohols or aldehydes, upon oxidation, yield the corresponding carboxylic acids, and methyl ketones yield acetic acid, among other products. Regulated reduction of carboxylic acids yields the corresponding aldehydes or primary alcohols.

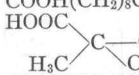
When the sodium or calcium salt of carboxylic acids is heated with sodium hydroxide or calcium oxide the hydrocarbon containing one less carbon atom than the acid is formed, e.g., sodium acetate yields methane, sodium benzoate yields benzene (and Na_2CO_3 or CaCO_3).

Acid anhydrides and acid or acyl chlorides are important organic reagents, e.g., acetic anhydride $((\text{CH}_3\text{CO})_2\text{O})$, benzoyl chloride ($\text{C}_6\text{H}_5\text{COCl}$).

When hydroxy- or amino-acids lose water or ammonia, respectively, characteristic reactions occur, as follows:

HYDROXY- OR AMINO ACID	ACID	PRODUCT
Alpha-hydroxy	$\text{CH}_3\text{CHOHCOOH}$	Lactide: $\begin{array}{c} \text{H}_3\text{C}-\text{CH}-\text{CO}-\text{O} \\ \quad \quad \\ \text{O}-\text{CO}-\text{HC}-\text{CH}_3 \end{array}$
Beta-hydroxy	$\text{CH}_3\text{CHOHCH}_2\text{COOH}$	Unsaturated acid: $\text{CH}_3\text{CH}=\text{CH}\cdot\text{COOH}$
Gamma-hydroxy	$\text{CH}_3\text{CHOHCH}_2\text{CH}_2\text{COOH}$	Gamma-lactone: $\begin{array}{c} \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CO} \\ \quad \quad \\ \text{O} \quad \quad \text{O} \end{array}$
Alpha-amino	$\text{CH}_2\text{NH}_2\cdot\text{COOH}$	Lactim: $\begin{array}{c} \text{CH}_2-\text{NH}-\text{CO} \\ \quad \quad \\ \text{CO}-\text{NH}-\text{CH}_2 \end{array}$
Beta-amino	$\text{CH}_2\text{NH}_2\cdot\text{CH}_2\cdot\text{COOH}$	Unsaturated acid: $\text{CH}_2=\text{CH}\cdot\text{COOH}$
Gamma-amino	$\text{CH}_2\text{NH}_2\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{COOH}$	Gamma-lactam: $\begin{array}{c} \text{CHCH}_2\text{CH}_2\text{CO} \\ \quad \quad \\ \text{NH} \quad \quad \text{NH} \end{array}$

SELECTED REPRESENTATIVE CARBOXYLIC ACIDS

ACID	FORMULA	MELTING POINT (°C.)	BOILING POINT (°C.)
1. Carbonic	(HO) ₂ CO		
2. Formic	H·COOH	8.5	100.5
3. Acetic	CH ₃ ·COOH	16.6	118
4. Propionic	C ₂ H ₅ ·COOH	-22	141
5. Normal-butyric (butanoic)	C ₃ H ₇ ·COOH	-8	163
6. Iso-butyric	(CH ₃) ₂ CH·COOH	-47	154
7. Valeric (pentanoic)	C ₄ H ₉ ·COOH	-59 appr.	187
8. Caproic (hexanoic)	C ₅ H ₁₁ ·COOH	9	202
9. Heptanic (oenanthylic)	C ₆ H ₁₃ ·COOH	17	260 appr.
10. Caprylic (octanoic)	C ₇ H ₁₅ ·COOH	16	237
11. Nonanoic (pelargonic)	C ₈ H ₁₇ COOH	12	254
12. Capric (decanoic)	C ₉ H ₁₉ ·COOH	31	269
13. Undecylic (undecanoic)	C ₁₀ H ₂₁ COOH	30	228 (160 mm.)
14. Lauric (dodecanoic)	C ₁₁ H ₂₃ ·COOH	48	225 (100 mm.)
15. Tridecylic (tridecanoic)	C ₁₂ H ₂₅ COOH	51	236 (100 mm.)
16. Myristic	C ₁₃ H ₂₇ ·COOH	58	250 (100 mm.)
17. Pentadecylic	C ₁₄ H ₂₉ ·COOH	52	257 (100 mm.)
18. Palmitic	C ₁₅ H ₃₁ ·COOH	64	340 appr. dec.
19. Margaric (heptadecanoic)	C ₁₆ H ₃₃ COOH	60	227 (100 mm.)
20. Stearic	C ₁₇ H ₃₅ ·COOH	69	383
21. Nondecylic	C ₁₈ H ₃₇ ·COOH	66	
22. Arachidic	C ₁₈ H ₃₉ COOH	75	
23. Behenic	C ₂₁ H ₄₃ COOH	83	
24. Lignoceric	C ₂₃ H ₄₇ COOH	80	
25. Cerotic	C ₂₅ H ₅₁ ·COOH	78	
26. Melissic	C ₂₉ H ₅₉ ·COOH	90	
27. Acrylic	CH ₂ :CH·COOH	12	142
28. Crotonic (alpha)	CH ₃ :CH:CH·COOH	72	185
29. Iso-crotonic (beta)	CH ₃ :CHCH ₂ COOH	15	172 dec.
30. 2-Methylacrylic	CH ₃ :C(CH ₃)·COOH	15	162
31. Vinylacetic	CH ₂ :CH·CH ₂ ·COOH	-39	163
32. Angelic (2-methycrotonic)	CH ₃ :CH:C(CH ₃)·COOH		
33. Oleic	CH ₃ (CH ₂) ₇ :CH:CH(CH ₂) ₇ ·COOH	14	286 (100 mm.)
34. Linoleic (linolic)	CH ₃ (CH ₂) ₄ :CH:CHCH ₂ CH:CH(CH ₂) ₇ COOH	-18	230 (16 mm.)
35. Linolenic (3 double bonds)	C ₁₇ H ₂₉ COOH		
36. Propargylic acid (propiolic)	CH:CCOOH	9	144 dec.
37. Furoic (pyromucic)	C ₄ H ₅ O·COOH(2)	131	231
38. Benzoic	C ₆ H ₅ COOH	122	249
39. Phenylacetic	C ₆ H ₅ CH ₂ COOH	77	265
40. Diphenylacetic	(C ₆ H ₅) ₂ CHCOOH	148	
41. Triphenylacetic	(C ₆ H ₅) ₃ CCOOH	265	
42. Cinnamic (beta-phenylacrylic)	C ₆ H ₅ CH:CHCOOH	133	300
43. Ortho-toluic	CH ₃ C ₆ H ₄ COOH (2)	102	259
44. Meta-toluic	CH ₃ C ₆ H ₄ COOH (3)	110	263
45. Para-toluic	CH ₃ C ₆ H ₄ COOH (4)	177	275
46. Oxalic	COOH·COOH	189	150 subl.
	{ anhydrous crys. 2H ₂ O	101	
47. Malonic	COOHCH ₂ COOH	136	dec.
48. Succinic	COOH(CH ₂) ₂ COOH	185	235
49. Glutaric	COOH(CH ₂) ₃ COOH	97	304 dec.
50. Adipic	COOH(CH ₂) ₄ COOH	151	265 (100 mm.)
51. Pimelic	COOH(CH ₂) ₅ COOH	103	272 (100 mm.)
52. Suberic	COOH(CH ₂) ₆ COOH	140	
53. Sebacic	COOH(CH ₂) ₈ COOH	135	295 (100 mm.)
54. Camphoric	HOOC  COOH dextro inactive	187 202	
55. Fumaric	COOHCH:CHCOOH	287	290
(trans-ethylene dicarboxylic)			
56. Maleic	COOHCH:CHCOOH	130	135 dec.
(cis-ethylene dicarboxylic)			
57. Ortho-phthalic	C ₆ H ₄ (COOH) ₂ (1,2)	191	dec.
(ortho-benzene dicarboxylic)			
58. Meta-benzene dicarboxylic	C ₆ H ₄ (COOH) ₂ (1,3)	330	subl.
(isophthalic)			
59. Para-benzene dicarboxylic	C ₆ H ₄ (COOH) ₂ (1,4)	subl.	
(terephthalic)			
60. 1,2,3-Benzenetricarboxylic	C ₆ H ₃ (COOH) ₃ (1,2,3)	190	
(hemimellitic)			
61. 1,2,4-Benzenetricarboxylic	C ₆ H ₃ (COOH) ₃ (1,2,4)	216 dec.	
(trimellitic)			