W

Wacker process A process for the manufacture of ethanal by the air oxidation of ethene. A mixture of air and ethene is bubbled through a solution containing palladium(II) chloride and copper(II) chloride. The Pd^{2+} ions form a complex with the ethene in which the ion is bound to the pi electrons in the C=C bond. This decreases the electron density in the bond, making it susceptible to nucleophilic attack by water molecules. The complex formed breaks down to ethanal and palladium metal. The Cu^{2+} ions oxidize the palladium back to Pd^{2+}, being reduced to Cu^{+} ions in the process. The air present oxidizes Cu^{+} back to Cu^{2+}. Thus the copper(II) and palladium(II) ions effectively act as catalysts in the process, which is now the main source of ethanal and, by further oxidation, ethanoic acid. It can also be applied to other alkenes. It is named after Alexander von Wacker (1846–1922).

Wade's rules A set of rules for predicting the structure of a cluster compound based on the number of electrons in the framework counted in a particular way. The electrons counted are known as **skeletal electrons**. The rules apply to polyhedra that have triangular faces (known as **deltahedra**). They were originally applied to the boron hydrides. Electron pairs in bonding between two boron atoms are counted as skeletal electrons but the pairs in B–H units are ignored. However, if a boron atom is connected to two hydrogens (BH_2), the second bond is counted with the skeletal electrons. According to the rules, if the formula is

$$[B_nH_n]^{2-}$$

and there are n+1 skeletal electron pairs, then the structure is **closo**. If the formula is

$$B_nH_{n+4}$$

and these are n+2 skeletal electron pairs, the structure is **nido**. If the formula is

$$B_nH_{n+6}$$

and these are n+3 skeletal electron pairs, the structure is **arachno**. The rules are named after the British chemist Kenneth Wade, who first formulated them in the early 1970s.

Wagenaar test *See* ACETONE–CHLOR–HAEMIN TEST.

Wagner-Meerwein rearrangement A rearrangement in which an alkyl group moves from a carbon atom to an adjacent carbon atom during a reaction. It often occurs to stabilize a carbocation formed as an intermediate during the reaction. Rearrangements of this type have been extensively studied in terpene chemistry.

Wallace, Alfred Russel (1823–1913) British naturalist, who in 1848 went on an expedition to the Amazon, and in 1854 travelled to the Malay Archipelago. There he noticed the differences between the animals of Asia and Australasia and devised *Wallace's line, which separates them. This led him to develop a theory of *evolution through *natural selection, which coincided with the views of Charles *Darwin; their theories were presented jointly to the Linnaean Society in 1858.

Wallace's line An imaginary line that runs between the Indonesian islands of Bali and Lombok and represents the separation of the Australian and Oriental faunas. It was proposed by Alfred Russel Wallace, who had noted that the mammals in SE Asia are different from and more advanced than their Australian counterparts. He suggested this was because the Australian continent had split away from Asia before the better adapted placental mammals evolved in Asia. Hence the isolated Australian marsupials and monotremes were able to thrive while those in Asia were driven to extinction by competition from placental mammals. *See also* ZOOGEOGRAPHY.

wall effect Any effect resulting from the nature or presence of the inside wall of a container on the system it encloses.

Walton, Ernest *See* COCKCROFT, SIR JOHN DOUGLAS.

warfarin 3-(alpha-acetonylbenzyl)-4-hydroxycoumarin: a synthetic *anticoagulant used both therapeutically in clinical

medicine and, in lethal doses, as a rodenticide (*see* PESTICIDE).

warm-blooded animal *See* ENDOTHERM.

warm front *See* FRONT.

warning coloration (aposematic coloration) The conspicuous markings of an animal that make it easily recognizable and warn would-be predators that it is a poisonous, foul-tasting, or dangerous species. For example, the yellow-and-black striped abdomen of the wasp warns of its sting. *See also* MIMICRY.

washing soda *Sodium carbonate decahydrate, $Na_2CO_3.10H_2O$.

waste product **1.** Any product of metabolism that is not required for further metabolic processes and is therefore excreted from the body. Common waste products include nitrogenous compounds (such as *urea and ammonia), carbon dioxide, and *bile. **2.** *See* RADIOACTIVE WASTE.

water A colourless liquid, H_2O; r.d. 1.000 (4°C); m.p. 0.000°C; b.p. 100.000°C. In the gas phase water consists of single H_2O molecules in which the H–O–H angle is 105°. The structure of liquid water is still controversial; hydrogen bonding of the type H_2O...H–O–H imposes a high degree of structure and current models supported by X-ray scattering studies have short-range ordered regions, which are constantly disintegrating and reforming. This ordering of the liquid state is sufficient to make the density of water at about 0°C higher than that of the relatively open-structured ice; the maximum density occurs at 3.98°C. This accounts for the well-known phenomenon of ice floating on water and the contraction of water below ice, a fact of enormous biological significance for all aquatic organisms.

Ice has nine distinct structural modifications of which ordinary ice, or ice I, has an open structure built of puckered six-membered rings in which each H_2O unit is tetrahedrally surrounded by four other H_2O units.

Because of its angular shape the water molecule has a permanent dipole moment and in addition it is strongly hydrogen bonded and has a high dielectric constant. These properties combine to make water a powerful solvent for both polar and ionic compounds. Species in solution are frequently strongly hydrated and in fact ions frequently written as, for example, Cu^{2+} are essentially $[Cu(H_2O)_6]^{2+}$. Crystalline *hydrates are also common for inorganic substances; polar organic compounds, particularly those with O–H and N–H bonds, also form hydrates.

Pure liquid water is very weakly dissociated into H_3O^+ and OH^- ions by self ionization:

$$H_2O \rightleftharpoons H^+ + OH^-$$

(*see* IONIC PRODUCT) and consequently any species that increases the concentration of the positive species, H_3O^+, is acidic and species increasing the concentration of the negative species, OH^-, are basic (*see* ACID). The phenomena of ion transport in water and the division of materials into **hydrophilic** (water loving) and **hydrophobic** (water hating) substances are central features of almost all biological chemistry. A further property of water that is of fundamental importance to the whole planet is its strong absorption in the infrared range of the spectrum and its transparency to visible and near ultraviolet radiation. This allows solar radiation to reach the earth during hours of daylight but restricts rapid heat loss at night. Thus atmospheric water prevents violent diurnal oscillations in the earth's ambient temperature. *See also* GREENHOUSE EFFECT.

water cycle *See* HYDROLOGICAL CYCLE.

water gas A mixture of carbon monoxide and hydrogen produced by passing steam over hot carbon (coke):

$$H_2O(g) + C(s) \rightarrow CO(g) + H_2(g)$$

The reaction is strongly endothermic but the reaction can be used in conjunction with that for *producer gas for making fuel gas. The main use of water gas before World War II was in producing hydrogen for the *Haber process. Here the above reaction was combined with the **water-gas shift reaction** to increase the amount of hydrogen:

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

Most hydrogen for the Haber process is now made from natural gas by steam *reforming.

water glass A viscous colloidal solution of sodium silicates in water, used to make silica gel and as a size and preservative.

water of crystallization Water present in crystalline compounds in definite proportions. Many crystalline salts form hydrates containing 1, 2, 3, or more moles of water per mole of compound, and the water may

be held in the crystal in various ways. Thus, the water molecules may simply occupy lattice positions in the crystal, or they may form bonds with the anions or the cations present. In the pentahydrate of copper sulphate ($CuSO_4.5H_2O$), for instance, each copper ion is coordinated to four water molecules through the lone pairs on the oxygen to form the *complex $[Cu(H_2O)_4]^{2+}$. Each sulphate ion has one water molecule held by hydrogen bonding. The difference between the two types of bonding is demonstrated by the fact that the pentahydrate converts to the monohydrate at 100°C and only becomes anhydrous above 250°C. **Water of constitution** is an obsolete term for water combined in a compound (as in a metal hydroxide $M(OH)_2$ regarded as a hydrated oxide $MO.H_2O$).

water potential Symbol Ψ. The difference between the chemical potential of the water in a biological system and the chemical potential of pure water at the same temperature and pressure. It is manifested as a force acting on water molecules in a solution separated from pure water by a membrane that is permeable to water molecules only. Water potential is measured in kilopascals (kPa). The water potential of pure water is zero; aqueous solutions of increasing concentration have increasingly negative values. Water tends to move from areas of high (less negative) water potential to areas of low (more negative) water potential. *Osmosis in plants is now described in terms of water potential.

water softening *See* HARDNESS OF WATER.

Watson, James Dewey (1928–) US biochemist, who moved to the Cavendish Laboratory, Cambridge, in 1951 to study the structure of *DNA. In 1953 he and Francis *Crick announced the now accepted two-stranded helical structure for the DNA molecule. In 1962 they shared the Nobel Prize for physiology or medicine with Maurice Wilkins (1916–2004), who with Rosalind Franklin (1920–58) had made X-ray diffraction studies of DNA.

Watson–Crick model The double-stranded twisted ladder-like molecular structure of *DNA as determined by James Watson and Francis Crick at Cambridge, England, in 1953. It is commonly known as the **double helix**.

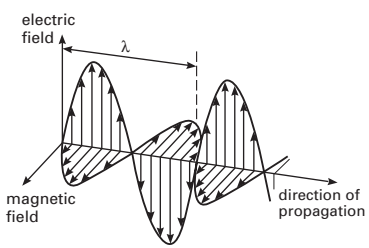
watt Symbol W. The SI unit of power, defined as a power of one joule per second. In electrical contexts it is equal to the rate of energy transformation by an electric current of one ampere flowing through a conductor the ends of which are maintained at a potential difference of one volt. The unit is named after James Watt (1736–1819).

wattmeter An instrument for measuring the power in watts in an alternating-current electric circuit. In a direct-current circuit, power is usually determined by separate measurements of the voltage and the current.

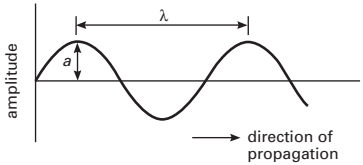
The **electrodynamic wattmeter** consists of two coils, one fixed (current) coil and one movable (potential) coil. The fixed coil carries the load current, and the movable coil carries a current proportional to the voltage applied to the measured circuit. The deflection of the needle attached to the movable coil indicates the power.

wave A periodic disturbance in a medium or in space. In a **travelling wave** (or **progressive wave**) energy is transferred from one place to another by the vibrations (*see also* STATIONARY WAVE). In a wave passing over the surface of water, for example, the water rises and falls as the wave passes but the particles of water on average do not move forward with the wave. This is called a **transverse wave** because the disturbances are at right angles to the direction of propagation. The water surface moves up and down while the waves travel across the surface of the water. Electromagnetic waves (see diagram) are also of this kind, with electric and magnetic fields varying in a periodic way at right angles to each other and to the direction of propagation. In sound waves, the air is alternately compressed and rarefied by displacements in the direction of propagation. Such waves are called **longitudinal waves**.

The chief characteristics of a wave are its



Wave. Electromagnetic waves.



Wave. Sine wave.

speed of propagation, its **frequency**, its **wavelength**, and its **amplitude**. The speed of propagation is the distance covered by the wave in unit time. The frequency is the number of complete disturbances (cycles) in unit time, usually expressed in *hertz. The wavelength is the distance in metres between successive points of equal phase in a wave. The amplitude is the maximum difference of the disturbed quantity from its mean value.

Generally, the amplitude (a) is half the peak-to-peak value. There is a simple relationship between the wavelength (λ) and the frequency (f), i.e. $\lambda = c/f$, where c is the speed of propagation. The energy transferred by a progressive *sine wave (see diagram) is proportional to a^2f^2. *See also* SIMPLE HARMONIC MOTION.

wave equation A partial differential equation of the form:

$$\nabla^2 u = (1/c^2)\partial^2 u/\partial t^2$$

where

$$\nabla^2 = \partial^2/\partial x^2 + \partial^2/\partial y^2 + \partial^2/\partial z^2$$

is the Laplace operator (*see* LAPLACE EQUATION). It represents the propagation of a wave, where u is the displacement and c the speed of propagation. *See also* SCHRÖDINGER EQUATION.

wave form The shape of a wave or the pattern representing a vibration. It can be illustrated by drawing a graph of the periodically varying quantity against distance for one complete wavelength. *See also* SINE WAVE.

wavefront A line or surface within a two- or three-dimensional medium through which waves are passing, being the locus of all adjacent points at which the disturbances are in phase. At large distances from a small source in a uniform medium, the fronts are small parts of a sphere of very large radius and they can be considered as plane. For example, sunlight reaches the earth with plane wavefronts.

wave function A function $\psi(x,y,z)$ appearing in the *Schrödinger equation in *quantum mechanics. The wave function is a mathematical expression involving the coordinates of a particle in space. If the Schrödinger equation can be solved for a particle in a given system (e.g. an electron in an atom) then, depending on the boundary conditions, the solution is a set of allowed wave functions (**eigenfunctions**) of the particle, each corresponding to an allowed energy level (**eigenvalue**). The physical significance of the wave function is that the square of its absolute value, $|\psi|^2$, at a point is proportional to the probability of finding the particle in a small element of volume, $dx dy dz$, at that point. For an electron in an atom, this gives rise to the idea of atomic and molecular *orbitals.

wave guide A hollow tube through which microwave electromagnetic radiation can be transmitted with relatively little attenuation. They often have a rectangular cross section, but some have a circular cross section. In transverse electric (TE) modes the electric vector of the field has no component in the direction of propagation. In transverse magnetic (TM) modes, the magnetic vector has no such component.

wavelength *See* WAVE.

wave mechanics A formulation of *quantum mechanics in which the dual wave–particle nature (*see* COMPLEMENTARITY) of such entities as electrons is described by the *Schrödinger equation. Schrödinger put forward this formulation of quantum mechanics in 1926 and in the same year showed that it was equivalent to *matrix mechanics. Taking into account the *de Broglie wavelength, Schrödinger postulated a wave mechanics that bears the same relation to *Newtonian mechanics as physical optics does to geometrical optics (*see* OPTICS).

wavemeter A device for measuring the wavelength of electromagnetic radiation. For frequencies up to about 100 MHz a wavemeter consists of a tuned circuit with a suitable indicator to establish when resonance occurs. Usually the tuned circuit includes a variable capacitor calibrated to read wavelengths and resonance is indicated by a current-detecting instrument. At higher frequencies a cavity-resonator in a waveguide is often used. The cavity resonator is fitted with a piston, the position of which de-

termines the resonant frequency of the cavity.

wave number Symbol *k*. The number of cycles of a wave in unit length. It is the reciprocal of the wavelength (*see* WAVE).

wave–particle duality The concept that waves carrying energy may have a corpuscular aspect and that particles may have a wave aspect; which of the two models is the more appropriate will depend on the properties the model is seeking to explain. For example, waves of electromagnetic radiation need to be visualized as particles, called *photons, to explain the *photoelectric effect while electrons need to be thought of as de Broglie waves in *electron diffraction. *See also* COMPLEMENTARITY; DE BROGLIE WAVELENGTH; LIGHT.

wave power The use of wave motion in the sea to generate energy. The technique used is to anchor a series of bobbing floats offshore; the energy of the motion of the floats is used to turn a generator. It has been estimated that there are enough suitable sites to generate over 100 GW of electricity in the UK.

wave theory *See* LIGHT.

wave-vector A quantity that simultaneously defines the magnitude of a *wave and its direction. The magnitude is equal to $2\pi/\lambda$, where λ is the wavelength, or $2\pi k$, where k is the *wave number.

wax Any of various solid or semisolid substances. There are two main types. Mineral waxes are mixtures of hydrocarbons with high molecular weights. Paraffin wax, obtained from *petroleum, is an example. Waxes secreted by plants or animals are mainly esters of fatty acids and usually have a protective function. Examples are the beeswax forming part of a honeycomb and the wax coating on some leaves, fruits, and seed coats, which acts as a protective water-impermeable layer supplementing the functions of the cuticle. The seeds of a few plants contain wax as a food reserve.

W boson (W particle) Either of a pair of elementary particles (W^+ or W^-), classified as **intermediate vector bosons**, that are believed to transmit the weak interaction (*see* FUNDAMENTAL INTERACTIONS) in much the same way as photons transmit the electromagnetic interaction. They are not, however, massless like photons, and are believed to have a rest mass of the order of 10^{-25} kg (80.4 GeV). W bosons were discovered at CERN in 1983 with the expected mass. *See also* Z BOSON.

weak acid An *acid that is only partially dissociated in aqueous solution.

weak interaction *See* FUNDAMENTAL INTERACTIONS.

weakly interacting massive particle (WIMP) *See* MISSING MASS.

weather The state of atmospheric conditions, including humidity, precipitation (e.g. rain, snow, hail), temperature, pressure, cloud cover, visibility, and wind, at any one place and time. A **weather forecast** is a prediction of the weather conditions to be expected at a particular place over a given period. These may be short-range (1–2 days), medium-range (5–7 days), or long-range (1 month or a season). The two chief methods employed in obtaining short-range and medium-range forecasts are **synoptic forecasting** and **numerical forecasting**. Synoptic forecasting involves the simultaneous observation of weather elements at a series of weather stations, the collection of data, and the plotting of the information obtained on synoptic charts (weather maps), from which forecasts can be made. Since the early 1960s data collected by satellites, such as pictures of cloud cover and infrared measurements, have been increasingly used in forecasting. Numerical forecasting involves the numerical solution of equations governing the motions and changes of atmospheric conditions. Computers are used to carry out the vast number of calculations. Both synoptic and numerical methods are unsuitable for long-range forecasts and instead statistical and analogue methods are used.

weathering The process of breakdown and alteration of rocks on the earth's surface by mechanical or chemical processes. Mechanical (physical) weathering includes the splitting of rocks through the action of frost and extreme temperature changes. Chemical weathering includes solution (the dissolving of solid materials by water); carbonation (the dissolving of soluble rocks and minerals by a weak carbonic acid formed by the combination of water with atmospheric carbon dioxide); oxidation (the combination of atmospheric oxygen with rock materials); and hydration (the chemical combination of rock materials with water). Organic weathering,

which may involve both chemical and mechanical processes, is caused by plants and animals. For example, burrowing animals and plant roots may physically break up rocks; lichens, which can exist on bare rock surfaces, cause decomposition through the removal of nutrients.

Web *See* WORLD WIDE WEB.

weber Symbol Wb. The SI unit of magnetic flux equal to the flux that, linking a circuit of one turn, produces in it an e.m.f. of one volt as it is reduced to zero at a uniform rate in one second. It is named after Wilhelm Weber.

Weber, Wilhelm Eduard (1804–91) German physicist, who became a professor at Göttingen. In 1833 he and Karl *Gauss built an electric telegraph between their laboratories. In 1843 Weber moved to Leipzig, where his main work was to develop a system of self-consistent elecrical units (as Gauss had already done for magnetism). Both systems were adopted in 1881. The SI unit of magnetic flux is named after him.

web log *See* BLOG.

weed *See* PEST.

Wegener, Alfred Lothar (1880–1930) German geologist and meteorologist, who became a professor at the University of Graz in 1924. He is best known for his theory of *continental drift, which he formulated in 1915.

weight The force by which a body is attracted to the earth. *See also* MASS.

weightlessness A condition of a body when it is an infinite distance from any other body. In practice the appearance of weightlessness occurs in space when the gravitational attraction of the earth on a body in space is equal to the centripetal force required by its orbital motion so that the body is effectively in free fall. Weightlessness can also be simulated for short periods in an aircraft flying a parabolic flight path, so that its occupants are again in free fall.

Weinberg–Salam model (WS model) *See* ELECTROWEAK THEORY.

Weismannism The theory of the **continuity of the germ plasm** published by August Weismann (1834–1914) in 1886. It proposes that the contents of the reproductive cells (sperms and ova) are passed on unchanged from one generation to the next, unaffected by any changes undergone by the rest of the body. It thus rules out any possibility of the inheritance of acquired characteristics, and has become fundamental to neo-Darwinian theory.

Western blotting (protein blotting) An *immunoassay for determining very small amounts of a particular protein in tissue samples or cells. The sample is subjected to electrophoresis on SDS-polyacrylamide gel to separate constituent proteins. The resultant protein bands are then 'blotted' onto a polymer sheet. A radiolabelled or fluorescently labelled antibody specific for the target protein is added; this binds to the protein, which can then be detected by autoradiography or a fluorescence detector. A variation of this technique is used to screen bacterial colonies containing cDNA clones in order to isolate those colonies expressing a particular protein. The name is derived by analogy to that of *Southern blotting.

Weston cell (cadmium cell) A type of primary *voltaic cell, which is used as a standard; it produces a constant e.m.f. of 1.0186 volts at 20°C. The cell is usually made in an H-shaped glass vessel with a mercury anode covered with a paste of cadmium sulphate and mercury(I) sulphate in one leg and a cadmium amalgam cathode covered with cadmium sulphate in the other leg. The electrolyte, which connects the two electrodes by means of the bar of the H, is a saturated solution of cadmium sulphate. In some cells sulphuric acid is added to prevent the hydrolysis of mercury sulphate. It is named after Edward Weston (1850–1936).

wet-and-dry bulb hygrometer *See* HYGROMETER.

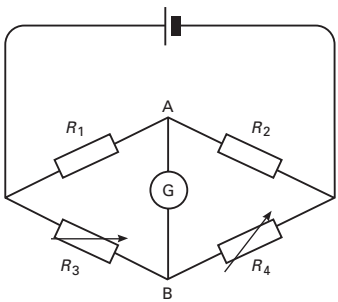
whalebone (baleen) Transverse horny plates hanging down from the upper jaw on each side of the mouth of the toothless whales (*see* CETACEA), forming a sieve. Water, containing plankton on which the whale feeds, enters the open mouth and is then expelled with the mouth slightly closed, so that food is retained on the baleen plates.

whales *See* CETACEA.

Wheatstone, Sir Charles (1802–75) British physicist, who set up as a musical instrument-maker in London. He studied acoustics and optics, inventing a stereoscope in 1838. His most important work, done with William Cooke (1806–79), was the development of an electric telegraph, which they

achieved in 1837. He gave his name to the *Wheatstone bridge, although he did not invent it.

Wheatstone bridge An electrical circuit for measuring the value of a resistance. In the illustration, R_1 is a resistance of unknown value, R_2 is a fixed resistance of known value, R_3 and R_4 are variable resistances with known values. When no current flows between A and B the bridge is said to be balanced, the galvanometer registers no deflection, and $R_1/R_2 = R_3/R_4$. R_1 can therefore be calculated. The Wheatstone bridge is used in various forms. In the **metre bridge**, a wire 1 metre long of uniform resistance is attached to the top of a board alongside a metre rule. A sliding contact is run along the wire, which corresponds to R_3 and R_4, until the galvanometer registers zero. Most practical forms use one or more rotary rheostats to provide the variation. The device was popularized though not invented by Sir Charles Wheatstone.



Wheatstone bridge.

whey *See* CURD.

white arsenic *See* ARSENIC(III) OXIDE.

white blood cell *See* LEUCOCYTE.

white dwarf A compact stellar object that is supported against collapse under self-gravity by the *degeneracy pressure of electrons. White dwarfs are formed as the end products of the evolution of stars of relatively low mass (about that of the sun); high-mass stars may end up as *neutron stars or *black holes (*see* STELLAR EVOLUTION). White dwarfs consist of helium nuclei (and carbon and oxygen nuclei in the more massive cases) and a *degenerate gas of electrons. A typical white-dwarf density is 10^9 kg m^{-3}; white dwarf masses and radii are in the region of 0.7 solar masses and 10^3 km respectively. There is a maximum mass for white dwarfs, above which they are unstable to gravitational collapse – this is known as the *Chandrasekhar limit and is about 1.4 solar masses.

white hole *See* WORMHOLE.

white matter Part of the tissue that makes up the central nervous system of vertebrates. It consists chiefly of nerve fibres enclosed in whitish *myelin sheaths. *Compare* GREY MATTER.

white mica *See* MUSCOVITE.

white spirit A liquid mixture of petroleum hydrocarbons used as a solvent for paint ('turpentine substitute').

Wiedemann–Franz law The ratio of the thermal conductivity of any pure metal to its electrical conductivity is approximately constant at a given temperature. The law is fairly well obeyed, except at low temperatures. The law is named after Gustav Wiedemann and Rudolph Franz, who discovered it empirically in 1853.

Wien formula *See* PLANCK'S RADIATION LAW.

Wien's displacement law For a *black body, $\lambda_m T$ = constant, where λ_m is the wavelength corresponding to the maximum radiation of energy and T is the thermodynamic temperature of the body. Thus as the temperature rises the maximum of the spectral energy distribution curve is displaced towards the short-wavelength end of the spectrum. The law was stated by Wilhelm Wien (1864–1928).

Wigner energy Energy stored in a crystalline substance as a result of irradiation. This phenomenon is known as the **Wigner effect**. For example, some of the energy lost by neutrons in a *nuclear reactor is stored by the graphite moderator. As a result, the crystal lattice is changed and there is a consequent change in the physical dimensions of the moderator. It is named after Eugene Wigner (1902–95).

Wigner nuclides Pairs of isobars with odd nucleon numbers in which the atomic number and the neutron number differ by one. ^{3}H and ^{3}He are examples.

Wigner's friend *See* SCHRÖDINGER'S CAT.

wiki A web site whose content can be changed and extended by users via their web browsers. The term is also used for web applications that facilitate this. Wikis are a useful technique for rapidly assembling and disseminating 'collective wisdom' ('wiki wiki' is Hawaiian for 'fast' or 'quick'). They have become popular on many levels, ranging from small private wikis through internal departmental or corporate wikis to such popular web sites as Wikipedia. Their major problem, for which they have been criticized, is the possibility of inappropriate or malicious changes. All wikis maintain lists of recent changes to and often a complete history of each web page, to aid the 'user community' in discovering and reverting unwanted changes. Often each web page has an associated discussion page where the merits of existing and potential changes can be debated. However, such self-policing has been found inadequate for highly exposed web sites with their large but unknown user base. These impose additional security measures: finely graded levels of trust that control the extent to which a user can make alterations; programmatic techniques that seek to identify suspicious changes; etc.

wild type Describing the form of an *allele possessed by most members of a population in their natural environment. Wild-type alleles are usually *dominant.

Wilkins, Maurice *See* CRICK, FRANCIS HARRY COMPTON.

Williamson's synthesis Either of two methods of producing ethers, both named after the British chemist Alexander Williamson (1824–1904). **1.** The dehydration of alcohols using concentrated sulphuric acid. The overall reaction can be written

$$2ROH \rightarrow H_2O + ROR$$

The method is used for making ethoxyethane ($C_2H_5OC_2H_5$) from ethanol by heating at 140°C with excess of alcohol (excess acid at 170°C gives ethene). Although the steps in the reaction are all reversible, the ether is distilled off so the reaction can proceed to completion. This is **Williamson's continuous process**. In general, there are two possible mechanisms for this synthesis. In the first (favoured by primary alcohols), an alkylhydrogen sulphate is formed

$$ROH + H_2SO_4 \rightleftharpoons ROSO_3H + H_2O$$

This reacts with another alcohol molecule to give an oxonium ion

$$ROH + ROSO_3H \rightarrow ROHR^+$$

This loses a proton to give ROR.

The second mechanism (favoured by tertiary alcohols) is formation of a carbonium ion

$$ROH + H^+ \rightarrow H_2O + R^+$$

This is attacked by the lone pair on the other alcohol molecule

$$R^+ + ROH \rightarrow ROHR^+$$

and the oxonium ion formed again gives the product by loss of a proton.

The method can be used for making symmetric ethers (i.e. having both R groups the same). It can successfully be used for mixed ethers only when one alcohol is primary and the other tertiary (otherwise a mixture of the three possible products results).

2. A method of preparing ethers by reacting a haloalkane with an alkoxide. The reaction, discovered in 1850, is a nucleophilic substitution in which the negative alkoxide ion displaces a halide ion; for example:

$$RI + {}^-OR' \rightarrow ROR' + I^-$$

A mixture of the reagents is refluxed in ethanol. The method is particularly useful for preparing mixed ethers, although a possible side reaction under some conditions is an elimination to give an alcohol and an alkene.

Wilson, Charles Thomson Rees (1869–1959) British physicist, born in Scotland, who studied physics with J. J. *Thomson in Cambridge. His best-known achievement was the development of the *cloud chamber in 1911, for which he was awarded the 1927 Nobel Prize for physics.

Wilson cloud chamber *See* CLOUD CHAMBER.

wilting The condition that arises in plants when more water is lost by evaporation than is absorbed from the soil. This causes the cells to lose their *turgor and the plant structure droops. Plants can normally recover from wilting if water is added to the soil, but permanent wilting and possible death can result if the plant does not have access to water for a long period of time. In certain plants wilting is important as a mechanism to avoid overheating: when the leaves droop they are taken out of direct contact with the sun's rays. When the sun sets the plant can begin to transpire at the normal rate and the cells of the leaves regain their turgor.

WIMP Weakly interacting massive particle. *See* MISSING MASS.

Wimshurst machine A laboratory electrostatic generator. It consists of two insulating discs to which radial strips of metal foil are attached. After a few strips have been charged individually, the discs are rotated in opposite directions and the charge produced on the strips by induction is collected by metal combs or brushes. It was invented by James Wimshurst (1836–1903).

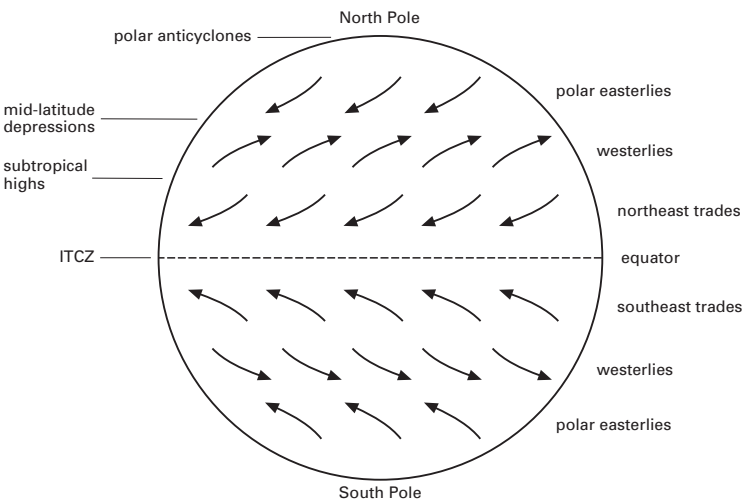
wind The motion (usually horizontal) of air relative to the earth's surface. The **general circulation of the atmosphere** – the large-scale patterns of wind and pressure that persist throughout the year or recur seasonally – results largely from differences in the net radiation received at the earth's surface. However, it is modified by the rotation of the earth, the presence of mountain barriers, the relative distribution of land and sea, and the positions of the ocean currents. Although the resulting wind circulation patterns are complex, they can be simplified into a series of belts (see illustration). Surface heating, which is at its greatest along the equator, creates a belt of low pressure – the intertropical convergence zone (ITCZ) – towards which the airstreams of the northern and southern hemispheres converge. On either side of the ITCZ lie the trade wind belts: the northeast trade winds in the northern hemisphere and the southeast trade winds of the southern hemisphere. The trade winds are separated from the westerlies – the predominant winds in the mid-latitudes of both hemispheres – by the subtropical high-pressure belt (the horse latitudes), which lies between about 30° and 35° latitude. Near to the poles are the polar easterlies, separated from the westerlies by the subpolar low-pressure troughs.

window **1.** A band of electromagnetic wavelengths that is able to pass through a particular medium with little reflection or absorption. For example, there is a **radio window** in the atmosphere allowing radio waves of wavelengths 5 mm to 30 m to pass through. This radio window enables *radio telescopes to be used on the surface of the earth. **2.** A period of time during which an event may occur in order to achieve a desired result. For example a **launch window** is the period during which a space vehicle must be launched to achieve a planned encounter.

windpipe *See* TRACHEA.

wind pollination *See* ANEMOPHILY.

wind power The use of winds in the



Wind. Global surface wind and pressure systems.

earth's atmosphere to drive machinery, especially to drive an electrical generator. Practical land-based **wind generators** (**aerogenerators**) are probably capable of providing some 10^{20} J (10^{14} kW h) of energy per year throughout the world and interest in this form of renewable energy is increasing. The power, P, available to drive a wind generator is given by $P = kd^2v^3$, where k is the air density, d is the diameter of the blades, and v is the average wind speed. Wind farms now exist in many parts of the world; California, for example, has the capacity to produce over 1200 MW from wind energy.

wing *See* FLIGHT.

wino *See* SUPERSYMMETRY.

wireless access point *See* ACCESS POINT.

withdrawal reflex *See* REFLEX.

witherite A mineral form of *barium carbonate, $BaCO_3$.

WMAP (Wilkinson Microwave Anisotropy Probe) A satellite launched in 2001 to investigate the *microwave background radiation. In 2003 a full-sky picture was obtained of the early universe (380 000 years after the big bang) showing temperature fluctuations at high resolution. The results supported the big-bang and inflation theories, and gave an age for the universe of 13.7×10^9 years. WMAP is named in honour of the US cosmologist and WMAP team member David Todd Wilkinson (1935–2002).

SEE WEB LINKS

- The NASA site for WMAP

Wöhler, Friedrich (1800–82) German physician and chemist, who became a professor of chemistry at Göttingen. In 1828 he made his best-known discovery, the synthesis of urea (an organic compound) from ammonium cyanate (an inorganic salt): *see* WÖHLER'S SYNTHESIS. This finally disproved the assertion that organic substances can be formed only in living things. Wöhler also isolated *aluminium (1827), *beryllium (1828), and *yttrium (1828).

Wöhler's synthesis A synthesis of urea performed by Friedrich Wöhler in 1828. He discovered that urea ($CO(NH_2)_2$) was formed when a solution of ammonium isocyanate (NH_4NCO) was evaporated. At the time it was believed that organic substances such as urea could be made only by living organisms, and its production from an inorganic compound was a notable discovery. It is sometimes (erroneously) cited as ending the belief in vitalism.

wolfram *See* TUNGSTEN.

wolframite (iron manganese tungsten) A mineral consisting of a mixed iron–manganese tungstate, $(FeMn)WO_4$, crystallizing in the monoclinic system; the principal ore of tungsten. It commonly occurs as blackish or brownish tabular crystal groups. It is found chiefly in quartz veins associated with granitic rocks. China is the major producer of wolframite.

Wolf–Rayet star An extremely hot bright type of star, often found inside a developing planetary nebula. Strong stellar winds give rise to a large loss of mass, which takes the form of a cloud of gas surrounding the star. As a result, its spectrum contains emission lines caused because the starlight has to pass through this gas. They were discovered in 1867 by C. J. E. Wolf (1827–1918) and G. A. P. Rayet (1839–1906).

Wollaston prism A type of quartz prism for producing plane-polarized light. It deviates the ordinary and extraordinary rays in opposite directions by approximately the same amount. The Wollaston prism, like the *Rochon prism, can be used with ultraviolet radiation. It is named after the inventor William Wollaston (1766–1828).

womb *See* UTERUS.

wood The hard structural and water-conducting tissue that is found in many perennial plants and forms the bulk of trees and shrubs. It is composed of secondary *xylem and associated cells, such as fibres. The wood of angiosperms is termed **hardwood**, e.g. oak and mahogany, and that of gymnosperms **softwood**, e.g. pine and fir. New wood is added to the outside of the old wood each growing season by divisions of the vascular cambium (*see* GROWTH RING). Only the outermost new wood (*sapwood) functions in water conduction; the inner wood (*heartwood) provides only structural support.

wood alcohol *See* METHANOL.

Wood's metal A low-melting (71°C) alloy of bismuth (50%), lead (25%), tin (12.5%), and cadmium (12.5%). It is used for fusible links in automatic sprinkler systems. The melting point can be changed by varying the

composition. It is named after William Wood (1671–1730).

Woodward–Hoffmann rules Rules governing the formation of products during certain types of organic concerted reactions. The theory of such reactions was put forward in 1969 by the American chemists Robert Burns Woodward (1917–79) and Roald Hoffmann (1937–), and is concerned with the way that orbitals of the reactants change continuously into orbitals of the products during reaction and with conservation of orbital symmetry during this process. *See also* FRONTIER-ORBITAL THEORY.

woofer A large loudspeaker designed to reproduce sounds of relatively low frequency, in conjunction with a *tweeter and often a mid-range speaker, in a high-fidelity sound reproducing system.

word A number of *bits, often 32, 48, or 64, processed by a computer as a single unit.

work The work done by a force acting on a body is the product of the force and the distance moved by its point of application in the direction of the force. If a force F acts in such a way that the displacement s is in a direction that makes an angle θ with the direction of the force, the work done is given by: $W = F s\cos\theta$. Work is the scalar product of the force and displacement vectors. It is measured in joules.

work function A quantity that determines the extent to which *thermionic or photoelectric emission will occur according to the Richardson equation or Einstein's photoelectric equation (*see* EINSTEIN EQUATION). It is sometimes expressed as a potential difference (symbol ϕ) in volts and sometimes as the energy required to remove an electron (symbol W) in electronvolts or joules. The former has been called the **work function potential** and the latter the **work function energy**.

SEE WEB LINKS

- Values given on Carl Nave's HyperPhysics site at Georgia State University

work hardening An increase in the hardness of metals as a result of working them cold. It causes a permanent distortion of the crystal structure and is particularly apparent with iron, copper, aluminium, etc., whereas with lead and zinc it does not occur as these metals are capable of recrystallizing at room temperature.

World Wide Web (WWW; Web) A computer-based information service developed at CERN in the early 1990s. It is a hypermedia system (*see* HYPERTEXT) distributed over a large number of computer sites that allows users to view and retrieve information from 'documents' contining 'links'. It is accessed by a computer connected to the *Internet that is running a suitable program.

Web documents may consist of textual material or a number of other forms, such as graphics, still or moving images, or audio clips. Within a document there will be material to be displayed and usually one or more links, which in a text document appear as highlighted words or phrases, or as icons. The links 'point' to other documents located elsewhere on the Web by means of a **URL** (universal resource locator), which contains information specifying, for example, the network address of the device holding the document and the local index entry for that document. Activating a link will result in the display of the requested document.

wormhole A theoretical structure in space–time bridging two universes. Early calculations on the physics of black holes indicated that such structures might exist as a result of extreme distortion of space–time. Matter falling into a black hole in one universe could then appear pouring out of a **white hole** in another universe. It is now thought that such links do not occur and that white holes, which spontaneously generate matter, do not exist.

W particle *See* W BOSON.

wrought iron A highly refined form of iron containing 1–3% of slag (mostly iron silicate), which is evenly distributed throughout the material in threads and fibres so that the product has a fibrous structure quite dissimilar to that of crystalline cast iron. Wrought iron rusts less readily than other forms of metallic iron and it welds and works more easily. It is used for chains, hooks, tubes, etc.

WS model Weinberg–Salam model. *See* ELECTROWEAK THEORY.

wurtzite structure A type of ionic crystal structure in which the anions have a hexagonal close packed arrangement with the cations occupying one type of tetrahedral hole. Each type of ion has a coordination number of 4. Examples of this structure are found in ZnS, ZnO, AlN, SiC, and NH_4F.

SEE WEB LINKS

- An interactive version of the structure

Wurtz reaction A reaction to prepare alkanes by reacting a haloalkane with sodium:

$$2RX + 2Na \rightarrow 2NaX + RR$$

The haloalkane is refluxed with sodium in dry ether. The method is named after the French chemist Charles-Adolphe Wurtz (1817–84). The analogous reaction using a haloalkane and a haloarene, for example:

$$C_6H_5Cl + CH_3Cl + 2Na \rightarrow 2NaCl + C_6H_5CH_3$$

is called the **Fittig reaction** after the German chemist Rudolph Fittig (1835–1910).

WWW *See* World Wide Web.