

# Glossary

**absorption:** dissolution of a vapor phase into a liquid phase.

**activation energy:** minimum energy that must be provided to reactants for a chemical reaction to occur.

**adiabatic:** refers to transformations occurring with no exchange of heat with the outside environment.

**adsorption:** surface retention of a vapor phase on a solid medium. Increased concentration of gas molecules on the surface of the solid, relative to the total amount of gas.

**alkaline (metals):** metals belonging to group I in the periodic classification of elements (lithium, sodium, potassium, rubidium, cesium, and francium).

**alkaline-earth (metals):** metals belonging to group IIA in the periodic classification of elements (beryllium, magnesium, calcium, strontium, barium, and radium).

**allothermal:** using heat provided by an outside source (opposite of **autothermal**).

**anaerobic:** developing or functioning in the complete absence of oxygen.

**angstrom:** unit of length (symbol: Å) equal to  $10^{-10}$  meter.

**anion:** negative **ion**.

**anisotropic:** exhibiting different properties according to direction.

**anode:** the name applied (improperly) to the negative **electrode** of a cell in a battery or stack, in particular in a fuel cell. *Positive* terminal of an **electrolysis** cell or of a photovoltaic cell.

**APU:** Auxiliary Power Unit.

**bacterium:** living microorganism, usually unicellular, featuring no distinct nucleus, breeding rapidly, and measuring less than a few **micrometers**.

**bar:** unit of pressure (1 bar =  $10^5$  **pascals** [the legal unit, symbol Pa], 1 **atmosphere** being equal to 101,325 Pa).

**biofuels: fuels** obtained from vegetable materials (starch crops such as cereals [wheat, corn] and potatoes, sugar crops [beet, Jerusalem artichoke], oil crops [rape, sunflower], soy beans, etc.). The two main categories are, on the one hand, *alcohols* and *ethers* (to be mixed with gasoline), in particular **ethanol** (beet **bioethanol**) and its derivative, ethyl tertiary butyl ether (**ETBE**), **methanol**, and methyl ethers; and, on the other hand, *oils* and their *esters* (rape methyl ester, or biodiesel, a fuel oil equivalent).

**biogas:** gas obtained from decomposition of organic materials.

**biomass:** the mass of living matter, whether vegetable (to a proportion of over 99%) or animal, present on the face of the Earth.

**biomimetic:** refers to a compound, or a process, made by analogy to a biological substance or process.

**biosphere:** the ensemble of ecosystems on the planet, comprising all living beings and the environments in which they live.

**butane: hydrocarbon** of the alkane or paraffin family, of formula  $C_4H_{10}$ . One of the gases used as liquefied petroleum gas (**LPG**). **Isobutane** has the formula:  $(CH_3)_2(CH-CH_3)$ .

**capillary (effects):** forces arising on the surface of a liquid, and influencing the shape of its boundary with the ambient environment, this being the more pronounced as dimensions get smaller.

**Carnot efficiency:** thermodynamic efficiency of an ideal machine, for which the cycle corresponds to a process where an ideal gas is held in a cylinder with insulated walls, closed by a piston placed between a hot and a cold source. This ideal cycle, comprising two expansion and two compression phases, all isothermal and **adiabatic**, is used as a reference for real cycles.

**catalysis:** a process involving a substance (the **catalyst**) having the ability to accelerate a chemical reaction without itself being altered, or only temporarily so.

**cathode:** the name applied (improperly) to the positive **electrode** of a cell in a battery or stack, in particular in a fuel cell. *Negative* terminal of an **electrolysis** cell or of a photovoltaic cell.

**cation:** positive **ion**.

**ceramic:** inorganic, nonmetallic material featuring a crystalline structure exhibiting a regular, periodic atomic arrangement, and, in some cases, **ionic** or **covalent** bonds.

**cermet: ceramic** material included in a metallic matrix.

**charge carriers: conduction electrons;** electric current is the displacement of charge carriers. In photovoltaics, **photon**-generated electrons and holes.

**chemical hydride:** a compound allowing nonreversible storage of **hydrogen**, and its release under the effect of a chemical reactant providing an additional supply of hydrogen, such as water, ammonia or alcohol.

## Energy units and conversions

### Main units of energy:

**joule:** 1 **J** =  $2.778 \cdot 10^{-7}$  kilowatt-hour or  $2.389 \cdot 10^{-7}$  thermie. Among multiples: the **megajoule** (1 **MJ** =  $10^6$  J) and the **gigajoule** (1 **GJ** =  $10^9$  J).

**thermie:** 1 **th** = 1.163 kilowatt-hour or  $4.186 \cdot 10^6$  joules

**British thermal unit:** 1 **Btu** =  $2.93 \cdot 10^{-4}$  kilowatt-hour or  $1.055 \cdot 10^3$  joules

**kilowatt-hour:** 1 **kWh** = 3.6 million joules. Main multiple of the **watt-hour (Wh)**, a unit of work and energy, the product of power by time. Other multiples: the **megawatt-hour** (1 **MWh** =  $10^6$  Wh), the **gigawatt-hour** (1 **GWh** =  $10^9$  Wh) and the **terawatt-hour** (1 **TWh** =  $10^{12}$  Wh)

**calorie:** 1 **Cal** =  $10^{-6}$  th

**electronvolt (eV):** unit of energy equal to  $1.6 \cdot 10^{-19}$  joule. This is the energy acquired by an **electron** accelerated by a potential difference of 1 volt.

### Main units of power:

**watt:** unit of power (**W**) corresponding to consumption of 1 joule per second; **MWe** = "electrical" **megawatt** (electrical power, as opposed to thermal).

Main multiples: the **kilowatt** (1 **kW** =  $10^3$  W), the megawatt (1 **MW** =  $10^6$  W), the **gigawatt** (1 **GW** =  $10^9$  W) and the **terawatt** (1 **TW** =  $10^{12}$  W).

**horsepower:** 1 **hp** = 745.7 watts

**metric horsepower:** 1 **ch** = 735.5 watts

### Other units:

**lge:** liter gasoline equivalent

**toe:** tonne oil equivalent (1 **toe** = 42 billion joules or 11,630 kWh). Multiples: **Mtoe** (million tonnes oil equivalent); **Gtoe** (billion tonnes oil equivalent)



# Glossary

**chlorophyll:** light-absorbing pigment that plays an essential role in **photosynthesis**.

**CO<sub>2</sub>, carbon dioxide or carbon gas:** gas produced during combustion of organic materials, responsible for part of the greenhouse effect.

**cogeneration or combined heat and power (CHP) generation:** simultaneous production of electricity and heat.

**cold isostatic compression:** cold compression process for metal and **ceramic** powders, used for series production of components. This is followed by **sintering**, which gives the part its mechanical cohesion.

**combined heat and power (CHP) generation:** see **cogeneration**.

**compartment:** in a living organism or an ecosystem, a biological space, of virtual character but measurable volume, occupied in homogeneous fashion (concentration) by a substance or molecular population of given behavior and physical-chemical form.

**composite:** a material formed by assembly of a number of materials, exhibiting properties the latter do not have in isolation. It may for instance comprise a skeleton (*reinforcement*) withstanding mechanical stress, and a coating material (*matrix*), as a rule a plastic material.

**conductivity:** characterizes the capacity for (heat, or electric) **conduction** of a substance. **Electric conductivity** is measured in **siemens** per unit length.

**conjugated polymer:** a **polymer** chain characterized by an alternation of saturated and unsaturated carbon-carbon bonds, leading to the presence of nonlocalized **electrons** (pi electrons).

**convection:** the ensemble of motions generated inside a fluid mass owing to differences in density and temperature at various points in this mass, contributing to heat transport. **Natural convection** is the automatic transfer of heat through such circulation.

**conversion efficiency (of a fuel cell):** the ratio between the energy supplied by the **fuel** and the energy recovered in the form of electric energy. The energy not converted into electric energy is released in the form of heat, and rejected in the form of hot water or steam.

**conversion efficiency (of a photovoltaic cell):** the ratio of maximum **electric power** output, over the product of generator area by measured incident irradiation.

**covalent:** participating in the chemical bond between two atoms through shared **electrons**.

**covalent bond:** a bond set up when two atoms, in order to saturate their outermost orbital, share one or more **electron** pairs. As a rule, covalent bonds are the strongest and most stable ones.

**cracking:** **hydrocarbon** refining process, through modification of the molecular structure under the effects of heat, pressure, and, in some cases, of a **catalyst**.

**cryogenic:** literally, "cold-generating;" more broadly: "relating to low temperatures" (cryogenic liquids have boiling points below -150 °C).

**CTL (coal to liquid):** transformation of coal into a liquid **fuel**.

**current (power) density:** in a fuel cell, current (power) delivered per electrode unit area (measured in A/cm<sup>2</sup> [W/cm<sup>2</sup>]).

**CVD (chemical vapor deposition):** thin film fabrication method, through deposition of a vapor phase formed by chemical reaction from a gaseous medium of different composition.

**cyanobacterium (from Greek *kyanos*, dark blue):** **bacterium** having the ability to use light energy in the same manner as plants.

**cycling:** alternation of charge and discharge.

**deflagration:** rapid combustion; the typical case being a gas or gas-line explosion. The oxygen is drawn from the atmosphere, the "explosive material" only providing the carbon and **hydrogen** (not to be confused with **detonation**).

**desorption:** motion of gas molecules away from the surface of a solid, thus resulting in a decreased concentration of gas molecules on the surface, relative to total gas concentration. A reversible process, comparable to evaporating water vapor condensation on a cold surface.

**detonation:** the outcome of an extremely rapid chemical reaction, accompanied by propagation of a shock wave, i.e. a very rapid, very intense variation in pressure (not to be confused with **deflagration**).

**distillation:** operation consisting in partial vaporization of a mixture in the liquid state, followed by selective condensation of the vapors, to achieve separation of the constituents.

**DME (dimethyl ether): hydrocarbon** of formula CH<sub>3</sub>-O-CH<sub>3</sub>, exhibiting physical properties intermediate between those of **butane** and **propane**, available in liquid form at 20 °C, at a pressure of 5.3 **bars**.

**doping agent:** an extraneous atom introduced into a crystal lattice, to alter its properties. For instance, a **semiconductor** will be doped to effect a modification of its electrical properties, through the presence of a *discrete permitted* energy level within the **band gap**, close to the **valence band** or the **conduction band**. The atom introduced thus releases a mobile **electron** or hole to one or the other of the permitted bands, increasing the material's **electric conductivity**.

**efficiency (of a fuel cell):** the ratio of cell **electric power** output, over the heating value of the **hydrogen** injected, not taking into account consumption by auxiliary systems.

**electric power:** the product of output voltage by the intensity of the current delivered.

**electrode:** conducting element fulfilling the functions of **electron** or **ion** emission, capture, or control, by means of an electric field (differentiated into **anode** and **cathode**).

**electrolysis:** displacement of **ions**, under the influence of a potential difference, towards **electrodes**, resulting in a deposit or gaseous discharge at the electrodes of the **oxidized** or **reduced** species.

**electrolyte:** liquid or solid medium enabling **ion conduction**.

**electromotive force:** voltage or potential difference between two points, having the ability to set a current in motion inside a circuit.

**electron:** negatively-charged elementary particle.

**electron conductivity:** see **ion, electron, or proton conductivity**.

**electron or ion conduction:** process whereby an **electron** or an **ion** moves through a material.

**electron-hole pair:** a pair of **carriers**, not bound to an atom, and thus able to move through the entire crystal in which they were formed, one of which is negative (**electron** in the **conduction band**), the other positive (absence of an electron in the **valence band**).

**electronic band gap, direct or indirect:** a **semiconductor** has an **electronic band** structure, i.e. featuring ranges of energies available to **electrons** in matter, linked to the periodic character of the atomic arrangement inside the crystal, and the wave character of electrons. The forbidden band (band gap) occurs between a permitted, filled (or nearly filled, at nonzero temperatures) band, the **valence band**, and an unfilled, empty or nearly empty, band, the **conduction band**. Photons with energy greater than the band gap generate **charge carriers** through electron transitions from one permitted band to the other. The band gap may be crossed with

emission of *phonons* (lattice vibration quanta) – one then speaks of **indirect** band gap (this being the case of **silicon**) – or with no such emission (**direct** band gap).

**electrostatic**: only involving Coulomb attraction or repulsion forces. Based on nonmoving electric charges (constant electric field).

**endothermic/exothermic**: involving heat absorption/release of heat.

**enthalpy**: a function defined by the sum of the internal energy of a system and the product of that system's volume by the pressure exerted on it.

**entropy (reaction entropy)**: a function of state serving as a measure of the disorder of a system.

**enzyme**: substance having the nature of a protein, which activates a biochemical reaction by **catalyzing** it.

**ETBE (ethyl tertiary butyl ether)**: an additive for heat engines (whether gasoline or diesel burning) obtained through transformation of **ethanol** of agricultural provenance.

**ethanol**: an alcohol (C<sub>2</sub>H<sub>5</sub>OH) derived from the gaseous **hydrocarbon** ethane (C<sub>2</sub>H<sub>6</sub>), or obtained from feedstock of agricultural origin (**bioethanol**).

**extrusion**: transformation process, used in particular for plastic materials, consisting in continuous forcing of a heat-softened material through a *die*, which gives its shape to the extruded section.

**fluidized bed**: a technique whereby a rising fluid current balances the apparent weight of the particles of a powdered substance, which then flows like a fluid.

**formulation**: the determination of the composition of a chemical substance.

**fossil**: applies to **fuels** originating inside the Earth, as coal, oil and **natural gas**, and to energies obtained from such fuels.

**fuel**: a substance combustion of which, i.e. its reaction with an **oxidizer** (commonly oxygen), yields usable energy.

**graphite**: crystalline form of almost pure carbon, featuring a sheet structure in which each atom is bound to three of its neighbors.

**greenhouse gas (GHG)**: a gas whose presence in the atmosphere tends to augment the natural greenhouse effect, the main such gases being **carbon dioxide** (CO<sub>2</sub>), water vapor, **methane**, and chlorofluorocarbons (the latter moreover impairing the Earth's **ozone** layer).

**GTL (gas to liquids)**: this pathway allows conversion of **natural gas** into liquid "petroleum" products, in particular diesel **fuel**.

**heat conduction**: the process whereby, in a medium, heat flows from a high-temperature region to another, lower-temperature, region, or from one medium to another coming into contact with it. Measured in W/m/K.

**high-pressure (storage)**: at a pressure much higher than atmospheric pressure.

**HTR**: high-temperature nuclear reactor.

**hybrid (vehicle)**: a vehicle combining two modes of energy generation. The currently favored formula combines an internal-combustion engine and a battery powering an electric traction system; the former, running at a constant rating, and thus at optimum efficiency, recharges the battery, which absorbs current peaks and recovers braking energy.

**hydrocarbon**: a molecule comprising solely carbon and **hydrogen** atoms.

**hydrocarbon fuel**: a **fuel** consisting in hydrocarbons.

**hydrogen**: the simplest atom, comprising one **proton** and one **electron**. Commonly occurring in its molecular form (H<sub>2</sub>), which associates two atoms.

**hydrogenase**: an **enzyme** (small protein of **bacterial** origin), highly sensitive to the presence of oxygen, having the ability to **catalyze**, in reversible fashion, production of **hydrogen** from **protons** and **electrons**.

**hydrolysis**: decomposition of a chemical species (molecule or **ion**) by water.

**infrared radiation**: a segment of the electromagnetic spectrum covering radiation of wavelengths ranging from 760–780 **nm** to 1 mm.

**ion**: an atom or molecule that has lost, or gained, one or more **electrons**, and has thus become electrically charged.

**ion conduction**: see **electron** or **ion conduction**.

**ion, electron, or proton conductivity**: quantitative measure of the ease with which an **ion, electron** or **proton** may move through a material.

**ionic bond**: a bond characterized by the *transfer* of **electrons** from one atom to another, with no *sharing*, however, as happens in a **covalent bond**.

**lithography**: a technique used in microelectronics to fabricate circuits of micro- and **nanometric** scale. Patterns are first traced on a resin (photosensitive **polymer**) which is exposed to radiation (UV radiation as a rule), then developed by a wet path, and transferred by dry etching to the active layers of the device. The resolution achieved is directly related to exposure wavelength.

**lower heating value (LHV)**: amount of heat released by complete combustion, at constant pressure, of a **normal cubic meter** of gas, the water yielded being so in the form of steam. The **higher heating value (HHV)** is the amount of heat released in the same conditions, after condensation of the water yield.

**LPG**: liquefied petroleum gas (**butane, propane**).

**mesh (crystal)**: elementary pattern of a crystal.

**metal hydride**: binary compound (alloy) which **absorbs** molecular **hydrogen** from gaseous hydrogen, and releases it again in reversible fashion when heat is applied. Storage capacity is of at least one atom hydrogen per atom metal.

**metallic bond**: a chemical bond which ensures the cohesion of the atoms in a metal. This involves very large numbers of atoms (typically several million) sharing free **electrons**, ensuring electric conduction within a metal object. In a metal, owing to the very large number of atoms, the energy levels in these atoms form bands: a (low-energy) **valence band**, and a **conduction band**, kept apart by a forbidden band or **band gap**.

**methane**: a gas (CH<sub>4</sub>), the main constituent of **natural gas**. It is released during decomposition of organic materials.

**methanol**: an alcohol (methyl alcohol) of formula CH<sub>3</sub>OH, derived from **methane**.

**micrometer (or micron)**: 1  $\mu\text{m}$  = 10<sup>-6</sup> meter.

**model**: simplified representation of a system or of a process, in order to simulate it.

**mole**: unit of amount of matter (symbol: **mol**) of a system which contains as many atoms or molecules as there are atoms of carbon in 0.012 kg of carbon, i.e. 6.03 · 10<sup>23</sup> units (Avogadro's number).

**mutant**: bearer of a transmissible alteration of the genetic message, occurring through alteration of a nucleotide sequence in DNA.

**nanometer**: 1 **nm** = 10<sup>-9</sup> meter.



**nanoparticle:** particle of **nanometer** size.

**nanstructuring:** formation of structural patterns on a **nanometric** scale.

**natural gas:** mixture of gaseous, saturated **hydrocarbons** (mostly **methane**) and other constituents (hydrogen sulfide, nitrogen dioxide, **carbon dioxide**), suitable for use as a **fuel**.

**neutron:** electrically neutral fundamental particle, of mass  $1.675 \cdot 10^{-27}$  kg. Neutrons, together with **protons**, are the constituents of atomic nuclei.

**noble metals:** precious metals, resistant to air and water (silver, gold, platinum).

**normal cubic meter:** 1 normal cubic meter (**Nm<sup>3</sup>**) of gas is a cubic meter of that gas at 0 °C, at a pressure of 101,325 Pa (**1 atmosphere**).

**NOx: nitrogen oxides.**

**ohmic loss:** in a fuel cell, drop in voltage due to the basic cells' internal resistance, and directly proportional to current intensity.

**osmosis:** transport of the solvent from a dilute solution to a concentrated solution through a membrane; **reverse osmosis:** separation process, through transport in the opposite direction.

**oxidation:** a reaction in which an atom or an **ion** loses **electrons**.

**oxidation–reduction:** reaction in which a **reducing agent** releases one or more **electrons** to an **oxidizing agent**. In the final equilibrium state, the oxidizing agent, the reducing agent and their respective conjugates are thus present together.

**ozone:** molecule comprising three oxygen atoms, present in the Earth's atmosphere. It is generated, on the one hand, at altitude, by the Sun's ultraviolet radiation, and, on the other hand, at ground level, by combustion of organic materials (automotive **fuels**, in particular).

**peak watt (Wp):** unit of power, corresponding, for a photovoltaic cell, to the output under maximum insolation.

**perfluorinated:** refers to an organic structure (perfluorochemical) in which all **hydrogen** atoms associated to carbon atoms are substituted by fluorine atoms.

**permeation:** molecular diffusion of a substance through a membrane, set in motion by a pressure gradient.

**PFCs: perfluorated** carbon compounds, or perfluorocarbons.

**photocatalysis:** the **catalysis** of chemical compounds under the influence of light.

**photolysis:** breaking of a chemical bond due to the energy of a **photon**.

**photon:** the *quantum* of energy of electromagnetic radiation. An elementary particle having neither mass nor electric charge, associated to such radiation (visible light, **infrared** or ultraviolet radiation, gamma radiation, or **X-radiation**, according to its energy).

**photooxidation: oxidation** of a molecule occurring due to the energy of a **photon**.

**photosynthesis:** the process through which plants, and some **bacteria**, use the Sun's energy to carry out the synthesis of organic molecules from **carbon dioxide** and water.

**plasma projection:** a technology for the forming of thick layers and bulky parts, through introduction of a powdered material into a thermal *plasma*, generated by an electric arc in a torch.

**polar [molecule]:** a molecule within which charges are not distributed homogeneously.

**polymerization:** gradual adding of **monomer** molecules one to ano-

ther, to form a **polymer**, i.e. a macromolecule consisting in the repetition of the same structural pattern.

**power density:** see **current (power) density**.

**ppm:** part per million; **ppmv:** part per million by volume (measure of concentration).

**process:** in industry, this refers to the physical or chemical process at the core of a production or transformation process.

**propane: hydrocarbon** of the alkane or paraffin family, of formula  $C_3H_8$ . One of the gases used as liquefied petroleum gas (**LPG**).

**proton:** elementary particle bearing a positive electric charge, equal to that of the **electron** and of opposite sign.

**proton conductivity:** see **ion, electron, or proton conductivity**.

**PVD (physical vapor deposition):** coating deposition technique, consisting in a vacuum evaporation technique applied to a variety of materials, the vapors, combined with reactant gases, yielding compounds which migrate spontaneously to the areas to be coated.

**pyrolysis:** chemical decomposition through the effect of heat.

**radioactivity:** a property, exhibited by some natural or artificial elements, of emitting spontaneously alpha particles (helium nuclei), beta particles (positrons [beta<sup>+</sup> emission] or **electrons** [beta<sup>-</sup> emission]), and/or gamma radiation (high-energy **photons**).

**rare earths:** this covers the group of lanthanides, i.e. the elements of atomic numbers (the number of **protons** in the nucleus) in the range 57 (lanthanum) to 71 (lutetium), to which are added, owing to their chemical properties, yttrium and scandium.

**redox:** short for **reduction–oxidation**: its **redox potential** characterizes a molecule's affinity to **electrons**; **redox center:** a molecular group participating in electron transfers between molecules.

**reduction:** a reaction in which an atom or an **ion** gains **electrons** released by a **reducing agent**. The opposite process to an **oxidation** reaction.

**reforming:** chemical **cracking** operation, applied to a **hydrocarbon** or alcohol molecule to transform it into its major constituents.

**screen printing:** direct printing technique, derived from the ancient serigraphy or silkscreen technique, allowing deposition through a screen, selectively blocked out by manual or photochemical stenciling processes, of a variety of opaque or transparent layers (conducting inks, stop-off lacquers, resists, etc.), onto a variety of substrates. This is used, in particular, for the fabrication of printed circuits, membranes, and photovoltaic cells.

**semiconductor:** a material featuring an electronic **band gap**, which is neither solely an insulator nor solely a conductor at nonzero temperatures, the electronic properties of which may be made to vary. Some of its **electrons**, being very weakly bound to their atoms, can become **conduction** electrons. A semiconductor can be of the **n type** (with mainly electron **charge carriers**) or of the **p type** (mainly hole charge carriers), according to the **doping agents** used.

**sequestration:** controlled capture and storage of an element present in, or released into, the environment. In the case of **CO<sub>2</sub>**, this involves capturing it at source, and transporting it to natural sites (oceans, aquifers, **hydrocarbon** reservoirs, coal seams...).

**silicon:** the most common **semiconductor**, used for the fabrication of photovoltaic cells. It is available in noncrystalline form (**amorphous silicon**) and in the crystalline state (c-Si), this category covering the various crystalline forms (microcrystalline [mc-Si], monocrystalline [sc-Si], multicrystalline [mc-Si], and polycrystalline [pc-Si]).

**sintering:** heat treatment, serving to form a **ceramic** from powdered precursors, at a temperature lower than the melting point of

the main constituent, in order to turn it into a continuous, tough solid mass.

**solid absorption-desorption:** exchange processes occurring between a gaseous phase and a solid phase, resulting in the setting up/breaking of bonds between molecules forming the gas and the substrate.

**sorption:** interaction process between a solid surface and an atom (whether **ionized** or not) or a molecule (*physisorption*, or *chemisorption*, according to the nature of the bonding involved).

**spinel:** oxide crystal structure, in which the oxygen **ions** form assemblies of the compact face-centered cubic type, the **cations** occupying octahedral and tetrahedral sites in these assemblies.

**stationary (application):** refers to a nonmoving (fuel-cell) application, as opposed to mobile, portable or vehicle onboard applications.

**stoichiometry:** the study of the proportions according to which, in a chemical reaction, reactants combine and products are formed. A reaction is said to be **stoichiometric** when reactant quantities stand in molar proportions identical to those appearing in the chemical equation.

**superconductor:** a metal or alloy in which resistivity (specific resistance to **electron** travel) suddenly vanishes to a near-zero value, at a critical temperature.

**synthesis gas:** mixture of **hydrogen**, carbon oxides (CO and **CO<sub>2</sub>**), **methane**, water, and various impurities.

**thermal power:** the amount of heat delivered per unit time in a machine (approximately equal to the product of coolant fluid flow rate by the temperature differential between the hot and cold sources).

**thermalhydraulics:** the science of the behavior and motion of fluids as a function of temperature.

**thermochemistry:** the application of the first law of thermodynamics (conservation of energy, equivalence of heat and work) to isothermal, isobaric chemical reactions.

**thermolysis:** the decomposition of a body by heat.

**thermoplastics:** one of the two main families of plastic materials (the other comprising the **thermosets**). They are "remoldable" when heated.

**transition metals:** the family of 30 chemical elements of atomic numbers 21 through 30, 39 through 48, and 71 through 80, including iron, manganese, platinum, etc.

**turbulence:** a flow mode in fluids, for which, onto the mean motion, a random agitation motion is superimposed.

**two-phase:** comprising two phases (solid, liquid, or gaseous) of the same body (e.g. liquid water and steam), or of two different bodies (water and air, for instance).

**valence:** the number of bonds an atom may set up.

**VNG:** "vehicular" natural gas.

**wafer:** a very thin slice of **silicon**, as a rule, onto which are collectively etched a number of electronic circuits, this then being sawn up, to obtain integrated circuits (processors, microsystems, or sensors, and photovoltaic cells in particular).

**X-rays:** electromagnetic radiation with wavelengths ranging from a few fractions of **nanometer** (0.005 nm) to 10 nm, and energies ranging from a few kiloelectronvolts to several hundred kiloelectronvolts.