7 Trasformazioni della materia, energia e ambiente

Summing-up

The term **system** identifies a portion of space that represents the object of study, while the **environment** is all that surrounds the system: the set of system and environment constitutes the **universe**.

A system which allows exchanges of matter and energy with the environment is defined as *open*, a system which only allows energy to be exchanged with the environment is defined as *closed*, and finally, a system which permits neither the exchange of matter nor energy with the environment is defined as *isolated*.

Thermal energy is a form of kinetic energy at the particle level, associated with the incessant movement of the atoms or molecules constituting a system.

Chemical energy is a form of potential energy at the particle level, associated with electrical interactions that are established between the particles constituting a system.

The combination of thermal and chemical energy is the store of **internal energy** of a system. The internal energy depends not only on the type, but also on the number of particles and is therefore an *extensive quantity*.

All the transformations of matter are accompanied by **energy transformations**. For chemical reactions, and more generally for all the transformations of matter, the *principle of the conservation of energy* applies: the total energy of the universe remains constant.

A transformation that leads to the final system possessing less chemical energy in total than the initial system is termed an *exoenergetic process*; surplus chemical energy is lost to the system environment in the form of thermal energy, electrical energy, light, etc.

A transformation that leads to the final system possessing more chemical energy in total than the initial system is termed an *endoenergetic process*; the system absorbs energy, in the form of thermal energy, electrical energy, light, etc., and turns it into chemical energy.

When the energy exchanged with the environment is thermal energy one talks of *exothermic* and *endothermic processes*.

To measure the heat released or acquired in the course of chemical reactions (**reaction heat**) special equipment called *calorimeters* are used. The heat absorbed by the calorimeter is calculated by multiplying the mass of water by the specific heat and the temperature change:

$$q = m \cdot c \cdot \Delta t$$

The unit of measurement of heat, and all other forms of energy is the **joule** (J), the specific heat of water is 4.184 J / (g ·°C)

To calculate the amount of heat released in combustion reactions, the **calorific value** is normally made reference to, which expresses the amount of heat you get for the complete combustion of 1kg or 1 m^3 of fuel.

The substances in foods that can provide energy for the life of human beings (and animals) are *glucides* (or carbohydrates), *lipids* (or fats) and *protides* (or proteins).

The chemical energy stored in food comes, directly or indirectly, from the sun (*photosynthesis*) and is made available through the complex processes known as *combustion cells*.

When a chemical reaction takes place at constant pressure, chemical energy is transformed into heat energy and the reaction heat coincides with the change of the quantity of state called **enthalpy (*H*)**.

The change in enthalpy of a system as a result of a reaction is obtained from the algebraic difference between the enthalpy of the products and the enthalpy of the reactants:

$$\Delta H = H_{\text{products}} - H_{\text{reactants}}$$

The balance between the energy needed to break the bonds in the reagents and that lost in forming new bonds in the products of the reaction gives the total balance for the reaction.

In endothermic reactions the enthalpy change of the system is always positive: that is ΔH is greater than zero.

$$\Delta H > 0$$

In exothermic reactions the enthalpy change of the system is always negative: that is ΔH is less than zero.

$$\Delta H < 0$$

The **standard enthalpy of formation ($\Delta H_f°$)** of each compound corresponds to the value of ΔH in the formation reaction of one mole of substance from elements in their standard state.

Hess's law states that, if the equation of a given reaction is the sum of algebraic equations for two or more reactions, the heat released or absorbed by the overall reaction is given by the sum of the reaction heats of the individual processes.

The energy needed for human activities comes mainly from chemical reactions, the combustion reactions from **fossil fuels** (coal, oil and natural gas). These are **non-renewable sources of energy**, since the reserves of these materials are destined to run out. Even uranium used to produce energy in nuclear power stations comes from exhaustible sources.

The reactions involving the burning of fossil fuels are also responsible for serious damage to health and the environment: some particularly alarming effects are *air pollution*, *acid rain* and the *greenhouse effect*.

Alternative methods of energy production are constantly under development: especially important are those that use **renewable sources of energy**, so called because they derive their energy directly from natural phenomena (hydropower, solar, wind, geothermal and others).