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Research Article

LAWS OF THERMODYNAMICS IN BIOLOGICAL PROCESSES

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ABSTRACT

Thermodynamics of biological processes is a branch of biophysics ¬that studies the general patterns of energy conversion. Thermodynamics ¬also considers the problems of stability and evolution of biological systems. In biology, the laws of thermodynamics are used, firstly, to calculate the parameters of energy transformations in the body and, secondly, to determine the efficiency of biological processes. The thermodynamic ¬aspect must be taken into account when studying physicochemical processes. The thermodynamics of biological processes served as the basis for developing ideas about the energy sources of life processes, and proved fruitful for understanding and quantitative analysis of such biological processes as the generation of biopotentials, osmotic phenomena, and muscle contractions.

KEYWORDS

Thermodynamic system, linear processes, entropy, synergy, enthalpy.

INTRODUCTION

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In our time of integration of scientific disciplines, the question of the fruitfulness of the mutual penetration of neighboring sciences has long ceased to be debatable. Recognized leader of the natural sciences of the XX century. - physics - gave rise to such border areas as physical chemistry, biophysics, astrophysics, geophysics, where the most important scientific events took place and are taking place. Looking at this diversity of frontier disciplines, one involuntarily wonders whether we are witnessing numerous fruitful unions of well-defined basic sciences, or new areas are being born before our eyes that threaten to grow to the size of the sciences that gave birth to them, and lead to a revision of the existing classification of the system of sciences.

In the hierarchy of basic sciences, chemistry is directly adjacent to physics. This neighborhood provided the speed and depth with which many branches of physics fruitfully wedged into chemistry. Perhaps it would be even more accurate to speak not of neighborhood, but of the fact that chemistry is surrounded by physics on all sides. Indeed, the subject of chemistry is matter and its transformation, or, bearing in mind the structural level of organization, molecules and their transformations. Chemistry borders, on the one hand, with macroscopic physics - thermodynamics, physics of continuous media, and on the other hand - with microphysics - statistical physics, quantum mechanics.

Today we will talk about biophysics. In some technical higher educational institutions, along with physics and chemistry, students also study biophysics.

RESULTS AND DISCUSSION

The table below shows the 2-module from the working curriculum of the subject of biophysics.

2-module. Thermodynamics of biological processes
Fundamentals of chemical thermodynamics. Linear processes. Thermodynamics of linear processes. Entropy. Work and energy. Thermodynamics of nonlinear processes. The concept of synergy. Enthalpy.

Thermodynamics, as a science, arose in the first half of the last century and developed on the basis of the study thermal processes and the operation of steam engines. At present, this science covers a vast area of physical and chemical phenomena accompanied by energy processes .

Thermodynamics is the science of the transformations of various types of energy during those interactions between bodies that are limited only by heat exchange and work. In a narrower sense, thermodynamics studies the general thermal properties of a substance at equilibrium and the patterns that characterize the process of approaching equilibrium. It is based on three fundamental laws that summarize the experience of practice and scientific research.

A thermodynamic system is a group of bodies or a body that is actually or mentally separated from the entire environment (external environment), which can energetically interact with each other or with other bodies and exchange matter with them.

The system can be a gas in a cylinder, a solution of reagents, a crystal of a substance. As can be seen from the definition, the system must contain a sufficiently

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large number of particles (atoms, molecules, electrons) so that such concepts of thermodynamics as heat, temperature, and pressure can be applied to it.

A part of a system with its inherent chemical composition and macroscopic properties is called a phase. The phases are separated from each other by physical surfaces, during the transition through which the properties rarely change. For example: water - ice.

If the system consists of one phase, then it is called homogeneous. The multiphase system is heterogeneous. The substances that make up the phases are called components. The system can interact with the external environment in different ways.

A thermodynamic system that exchanges energy but does not allow mass exchange with the environment is called closed.

A system that can exchange energy and mass with the environment is called an open system.

A system deprived of the ability to exchange both mass and energy with the environment is called isolated. In an isolated system, all macroscopic changes cease over time, and the value of any physical quantity at each point of the system remains constant. This state of an isolated system is called equilibrium.

There is no macroscopic energy transfer between the parts of a thermodynamic system in equilibrium. The equilibrium state cannot change by itself, without external influences on the system. The state of the system, which remains unchanged in time only due to some changes in the environment, is called stationary.

The first law of thermodynamics is one of the forms of the law of conservation of energy, established in its modern form by Hess (1840), Mayer (1842), Joule (1842) and Helmholtz (1847).

There are several formulations of the law of conservation of energy:

- Energy is neither created nor destroyed;
- A perpetual motion machine of the first kind is impossible;
- In any isolated system, the total amount of energy is constant.

In thermodynamics, another formulation of the law of conservation of energy is used, which is the first law of thermodynamics. This law operates with the quantities of heat and work that the system exchanges with the environment.

etc. , while absorbing heat Q and doing work A. Rice. 1.1 a

Since nothing changes in the system itself in a circular process, according to the law of conservation of energy

$$Q = A \qquad (1.1)$$

In this case, we will assume that + Q corresponds to the heat absorbed by the system, - Q to the heat released by the system.

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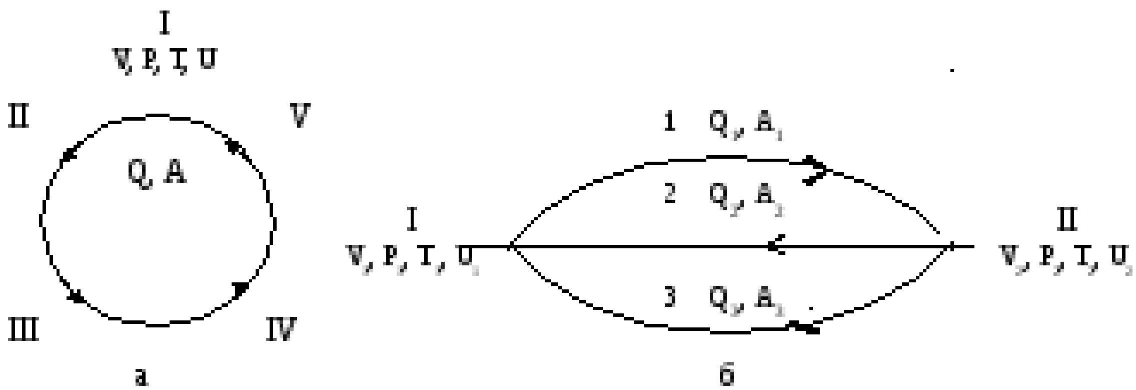

Fig.1.1. On the formulation of the first law of thermodynamics.

The amount of work in thermodynamics is considered to be positive (+ *A*), when the work is done by the system and with a minus sign (-*A*), if it is done by external forces on the system.

And now imagine that the system performs an open process along path 1, passing from state I to state II, while absorbing heat *Q* , and doing work A_1 . The system has passed into a different state, some changes have occurred in it and, therefore, the amounts of heat and work will not be equal.

$$Q_1 \neq A_1 \qquad (1.2)$$

Further, it can be assumed that the system returns to position I, but already along path 2, while absorbing heat Q_2 and doing work A_2 . and in this case it should be considered that $Q_2 \neq A_2$.

In general, the system has completed a circular process and therefore we can write

$Q_1 + Q_2$\u003d$A_1 + A_2$ (1. 3)

or

$Q_2 - A_2$\u003d$-(Q_1 - A_1)$ (1.4)

If we imagine that our system will move from state I to state II along 1 path, and a will return along another path - 3,4,5..., then we can write

$Q_2 - A_2$\u003d$Q_3 - A_3$\u003d$Q_4 - A_4$\u003d ... \u003d$Q_j - A_i$\u003d$-(Q_1 - A_1) = const$ (1.5)

It follows that the difference *Q* - *A* for a given initial and final state does not depend on the transition path and will be torn to change some property of the system. This property is internal energy. Therefore, according to the previous one, we can write:

$Q_1 - A_1$\u003d$U_2 - U_1$ (1. 6)

or

Q - *A* \ u003d ΔU \u003d $U_2 - U_1$ (1.7)

This ratio can be represented as:

$$Q = \Delta U + A \qquad (1.8)$$

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which is the mathematical notation of the first law of thermodynamics.
This law is formulated as follows:
The heat absorbed by the system is used to increase the internal energy of the system and to perform external work.

Thermodynamics forms the basis of extensive thermal engineering (technical thermodynamics and heat engineering). This, in particular, includes the study of processes in heat engines , which play a huge role in modern industry . The application of thermodynamics to chemical processes forms the subject of chemical thermodynamics . The latter develops methods for studying these processes and provides a basis for their understanding and regulation.

Chemical thermodynamics, considers the relationship between work and energy in relation to chemical transformations. Since a chemical transformation is usually accompanied by the release or absorption of a certain amount of heat, it, like other natural phenomena (including electrical and magnetic), accompanied by thermal effects, obeys the fundamental principles (beginnings) of thermodynamics. Chemical thermodynamics determines, first of all, the conditions (such as temperature and pressure) for the occurrence of chemical reactions and the equilibrium states they reach. The analysis of thermal phenomena is based on three fundamental principles, confirmed by numerous observations.

The heat released or absorbed by a particular chemical reaction is proportional to the degree of conversion of the reactants, determined by the amount of any of the consumed or formed products. The change in internal energy or enthalpy of the reacting system is determined by the chemical reaction equation. For example, the combustion of a mixture of gaseous methane and oxygen is described by the thermochemical equation

$$CH_4(\text{г}) + 2O_2(\text{г}) = CO_2(\text{г}) + 2H_2O(\text{ж});$$

$$\Delta H^{\circ} = -212{,}798 \text{ ккал},$$

Here, the letters in brackets denote the aggregate states of substances (gas or liquid). The symbol ⍰ H ⍰ denotes the change in enthalpy in a chemical transformation at a standard pressure of 1 atm and a temperature of 298 K (25⍰ C) (the degree sign in the superscript H indicates that this value refers to substances in standard states (at p = 1 atm and T = 298 K)). The chemical formula of each substance in such an equation denotes a well-defined amount of a substance, namely its molecular weight, expressed in grams. The molecular weight is obtained by adding the atomic masses of all the elements included in the formula with coefficients equal to the number of atoms of a given element in the molecule.

RESULTS

We see that physics, on an ever-larger scale and more and more fruitfully, intrudes into chemistry. Physics reveals the essence of qualitative chemical regularities, supplies chemistry with perfect research tools. The relative volume of biophysics is growing, and there are no reasons that can slow down this growth. All these circumstances have given rise among physicists to the extreme point of view that chemistry and physics can no longer be regarded as two separate sciences.

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