BY THE PROBLEM OF PHASE TRANSITIONS

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Phase transitions occur in the majority of thermal and chemical-physical phenomena. Therefore, at present the study of phase transitions stand out in the vast region of interesting science. The conditions (temperature and pressure) under which the substance exists in the different phases (gas, liquid or solid) are in the form of a phase diagram [1, 6].

The purpose of research - analysis of phase transitions based on the thermodynamic method.

The results of research. Consider the equilibrium between the liquid and gas-like phase (see. Figure). The system is closed and at a fixed temperature, consists only of the liquid and vapor are in equilibrium.

When the temperature is approaching the equilibrium is approaching a critical state.
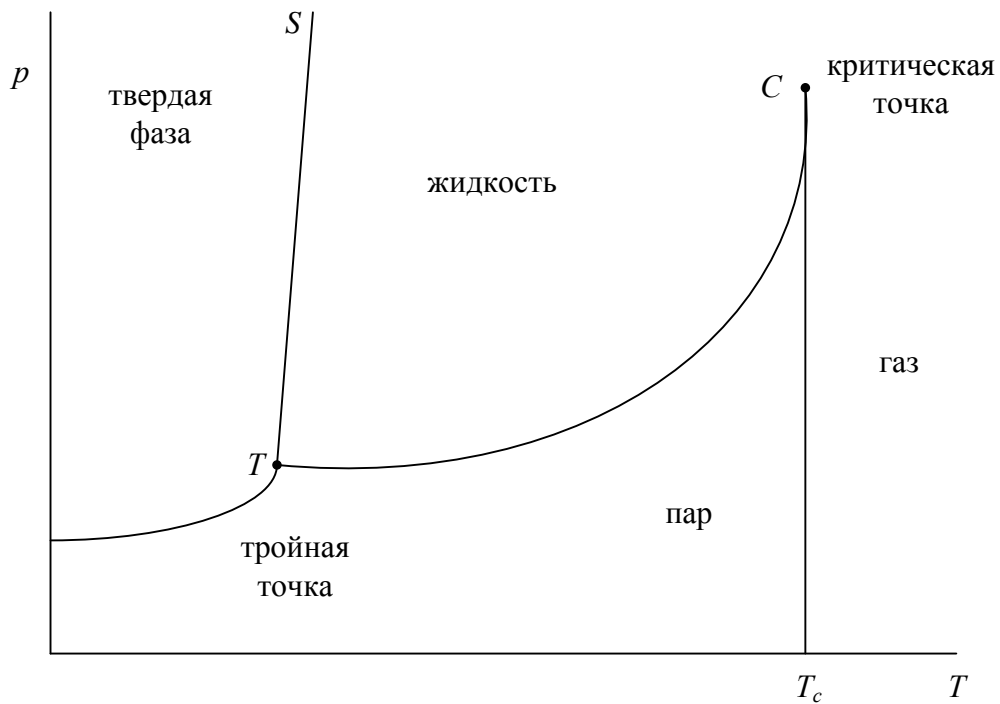
Phase diagram of the one-component system:

- - Equilibrium curves (at all points on these curves the chemical potentials of the equilibrium phases are equal); T - triple point; C - a critical point; - The critical temperature above which the gas can not be converted into the liquid state, the pressure increasing

Consider a heterogeneous system in which the two phases occupy different volumes. Under these conditions, the liquid is irreversibly converted to steam, or vice versa; process is as long as the two phases is not an equilibrium. Exchange of substances between the two phases can be considered as "chemical reaction" equation is conventionally written in the form:

$$\Pi = \text{Ж}, \tag{1}$$

t. e. = liquid vapor. Let: Gas - G, couples - P, the liquid phase - F, solid - S. exchange of substances between the phases is called phase reaction. The phase response is used for the quantitative description of the conversion phase.

Let - chemical potentials in the two phases of matter. Indices "" and "" means vapor and liquid phases. In equilibrium, the entropy production in any

irreversible process must vanish. This implies that the affinity corresponding to a phase transition liquid - vapor should vanish, ie

$$A = \mu_k^{\text{Ж}}(p,T) - \mu_k^{\Pi}(p,T) = 0; \tag{2}$$

$$\mu_k^{\text{Ж}}(p,T) = \mu_k^{\Pi}(p,T),$$

where explicitly stated that both chemical potential - a function of pressure and temperature. Of equal chemical potential, it follows that when the liquid is in equilibrium with its vapor pressure and temperature are independent variables, and so on and there is a phase diagram equilibrium curve.

Mass transfer between phases occurs.

Examples of mass transfer between the phases are in the evaporation of the liquid gas (gas-liquid) mass transfer between the solid surface of the structural material and coolant. When moving a substance from one phase to the other occurs in the resistance of each phase and of their border. In some problems of mass transfer resistance to accept the interface to be negligible, as evidenced by the experimental data of real systems. Exceptions are systems which are observed at the boundary of any deposits, impurities, surfactants, corrosion processes, etc. In the propagation of heat, such as from liquid to gas occurs continuous temperature field. The temperature at the interface is the same for each phase (). The total thermal resistance (inverse of the heat transfer coefficient) can be represented as the sum of the thermal resistance on the part of each phase.

The amount of heat transfer coefficients on each side:

$$1/k = 1/a' + 1/a''. \tag{3}$$

The heat flux density

$$q = k(T' - T'').$$

In the case of mass transfer, if the two phases are in equilibrium and mass transfer resistance at the border is no concentration at the interface are not equal. This is because as the engine capacity of the selected name concentration - driving potential for mass transfer phase only within, but not between the phases. Correct regarded as the driving force between the chemical potentials.

The difference between the bulk and surface concentration of the substance in each phase can be expressed in terms of mass flux density and local mass transfer coefficients in each phase.

The moisture content in the air can be determined psychrometric method, which is based on the measurement of temperature by means of dry and wet thermometers. If all the heat going to sweat, is brought by convection, the mass flow per unit of surface heat flux density is given by:

$$\left.\begin{array}{l} j = \beta\rho(d_s - d); \\ q = \alpha(t - t_{\text{M}}) = jr, \end{array}\right\} \tag{4}$$

where - the moisture content (mass of water vapor in 1 kg of dry air); - Moisture saturated air; - The temperature of dry and wet bulb; - Heat of vaporization of water at a given pressure.

Hence we have

$$\frac{t - t_{\text{M}}}{d_s - d} = \frac{r\beta}{\alpha} \approx \frac{r}{c_p}, \tag{5}$$

We introduce the concept of chemical potential. With the redistribution of mass redistribution of energy in the system. Weight is a quantitative measure of the change, the system undergoes regarded as state coordinates. As a potential mass George. W. Gibbs suggested quantity called chemical potential. The number of mass transfer effects is defined as where - weight.

If the system is heterogeneous, consisting of several components, the first law of thermodynamics can be written as:

$$dU = TdS = pdV + \sum_{k=1}^{n} \mu_k dm_k, \tag{6}$$

where - internal energy; - Temperature; - The entropy; - Pressure; - The volume; - Component; - Chemical potential of the component; - Weight of the component.

Isobaric-isothermal potential Gibbs expressed as follows:

$$dG = Vdp - SdT. \tag{7}$$

For the equilibrium of the process. $dG = 0$

It is clear that the equality of the chemical potentials (2) must be carried out between any two phases in equilibrium. If there was a P phase, then we would have a general equilibrium condition:

$$\mu_k^1(p,T) = \mu_k^2(p,T) = \mu_k^3(p,T) = ...\mu_k^P(p,T). \qquad (8)$$

where the superscript indicates the phase and the bottom - the component.

The figure can be seen another interesting feature: there is a critical point in which finishes the equilibrium curve of the vehicle (between liquid and vapor phases). If the gas temperature is higher than Tc, the gas can not be compressed (converted to a liquid) by increasing the pressure: the pressure is increased the density increases, but the phase shift in the capacitor occurs.

The single-phase system, where there is, for example, only the gas, the intensity variables ¬- pressure and temperature - can vary independently. But when the two are in equilibrium phases such as steam and liquid, p and T are no longer independent. Since the chemical potential of the two phases must be equal, i.e. , Independent of one only of the two intensive variables. The number of independent variables intensive due to the number of phases in equilibrium, and the number of components in the system.

In addition to the phase rule, open Gibbs, there is another comment made by Pierre Duhem, and was named Duhem theorem. It is formulated as follows: for any number of phases, components and chemical reactions if the initial number of moles of all components is given, the equilibrium state of a closed system is completely determined by two independent variables.

Note that the Gibbs phase rule determines the total number of intensive independent variables and the theorem Duhem - the total number of independent intensive and extensive variables in a closed system.

There are phase transitions of the first and second kind. [2] The chemical potential at the first order phase transition varies continuously, but its derivative is discontinuous.

Characteristic features of phase transitions is that in this case changes the thermodynamic quantities not significant: molar entropy changes and molar

volume are continuous, but have breaks derivatives thereof. Similarly, the gap is the second derivative of the chemical potential.

As a result, phase transitions, usually a change in the symmetry of the system, which is characterized by the so-called order parameter. The latter is usually selected so that it is equal to zero on one side of the phase transition.

The system liquid - liquid or liquid - vapor and vapor - liquid symmetry is not affected. The division of the phase transitions in the two kinds of multiple conditional, as in liquid crystal systems are known phase transitions of the first kind, very close to the phase transitions of the second kind. It transitions with a small jump of the order parameter and the small heat when strongly developed fluctuations.

In some systems, such as adsorption heat pumps, heat accumulators in porous, efficiency of energy systems are mainly determined by the level of phase transitions occurring.

Note that the porous media play an important role not only in the technical fields, but also in the nature, biology and deserve comprehensive analysis.

The initial system of equations is written as:

– in the direction: Z :

$$; \frac{\partial}{\partial Z}(VU) + \frac{1}{R^n}\frac{\partial}{\partial R}(R^n VU) = -\frac{\partial P}{\partial Z} + \frac{1}{\mathrm{Re}}\left[\frac{\partial}{\partial Z}\left(\frac{\partial U}{\partial Z}\right) + \frac{1}{R^n}\frac{\partial}{\partial R}\left(R^n\frac{\partial U}{\partial R}\right)\right] - f\frac{U}{D_a\,\mathrm{Re}}; \quad (9)$$

– in the direction R :

$$\frac{\partial}{\partial Z}(UV) + \frac{1}{R^n}\frac{\partial}{\partial R}(R^n VU) = -\frac{\partial P}{\partial R} + \frac{1}{\mathrm{Re}}\left[\frac{\partial}{\partial Z}\left(\frac{\partial V}{\partial Z}\right) + \frac{1}{R^n}\frac{\partial}{\partial R}\left(R^n\frac{\partial V}{\partial R}\right)\right] -$$

$$- f\frac{V}{D_a\,\mathrm{Re}} - f\frac{V}{\mathrm{Re}\,R^2}n; \quad (10)$$

– energy equation:

$$\frac{\partial}{\partial Z}(U\Theta) + \frac{1}{R^n}\frac{\partial}{\partial R}(R^n V\Theta) = \frac{1}{P_e}\left(\frac{\partial^2\Theta}{\partial Z^2}\right) + \frac{1}{P_e R^n}\frac{\partial}{\partial R}\left(R^n\frac{\partial\Theta}{\partial R}\right); \quad (11)$$

– entropy generation:

$$E_g = \left(\frac{\partial \Theta}{\partial Z}\right)^2 + \left(\frac{\partial \Theta}{\partial R}\right)^2 + (1-f)Br_m\left\{2\left[\left(\frac{\partial V}{\partial R}\right)^2 + \left(\frac{V}{R}n\right)^2 + \left(\frac{\partial U}{\partial Z}\right)^2\right] + \right.$$

$$\left. + \left[\frac{\partial V}{\partial Z} + \frac{\partial U}{\partial R}\right]^2\right\} + f\frac{Br_m}{D_a}[\overline{V}]^2. \tag{12}$$

In equations (8 - 12), the notation:

$Z = z/z_{in}$; $U = u/u_{in}$; $V = v/v_{in}$; $R = r/r_{in}$; $\Theta = (T - T_{in})/T_w - T_{in}$; $P = p/p_{in}$;

$\Theta = (T - T_{in})/T_w - T_{in}$; $P = p/p_{in}$; D_a – Darcy number; Re – Reynolds number;

Br_m - the converted number Brinkman; z and r - coordinates (r - range); υ - Velocity components; ρ - the density; f - the parameters determining the degree of porosity of the test body.

Entropy method for analyzing energy systems received a special development in the past two or three decades, the scientific work of A. run and T. Morozyuk.

Conclution

These regularities of phase transitions can be the basis for a more complete and correct solution of these processes. Assessment of the level of phase transitions is recommended to base on entropy analysis.