CONTRIBUTION TO THE KINETICS OF THE PROCESS OF DISSOLUTION

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Some characteristics of the kinetic equation of dissolution are discussed, bearing in mind that in the course of the process, along with the concentration of the solution, the surface of the soluble substance is also changed. The opportunity for the application of an exponential kinetic equation is pointed out. Methods are proposed for calculating the solubility and also for using the integral forms of the exponential equation. The meaning of the coefficient of proportionality $\kappa$ is explained.

In accordance with the contemporary diffusion kinetic theory of heterogeneous processes, the equation for the kinetics of dissolution has the following form

$$r = k(c_s - c)S$$

where

$$k = \gamma D / (D + \gamma \delta)$$  \hspace{1cm} (2)

and $\gamma$ is the rate constant of the interphase chemical process, $D$ is the coefficient of diffusion, $\delta$ - the effective (conditional) thickness of the boundary diffusion layer, $S$ - the size of the surface of the soluble substance, $c$ - the running concentration of the substance in solution, $c_s$ - the concentration of saturation and $r$ - the rate of dissolution.
Generally, the integral form of Eq. (1), which is most often used in experimental research of this process, is obtained on the condition that $S = \text{const}$. Only in some particular cases is it taken into consideration that a constant surface of the soluble substance is not always realized.

In this paper some peculiarities of Eq. (1) for the kinetics of dissolution are discussed, which follow from the circumstance that during the process of dissolution, along with the concentration of the solution, the size and character of the surface of the soluble substance are also changed. The study is not bound to a concrete mechanism explaining this change. It is considered that the change of the surface is directly connected with the increase of the concentration of the solution, that is $S \sim dS/dc$.

In the process of dissolution, with increasing concentration $c$ the surface of the soluble substance $S$ decreases, thus

$$S = -\kappa(dS/dc)$$

where $\kappa$ is the coefficient of proportionality.

After integrating this expression, keeping in mind the initial condition ($t = 0, c = 0, S = S_0$), we obtain

$$S = S_0 \exp \left( -\frac{c}{\kappa} \right)$$

As a result of this, Eq. (1) for the kinetics of dissolution takes the form

$$r = kS_o \left( c_s - c \right) \exp(c/\kappa)$$

From the analysis of this equation it follows that

(a) $r \to r_o = kS_o c_s$ when $t \to 0$ and $c \to 0$;
(b) $r \to 0$ when $c \to c_s$;
(c) When $1 > (c/\kappa) > 0$ the exponential term in the Eq. (5) does not visibly influence the rate of dissolution and it can be omitted.

These three cases in fact coincide with the familiar kinetic equation (1) for the process of dissolution.