A GRAPHIC METHOD FOR DETERMINING THE ACTIVITY OF IRRADIATED SPECIMENS

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If 1 g of material (at. wt. \( A_{at} \), activation cross section \( \sigma \)) is irradiated in a stream of thermal neutrons \( \Phi = 10^{13} \) neutrons/cm\(^2\)-sec for a period of time \( t \), then after a period of time \( t_1 \) between the moment the irradiation was stopped to the moment when the customer receives the irradiated material, the total activity of the specimen \( A \) will be fairly accurately determined by the following formula:

\[
A = 163 \frac{p\sigma}{A_{at}} (1 - e^{-\frac{0.693t}{T_{1/2}}}) e^{-\frac{0.693t_1}{T_{1/2}}},
\]

where \( p \) is the relative content of activating isotope in the chemical element; \( T_{1/2} \) is the half-life of the isotope obtained due to irradiation; \( e \) is the base of natural logarithms. Since for any isotope the values \( k = 163 \frac{p\sigma}{A_{at}} \) and \( m = \frac{0.693}{T_{1/2}} \) are constant, then formula (1) can be expressed in the form

\[
A = k(1 - e^{-mt}) e^{-mt_1},
\]

hence it follows that \( A \) is a function of two variables: \( A = f(t,t_1) \).

This function is a spatial curve which can be represented stereometrically in a spatial coordinate system (see Figs. 1-5). The coordinate axes of such a system have logarithmic scales; all three variables (activity \( A \), time of activation \( t \) and time of decay \( t_1 \)) change over a fairly wide range. Thus, the scales of times of activation and decay cover a range of times 1 to 100,000 min, i.e., from 1 min to almost 70 days.

Fig. 1. The function \( A = f(t,t_1) \) for the \( W^{187} \) isotope.

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With a new time of activation and hence a new time of decay we obtain an activity which for each separate isotope will depend on the numerical value of $p$, $A$, $T_2$, and $o$. Calculations of the activity from formula (2) show that the values of activity under these conditions change over a fairly wide range. For this reason the origin of the coordinate axis $A$ is chosen so that the graphical representation of the function $A = f(t, t_1)$ for any isotope is within the limits of coordinates for the values $A \approx 10^{-6}$ C. Under these conditions the values of activity of only some isotopes (gold, iridium, etc.) can reach the maximum value ($\approx 10^3$ C). Consequently, the value of the activity $A$ changes from $10^{-6}$ to $10^3$ C, and it is thus essential that the axis of the coordinates of activity $A$ have a logarithmic scale.

We will try to solve two problems. We will answer the question of the first problem: what is the activity of 1 g of tungsten at any moment of time if it is known that the values of $t$ and $t_1$ change between 1 and 100,000 min? When tungsten is irradiated by a stream of thermal neutrons two isotopes are formed: $W^{187}$ and $W^{185}$. In Figs. 1 and 2 the relationship $A = f(t, t_1)$ is given for these isotopes in a system of spatial coordinates.

The problem is solved graphically in the following way. A sheet of transparent paper is placed on Fig. 1 and a pencil is used to draw the contours of the spatial coordinate system and also a graph of the function $A = f(t, t_1)$ for the $W^{187}$ isotope. The contours of the graph of the function for the $W^{185}$ isotope are then transferred to the obtained

Fig. 2. The function $A = f(t, t_1)$ for the $W^{185}$ isotope.

Fig. 3. Combined graph of the function $A = f(t, t_1)$ for the isotopes $W^{187}$ and $W^{185}$.