Half-life

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Content

The time required for one-half of a given material to undergo chemical reactions; also, the average time interval required for one-half of any quantity of identical radioactive atoms to undergo radioactive decay.

Chemical reactions

The concept of the time required for all of the material to react is meaningless, because the reaction goes very slowly when only a small amount of the reacting material is left and theoretically an infinite time would be required. The time for half completion of the reaction is a definite and useful way of describing the rate of a reaction.

The specific rate constant *k* provides another way of describing the rate of a chemical reaction. This is shown in a first-order reaction (1),

$$k = \frac{2.303}{t} \log \frac{c_0}{c} \tag{1}$$

where c_0 is the initial concentration and *c* is the concentration at time *t*. The relation between specific rate constant and period of half-life, $t_{1/2}$, in a first-order reaction is given by Eq. (2).

$$t_{1/2} = \frac{2.303}{k} \log \frac{1}{1/2} = \frac{0.693}{k} \tag{2}$$

In a first-order reaction, the period of half-life is independent of the initial concentration, but in a second-order reaction it does depend on the initial concentration according to Eq. (3).

$$t_{1/2} = \frac{1}{kc_0} \tag{3}$$

See also: **Chemical dynamics (/content/chemical-dynamics/126900)**

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Radioactive decay

The activity of a source of any single radioactive substance decreases to one-half in 1 half-period, because the activity is always proportional to the number of radioactive atoms present. For example, the half-period of ^{60}Co (cobalt-60) is $t_{1/2}$ = 5.3

years. Then a ^{60}Co source whose initial activity was 100 curies will decrease to 50 curies in 5.3 years. The activity of any radioactive source decreases exponentially with time t, in proportion to $\exp{-0.693 t/t_{1/2}}$. After 1 half-period (when $t = t_{1/2}$) the activity will be reduced by the factor $e^{-0.693} = ½$. In 1 additional half-period this activity will be further reduced by the factor ½. Thus, the fraction of the initial activity which remains is ½ after 1 half-period, ¼ after 2 half-periods, ⅛ after 3 half-periods, 1/16 after 4 half-periods, and so on.

The half-period is sometimes also called the half-value time or, with less justification, but frequently, the half-life. The half-period is 0.693 times the mean life or average life of a group of identical radioactive atoms. The probability is exactly ½ that the actual life-span of one individual radioactive atom will exceed its half-period. *See also:* **Radioactivity (/content/radioactivity/569000)**

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Additional Readings

B. J. McParland, *Nuclear Medicine Radiation Dosimetry: Advanced Theoretical Principles*, Springer, New York, 2010

W. J. Spruill and W. E. Wade, *Concepts in Clinical Pharmacokinetics*, 5th ed., American Society of Health-System Pharmacists, Bethesda, MD, 2010