An Alternate Form of the Integrated First-Order Rate Equation

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Abstract
Derivation of a first-order equation suitable for use in beginning energy science and chemistry courses is shown to be

\[ A = A_o / 2^{t/t_{1/2}} \]

Where,

- \( A_o \) is the original amount of the sample
- \( A \) is the amount
- \( T \) is time t and
- \( t_{1/2} \) is the half-life

\( A_o \) is larger than \( A \)

Derivation of the Alternate Form
Radioactive processes and many chemical processes follow first order kinetics. The usual equations found in general chemistry textbooks are:

- a. \[ \ln A/A_0 = kt \]
- b. Changing the rate constant to half-life, \( \ln 2 = k t_{1/2} \), where \( t_{1/2} \) is the half-life.
- c. Solving equation 2 for \( k \) and substituting into equation 1 the result is \( \ln A_0/A = (\ln 2)t/t_{1/2} \).
- d. Rearranging equation 3 gives \( A = A_o e^{(\ln 2)t/t_{1/2}} \) as indicated in [1].
- e. Since \( \ln 2 = 2 \), substitution into equation 4 yields \( A = A_o / 2^{t/t_{1/2}} \) the Alternate Form of the Integrated first-order rate equation

Our students have found equation 5 to be relatively easier to use than equations 1 and 2. In equation 5, by dividing the time by the half-life, they get a number. On their calculators, they enter the number 2, \( y^2 \), the number and press=The result is divided into \( A_o \) giving the value for \( A \). For radioactive processes, the values of \( A_o \) and \( A \) may be in mass, such as grams, or activity in Becquerel’s (counts/second). For chemical processes, units for \( A_o \) and \( A \) may be written as rates, such as molarity/second.

References

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