Answer on the question #67039, Chemistry / Physical Chemistry

Question:

1. For a certain first order reaction, it is found that it takes 156 seconds for the concentration of reactant to fall from 0.100 M to 0.0500 M. How much time would it take for the concentration of reactant to fall from 0.0500 M to 0.0250 M?

Solution:

First order kinetics is described by the following equation:

$$Rate = k[A] = -\frac{d[A]}{dt}$$

Rearranging and integrating that equation, we get:

$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$$

where $[A]_0$ and $[A]_t$ are initial and the concentration of the reactant at the time t, respectively, and k is the rate constant.
Thus, we can easily find the rate constant from the data given and apply it to know the time that it takes for the fall in concentration from 0.0500M to 0.0250M.

$$k = -\frac{1}{t} \cdot \ln\left(\frac{[A]_t}{[A]_0}\right) = -\frac{1}{156\ (s)} \cdot \ln\left(\frac{0.0500}{0.100}\right) = 0.00444(s^{-1})$$

Then, the time that it takes for a concentration to fall from 0.0500M to 0.0250M is:

$$t = -\frac{1}{k} \cdot \ln\left(\frac{[A]_t}{[A]_0}\right) = -\frac{1}{0.00444(s^{-1})} \cdot \ln\left(\frac{0.0250}{0.0500}\right) = 156\ s$$

Answer: It will take 156s for the concentration to drop from 0.0500M to 0.0250M.

P.S. One can admit, that for the first order reaction, it is easy to calculate, because in both cases the concentration drops twice, so the answer will be the same 156s. Although, I decided to show more the mathematical and straightforward solution for better comprehension.