Kinetics I Quiz **Name:** Key

May I post your solution? [ ] Yes [ ] No [ ] Yes, but redact my name

Consider the reaction: **A → B**

The initial concentration of A is $[A]_0$ = 0.561 M. You determine the first three, successive half-life times of A to be 483, 483, and 483 seconds.

How long will it take for the concentration of A to decrease to 0.241 M?

Recall that the rate law can be expressed as $\text{Rate} = k[\text{A}]^a$

where *k* is the rate constant, $[\text{A}]$ is the concentrations of the reactant A, and a is the order of the reaction with respect to reactant A.

To determine the order a, we can analyze the half-life times. Recall that the following is true:

- Zero-order (a = 0): $t_{1/2} = \frac{[\text{A}]_0}{2k}$ and successive half-life times will decrease as the reaction goes on
- First-order (a = 1): $t_{1/2} = \frac{\ln(2)}{k}$ and successive half-life times will be constant as the reaction goes on
- Second-order (a = 2): $t_{1/2} = \frac{1}{k[\text{A}]_0}$ and successive half-life times will increase as the reaction goes on

Because the successive half-life times remain constant ($t_{1/2} = 483\ \text{s}$) as our reaction goes on, we know this reaction must be first order with respect to $[\text{A}]$ and the rate law and integrated raw law are:

$$\text{Rate} = k[\text{A}]^1$$

$$\ln[\text{A}]_t = -kt + \ln[\text{A}]_0$$

We can use the integrated rate law to find the time it takes for the concentration to decrease from 0.561 M to 0.241 M, but we first need to find the rate constant, *k*. To find the rate constant, we can plug in the data for one of the half-life times into the half-life equation above:

$$t_{\frac{1}{2}} = \frac{\ln(2)}{k}$$

$$483\ \text{s} = \frac{0.693}{k}$$

$$k = 0.00143_5\ \text{s}^{-1}$$

Now we can use the integrated rate law to solve for the time:

$$\ln[\text{A}]_t = -kt + \ln[\text{A}]_0$$

$$\ln[0.241\ \text{M}] = -(0.00143_5\ \text{s}^{-1})t + \ln[0.561\ \text{M}]$$

$$t = -\frac{\ln[0.241\ \text{M}] - \ln[0.561\ \text{M}]}{0.00143_5\ \text{s}^{-1}}$$

$$t = -\frac{-1.422_{95} - (-0.578_0)}{0.00143_5\ \text{s}^{-1}}$$

$$t = 589\ \text{s}\ \{3\ \text{sig. figs}\}$$

For logarithmic operations, the number of significant figures is reflected in the number of digits reported to the right of the decimal point. For instance, there are 3 significant figures in the value 0.241 M. When we take the (natural) logarithm of this value, we need to report the computed value to 3 significant figures after the decimal point:

$$\ln(0.241) = -1.422958345 = 1.423$$

You may ask why. The reason is that the digit before the decimal point represents the *magnitude* of the value 0.241. Remember that the definition of a logarithm is related to exponentiation via

$$\log_b(x) = y \quad \text{if} \quad b^y = x$$

As such, the preceding digit represents the power to which the base is raised to, similar to the way that we disregard the power of ten when we write scientific notation, such as 2.41×10^{-1}.