

Kinetic of the Hydrolysis of Urea: Part II

Open the file “Hydrolysis of Urea,” which shows a plot of [urea] as a function of time. Determine the rate law for this reaction by linearizing the data. You may do this by creating a new calculated column or by copying and pasting the data into Excel. To see the data, select Insert: Table from the main menu. Using your results, answer the following set of questions:

(1). What is the reaction’s rate constant and rate law?

Answer. A graph of $\ln[\text{urea}]$ as a function of time is linear; thus, the reaction is first-order. The rate constant is the negative slope of this plot, or 0.0850 d^{-1} , The rate law, therefore, is

$$R = k[\text{urea}] = 0.0851 \text{ d}^{-1} \times [\text{urea}]$$

(2). What is the original concentration of urea?

Answer. Although we have an experimental [urea] at $t = 0$, we also can calculate it using the linearized rate law, which is equivalent to $\ln[\text{urea}]_0$; thus, $\ln[\text{urea}]_0 = -0.105$ and $[\text{urea}]_0 = 0.900 \text{ M}$.

(3). What is the reaction’s half-life?

Answer. For a first-order reaction the half life is

$$t_{1/2} = \frac{0.693}{k} = \frac{0.693}{0.0850 \text{ d}^{-1}} = 8.15 \text{ d}$$

(4). What is the expected rate of the reaction at $t = 10$ days?

Answer. To find this we use the tangent tool to determine the slope at $t = 10$ days. This gives a result of 0.034 M/d . We also can calculate the rate by determining the concentration of urea at $t = 10$ days using the integrated form of the rate law and then substituting into the rate law; thus

$$\ln[\text{urea}]_{t=10} = \ln[\text{urea}]_0 - kt$$

$$\ln[\text{urea}]_{t=10} = \ln(0.900) - (0.0850\text{d}^{-1}) \times (10\text{d}^{-1})$$

$$\ln[\text{urea}]_{t=10} = -0.955$$

$$[\text{urea}]_{t=10} = 0.385 \text{ M}$$

$$R = k[\text{urea}]$$

$$R = (0.0850\text{d}^{-1}) \times (0.385 \text{ M}) = 0.033 \text{ M/d}$$

(5). How many days will it take for the [urea] to reach 0.050 M ?

Answer. We can calculate this using the integrated rate law as well; thus

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

$$\ln(0.050) = \ln(0.900) - (0.0850 \text{ d}^{-1}) \times t$$

$$t = 34.0 \text{ d}$$

(6). If the original concentration of urea is 5.0 M, how long will it take for the concentration to reach 0.10 M?

Answer. Changing the initial concentration has no effect on the rate law, which remains the same; thus

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

$$\ln(0.10) = \ln(5.0) - (0.0850 \text{ d}^{-1}) \times t$$

$$t = 46.0 \text{ d}$$