

## 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  $0.0850 \text{ d}^{-1}$ , 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  $0.034 \text{ M/d}$ . 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  $0.050 \text{ M}$ ?

**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

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

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

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