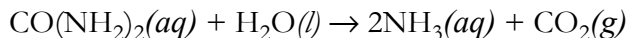


## Kinetics of the Hydrolysis of Urea

The data file “Hydrolysis of Urea,” which is in your group’s Dropbox folder, contains data collected during the hydrolysis of urea



displayed as a plot showing the [urea] as a function of time. The rate of the reaction is defined as the change in the concentration of urea per unit change in time; that is

$$\text{Rate} = \frac{\Delta[\text{urea}]}{\Delta\text{time}} = \frac{d[\text{urea}]}{dt}$$

Note that you can move a cursor, which displays three values—the [urea], the time, and the slope ( $d[\text{urea}]/dt$ )—and that you can interpolate between the data points. Use this data to answer the following questions.

1. What is the average rate between  $t = 4$  days and  $t = 16$  days?

*To find this we measure the [urea] at  $t = 4$  days and 16 days and solve; thus*

$$R = \frac{0.231 - 0.641}{16.0 - 3.99} = -0.0341 \text{ M/d}$$

2. What is the rate at  $t = 10$  days?

*Using the cursor function, the slope at  $t = 10$  days is  $-0.034 \text{ M/d}$ .*

3. What happens to the reaction’s rate over time? Explain your reasoning.

*The rate decreases as the reaction proceeds. We know this because the slope of the tangent line, which is  $d[\text{urea}]/dt$ , decreases with time.*

4. At what point in time does the reaction have it’s greatest rate?

*The reaction’s greatest rate is at time  $t = 0$ ; that is, the rate is greatest at the instant the reaction begins.*

5. To what value is the rate approaching?

*The rate is approaching a value of zero, which is the rate when the reaction reaches its equilibrium point.*

6. The [urea] as a function of time appears to follow a predictable pattern. Fit an appropriate equation to this data (*hint: you have seen similar data in lab*) and speculate on the meaning of the equation’s variables.

*This data should remind you of Newton’s law. Fitting the data to the equation  $[\text{urea}]_t = Ae^{-Ct} + B$  gives the result shown to the right. Comparing this to Newton’s law should convince you that  $A$  is the initial concentration of urea,  $[\text{urea}]_0$ , and that  $B$  is the concentration of urea when the reaction reaches equilibrium. In Newton’s law,  $C$  is a constant that describes the object’s inherent ability to radiate heat to the environment; here  $C$  is a constant related to the reaction’s tendency to occur. We call this the reaction’s rate constant, about which we will learn more later.*

