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

$$CO(NH_2)_2(aq) + H_2O(l) \rightarrow 2NH_3(aq) + CO_2(g)$$

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

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

Note that you can move a cursor, which displays three values—the [urea], the time, and the slope (d[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 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[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 $[urea]_t = Ae^{-Ct} + B$ *gives the result shown to the right. Comparing this to Newton's law should convince you that A is the initial concentration of urea,* $[urea]_o$*, 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.*