NMSI Super Problem: Integrated Rate Laws
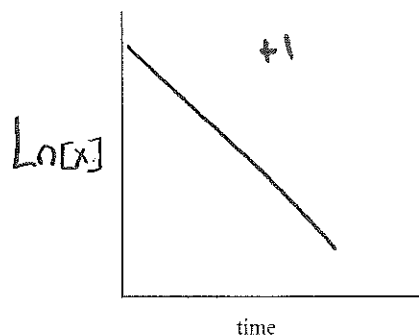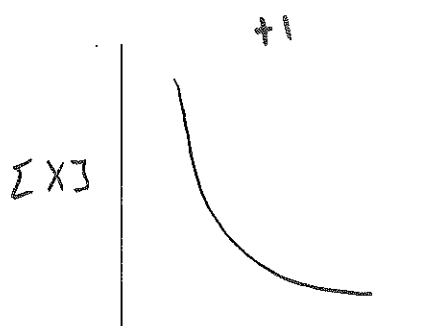
½

Key

The decomposition of substance X was experimentally observed at 25°C and shown to be first order with respect to X. Data from the experiment are shown below.

← on graphing cal

L2	L1
[X] M	Time (min)
0.100	0
0.088	2
0.069	6
0.054	10
0.043	14
0.030	???

+1

[X]

+1

Ln[X]

time

← from graphing cal

a. For each of the graphs above

   +1 ✓ i. Sketch the expected curve based on the labeled axes. You do not need to plot the exact data.

   ii. Write the rate law for the decomposition of substance X.
   +1   Ln[X] is the straight Line so 1st order   Rate = K[X]

   iii. Explain how one of the two graphs above can be used to determine the rate constant, k. Be sure
   to specify which graph. The slope of the straight line for Ln[X]
   +1   vs time is equal to the Rate Constant K   slope = -K

b. Based on the above data

   i. Calculate the rate constant for this reaction. Be sure to include units.
   From graphing calculator looking at linear regression   y = A + bx
   b is slope   K = -.0604 min^{-1} unit M $\cdot$ n
   mo   n=1

   ii. How many minutes will it take for [X] to become 0.030 M?
   min = ? @ $[A]_t$ = 0.030 M

   1st order $\ln[A]_t - \ln[A_0] = -Kt$
   $\ln[0.030 M] - \ln[0.100 M] = -(-0.0604)t$ +1

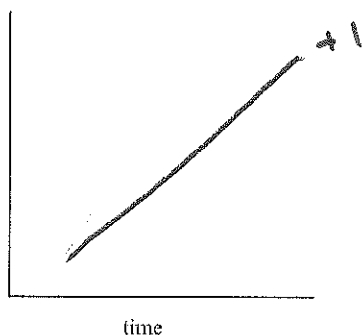 $t = 19.9$ min   +1 for correct substitution

In a different experiment, the decomposition of substance Y at 50°C was determined to have the following rate law.

$$\text{Rate} = k\,[Y]^2$$

← 2nd order

[handwritten diagrams: 0, 1, 2]

+1 $\dfrac{1}{[Y]}$ [graph with time on x-axis, +1]

time

c. On the axes above

   i. Sketch the graph that is expected to provide a linear relationship when plotted against time. Be sure to label the y-axis.

   ii. What does the slope of this line represent?

   +1 Slope = k

d. The temperature of this reaction was increased from 50°C to 100°C. Predict the effect this would have on each of the following.

   i. Rate of the reaction The 50°C increase in temp will increase the Rate of the Reaction

   ii. Rate constant, k

   +1 The Rate K will Increase

e. Sketch the graph of the reaction at 100°C on the plot in part (c)

   ← greater positive slope due to ↑ temp +1

   $\dfrac{1}{[Y]}$ [graph with two lines, time on x-axis, +1]

   time