Department of Chemistry
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Name:________________

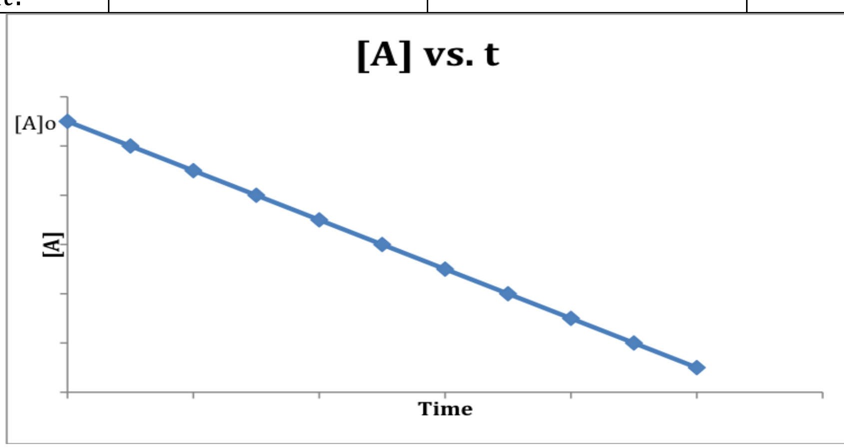
Kinetics Unit Activity – Chemical Kinetics II KEY

The purpose of this activity is to develop concepts of chemical kinetics: Specifically to deepen your understanding and familiarity with some integrated rate equations.

Complete the following table for the reactions in which the rate law depends on the concentration of A for the following:

	0 order	**1st order**	**2nd order**
Rate law	Rate = k	Rate = k[A]	Rate = $k[A]^2$
Integrated rate	$[A] = [A]_0 - kt$	$[A]_t = [A]_0 e^{-kt}$ $\ln[A]_t = -kt + \ln[A]_0$	$4.762 = (2.36 \times 10^{-2})t$
Half life	$t_{1/2} = \frac{[A]_0}{2k}$	$t_{1/2} = \frac{\ln(2)}{k}$	$t_{1/2} = \frac{1}{k[A]_0}$

	0 order	**1st order**	**2nd order**
Plot to determine the order of a reaction. Determine what should be plotted on the y-axis for each type of rate law. Time will be on the x- axis for each. Sketch the plot that gives the straight line, and indicates the order of the rate law.	[A] vs. t	ln[A] vs. t	$\frac{1}{[A]}$ vs. t
Slope of line plotted will equal what?	-k	-k	k



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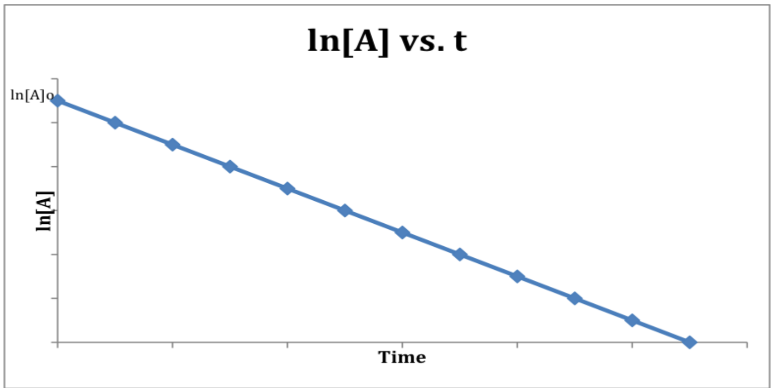

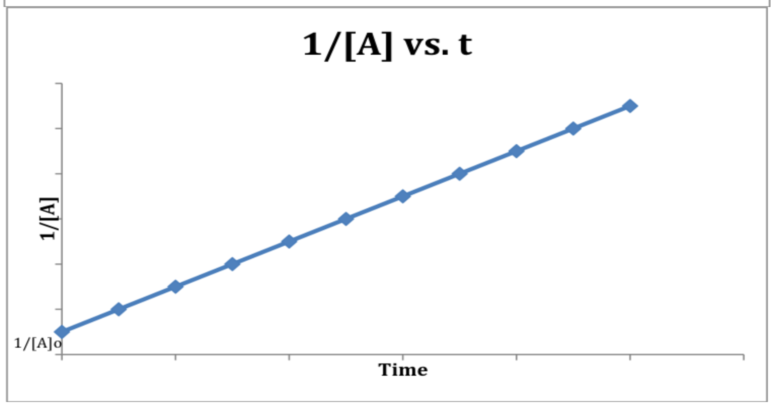

1. The decomposition of N_2O follows first-order kinetics. This means

$$N_2O(g) \rightarrow N_2(g) + \frac{1}{2}O_2(g)$$

(the rate of decomposition of N_2O) = k[N_2O]
If an initial sample has a concentration of 0.20 M, what is the concentration after 100 ms given the rate constant for this reaction is k = 3.4 s^{-1} (at 780°C)?
$[A](t) = [A]_0e^{-kt}$
$[A] = (0.2M)e^{-(3.4)(0.1)}$
[A] = 0.14 M

2. Using the following data decide if the decomposition of N_2O_5 is first order. How would you determine the value of the rate constant, k, from this data?

T(min)	$[N_2O_5]_t$ (M)	$\ln[N_2O_5]_t$
0	15×10^{-3}	-4.2
200	9.6×10^{-3}	-4.6
400	6.2×10^{-3}	-5.1
600	4.0×10^{-3}	-5.5
800	2.5×10^{-3}	-6.0
1000	1.6×10^{-3}	-6.4

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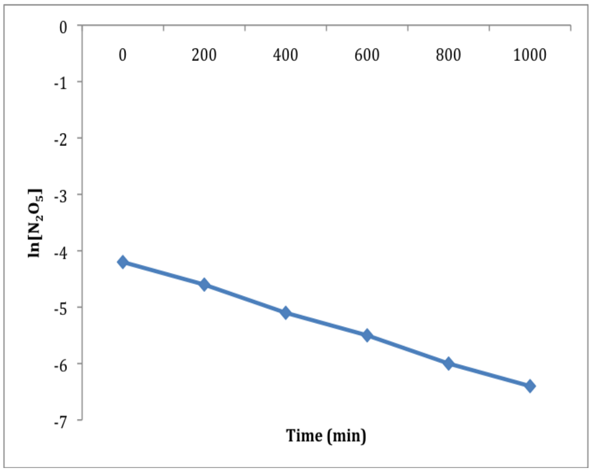

If we plot the natural log of N_2O_5 against time, a fairly linear relationship is observed. Therefore, we can conclude that this is a first order reaction. We could determine k by finding the slope of this linear relationship and multiplying it by negative one.

3. How long will it take for the concentration of "A" to decrease to 1.0 % of its initial value in a first order reaction of the form A→ products with k = 1.0 s^{-1}?

Let's say that I have 100 kg of A. After a certain amount of time I will be left with 1% of 100 kg or 1 kg.

OR rearrange to put [A] over $[A]_0$ such that you can use a ratio of the two concentrations

Then...

$[A]_t = [A]_0 e^{-kt}$

$$\frac{[A]}{[A]_0} = e^{-kt}$$

$$\frac{1}{100} = 0.01 = e^{-(1.0)t}$$

$\ln(0.01) = -t$

4.6 s = t

4. Pu-239 has a half-life of 24, 000 years. It is a by-product of nuclear power plants. How many years must pass before the radioactivity drops to 30 % of its initial value.

Half-lives are first order kinetics, so we can use first-order concepts to help us.
Before we can jump into the integrated rate law, we need to find the value of k.

$$t_{1/2} = \frac{\ln(2)}{k}$$

$$24000 = \frac{\ln(2)}{k}$$

$k = 2.888 \times 10^{-5}$

Now we can use the first-order rate law to find time, t. Let's say that I have 100 g of Pu-239. After a certain amount of time I will be left with 30% of 100 g or 30 g.
OR rearrange to put [Pu] over $[Pu]_0$ such that you can use a ratio of the two concentrations

$[A](t) = [A]_0 e^{-kt}$

$$\frac{[A]}{[A]_0} o= e^{-kt}$$

$$\frac{30}{100} = 0.3 = e^{-(2.888x10-5)t}$$

$\ln(0.3) = -2.888 \times 10^{-5} t$

t = 41687 years

5. A particular reaction is second order with respect to a reactant A (and zeroth order with respect to all other reactants). The rate constant for this reaction is $k = 2.36 \times 10^{-2}\ M^{-1}\ s^{-1}$. Given the initial concentration of A, $[A]_0 = 0.84$ M, calculate the time needed for the concentration of A to decrease to 20 % of its original value.

Now we have a defined starting amount, so we no longer have to imagine that we have 100g or 100kg of the substance. We can find 20% of 0.84 M by multiplying 0.84 M by 0.2. After a certain amount of time the concentration of A would reach 20% of 0.84 M or 0.168 M.

$$\frac{1}{[A]} = \frac{1}{[A]_0} + kt$$

$$\frac{1}{0.168} = \frac{1}{0.84} + (2.36 \times 10^{-2})t$$

$$\frac{1}{0.168} - \frac{1}{0.84} = (2.36 \times 10^{-2})t$$

$$4.762 = (2.36 \times 10^{-2})t$$

201.8 seconds = t