

Name _____
Kinetics: Time (Integrated rate Law)

Integrated Rate law

- Using the integrated rate laws students will be able to solve for various concentrations and times as a reaction progresses.
- Students will be able to describe and calculate half-lives of 1st order reactions.
- Students will be able to graph each type of order of reactions.
- Students will be able to determine the order of a reaction based on the graphical representations.

1. (Brady587) Dinitrogen pentoxide, N_2O_5 , is not very stable. In the gas phase or dissolved in a non-aqueous solvent, like carbon tetrachloride, it decomposes by a first order reaction into N_2O_4 and O_2 .
 $2N_2O_5 \rightarrow 2N_2O_4 + O_2$ Rate = $k[N_2O_5]$

At 45C, the rate constant for the reaction in carbon tetrachloride is $6.22E-4$ /s. If the initial concentration of N_2O_5 in the solution is 0.100M, how many minutes will it take for the concentration to drop to 0.0100M?

$$\ln [] = -kt + \ln []$$

$$\ln [0.1] = -6.22E-4(t) + \ln [0.01]$$

$$t = 3701 \text{ sec} / 60 = \boxed{61 \text{ min}}$$

2. (Brady590) Nitrosyl Chloride, $NOCl$, decomposes slowly to NO and Cl_2 . The rate constant equals 0.020 L/mol s at a constant temperature. If the initial concentration of $NOCl$ in a closed reaction vessel is 0.050 M, what will be the concentration after 30 minutes. The reaction is second order.

2nd order sec $\frac{1}{[]} = kt + \frac{1}{[]}$ $\frac{1}{[]} = 0.02 \frac{t}{(1800 \text{ s})} + \frac{1}{[0.05]}$

3. (Chang521) The conversion of cyclopropane to Propene in the gas phase is a first order reaction with a rate constant of $6.7E-4$ (1/sec)

- If the initial concentration of cyclopropane was .25M, what is the concentration after 8.8 min?
- How long will it take cyclopropane to decrease in concentration from .25M to .15M.
- How long will it take to convert 74% of the starting material?

2 half lives

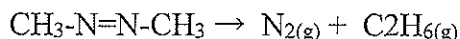
$$\ln [] = -kt + \ln []$$

a) $\ln () = -6.7E-4(528) \ln(0.25)$
 $[] = 0.175$

b) $\ln 0.15 = -6.7E-4(t) + \ln(0.25)$
 $t = 762 \text{ sec.}$

$\ln(0.065) = -6.7E-4(t) + \ln(0.25)$
 $t = 2010 \text{ sec}$

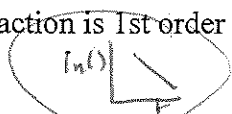
4. (Chang523) The rate of decomposition of azomethane is studied by monitoring the partial pressure of the reactant as a function of time.



The data obtained at 300°C is shown below:

Time (s)	partial pressure (mmHg Azomethane)	ln partial pressure	1/partial pressure
0	284	5.64	0.0035
100	220	5.39	0.0045
150	193	5.26	0.0051
200	170	5.13	0.0058
250	150	5.01	0.0066

- a) Confirm this reaction is 1st order using the data provided?



which Relationship is linear

- b) Determine the K for this reaction.

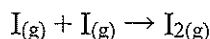
Several ways = Slope = K

$$.25/50 = 0.005$$

$$\text{or use } \ln(\dots) = -kt + \ln(\dots)$$

$$K =$$

5. (Chang527)



This reaction follows second-order kinetics and has a high rate constant of $7.5 \times 10^7 \text{ M}^{-1}\text{s}^{-1}$ at 23°C.

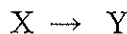
- a. If the initial concentration of I was 0.086M, calculate the concentration after 2.0 min.

→ went to completion, $\frac{1}{[I]} = \frac{1}{0.043\text{M}}$ (of I_2 at 2 min)

- b. What is the initial rate of the reaction if the $\text{I} = 0.00500\text{M}$?

$$\text{I.R.} = k[\text{I}]^2$$

$$7.5 \times 10^7 (0.086)^2 = 5.5 \times 10^7 \frac{\text{M}}{\text{s}}$$



6. A chemical reaction is proceeding in a single step reaction as see above. If the concentration of X decomposes from 0.8 to 0.6 in 25 min. Answer the following questions.

- a. What is the order of the reaction? 1st

- b. What is the K for this reaction?

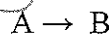
$$\ln(0.6) = -k(25) + \ln(0.8)$$

- c. What is the half life of this reaction?

$$k = 1.15$$

$$\frac{1.693}{k} = t_{1/2}$$

$$t = 1.47 \text{ min}$$



7. A reaction as listed above is a single step reaction and has a half-life of 30 seconds. Answer the following questions.

- a. If A starts at 0.5M, What is the concentration after 1 minute?

$$.5 \rightarrow .25 \rightarrow .125$$

- b. If A starts at 0.5M, what is the concentration of A after 2 half lives?

$$.125$$

- c. What is the K value?

$$\frac{1.693}{t_{1/2}} = k_{1/2}$$

$$\frac{0.693}{30} = 0.0231 = k$$