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[.1] = -6.22E-4(t) + ln[0.01]

   t = 3701 sec/60 = 61 min

2. (Brady590) Nitrosyl Chloride, NOCl, decomposes slowly to NO and Cl_2. The rate constant equals 0.020L/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   1800 sec

   $\frac{1}{[\ ]} = Kt + \frac{1}{[\ ]}$ $\frac{1}{?} = 0.02t_{(1800)} + \frac{1}{[.05]}$

   ? = 0.0175 M

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

   ln( ) = -kt + ln( )

   a) ln( ) = -6.7E-4(528) ln(0.25)

   [ ] = 0.175

   b) ln 0.15 = -6.7E-4(t) + ln(.25)

   t = 762 sec.

   2 half lives

   ln(0.065) = -6.7E-4(t) + ln(.25)

   t = 2010 sec

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

$CH_3\text{-}N\text{=}N\text{-}CH_3 \rightarrow N_{2(g)} + C_2H_{6(g)}$

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 or use $\ln[\,] = -Kt + \ln[\,]$ K =

5. (Chang527)

$$I_{(g)} + I_{(g)} \rightarrow I_{2(g)}$$

This reaction follows second-order kinetics and has a high rate constant of 7.5E9 /M*s at 23°C.

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

→ went to completion, $\frac{1}{2}$ = .043M of I_2 at 2 min

b. What is the initial rate of the reaction if the I = 0.00500M?

$\frac{1}{[\,]} = Kt + \frac{1}{[\,]}$

I_0 Rate = $K[I]^2$

$7.5E9[0.086]^2 = 5.5E7$ mol/L·s

$$X \rightarrow Y$$

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

$\ln[.6] = -K(.25) + \ln(.8)$

K = 1.15

$\frac{.693}{K} = t_{1/2}$ t = .602 min

$$A \rightarrow B$$

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 → .25 → .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?

$\frac{.693}{t_{1/2}} = K_{1/2}$ $\frac{0.693}{30} = 0.0231 = K$