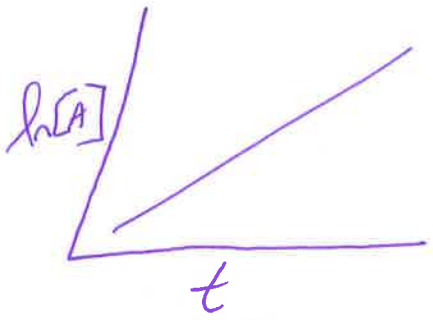
AP Chemistry
KINETICS REVIEW

First Order

Rate Law: $Rate = k[A]$

Integrated Rate Law: $\ln[A]_t = -kt + \ln[A]_0$



slope = $-k$

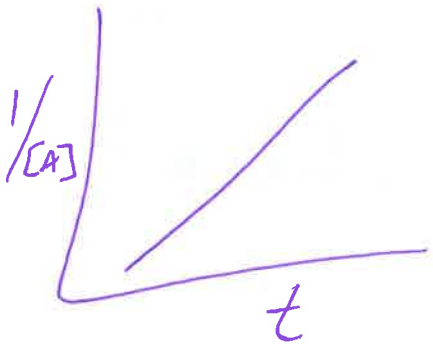
y-int = $\ln[A]_0$

$t_{1/2} = \frac{0.693}{k}$

Second Order

Rate Law: $Rate = k[A]^2$

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



slope = k

y-int = $\frac{1}{[A]_0}$

$t_{1/2} = \frac{1}{k[A]_0}$

Zero Order

RL: $Rate = k[A]^0 = k$

IRL: $[A]_t = -kt + [A]_0$

slope = $-k$

y-int = $[A]_0$

$t_{1/2} = \frac{[A]_0}{2k}$

Example:

The reaction of butyl-bromide $(CH_3)_3CBr$ with water is represented by the equation:

$$(CH_3)_3CBr + H_2O \rightarrow (CH_3)_3COH + HBr$$

The following data were obtained from three experiments using the method of initial rates:

$Rate = k[(CH_3)_3CBr]^m[H_2O]^n$

	Initial $[(CH_3)_3CBr]$ mol L^{-1}	Initial $[H_2O]$ mol L^{-1}	Initial rate mol $L^{-1}min^{-1}$
Experiment 1	5.0×10^{-2}	2.0×10^{-2}	2.0×10^{-6}
Experiment 2	5.0×10^{-2}	4.0×10^{-2}	2.0×10^{-6}
Experiment 3	1.0×10^{-1}	4.0×10^{-2}	4.0×10^{-6}

a. What is the order with respect to $(CH_3)_3CBr$?
b. What is the order with respect to H_2O?
c. What is the overall order of the reaction?
d. Write the rate equation.
e. Calculate the rate constant k for the reaction, including units.
f. What is the half life of this reaction?

$\frac{Ex1}{Ex2} = \frac{2\times10^{-6} = k(5\times10^{-2})^m(2\times10^{-2})^n}{2\times10^{-6} = k(5\times10^{-2})^m(4\times10^{-2})^n}$

$\frac{Ex2}{Ex1} = \frac{2\times10^{-6} = k(5\times10^{-2})^m(4\times10^{-2})^n}{2\times10^{-6} = k(5\times10^{-2})^m(2\times10^{-2})^n}$

$1 = 2^n$

$n = 0$

$\frac{Ex3}{Ex2} = \frac{4\times10^{-6} = k(1\times10^{-1})^m(4\times10^{-2})^0}{2\times10^{-6} = k(5\times10^{-2})^m(4\times10^{-2})^0}$

$2 = 2^m \quad m = 1$

a) 1st

b) 0

c) 1st

d) $Rate = k[(CH_3)_3CBr]$

e) $4\times10^{-6}\ mol/L\ min = k\left(1\times10^{-1}\ \frac{mol}{L}\right)$ $\boxed{k = 4\times10^{-5}\ min^{-1}}$

f) $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{4\times10^{-5}} = \boxed{17325\ min}$

Example:

The decomposition of ozone in the upper atmosphere to dioxygen occurs by a two-step mechanism. The first step is a fast reversible step and the second is a slow reaction between an oxygen atom and an ozone molecule:

Step 1:	$O_3(g) \leftrightarrow O_2(g) + O(g)$	Fast equilibrium
Step 2:	$O_3(g) + O(g) \rightarrow 2O_2(g)$	Slow

a. Which is the rate determining step?

c. Write the rate equation for the overall reaction.

a) Step 2 (slowest step)

b) $Rate = k[O_3][O]$

$K = \frac{[O][O_2]}{[O_3]}$ $\quad [O] = \frac{K[O_3]}{[O_2]}$

$$Rate = k'[O_3]^2[O_2]^{-1}$$