

11: KINETICS PROBLEMS

Differential Rate Law: rate of change over time

Integrated Rate Law: concentration as function of time

Order	Diff. Rate Law	Int. Rate Law
0 th	$\frac{d[A]}{dt} = -k$	$A(t) = A_0 - kt$
1 st	$\frac{d[A]}{dt} = -k[A]$	$A(t) = A_0 e^{-kt}$
2 nd	$\frac{d[A]}{dt} = -k[A]^2$	$A(t) = \frac{A_0}{1 + ktA_0}$

① Show that:

- $[A]$ vs t if 0th order.
- $\ln [A]$ vs t if 1st order.
- $\frac{1}{[A]}$ vs t if 2nd order.

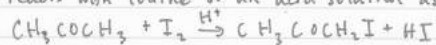
using the Integrated Rate Laws.

② The half-life of a 1st order reaction is $\frac{\ln 2}{k}$. Prove this using the integrated rate law.

③ If half-life of a reaction increases as initial reactant concentration increases, reaction order is

- A. zero C. second
B. first D. third

④ Propanone reacts with iodine in an acid solution as shown:



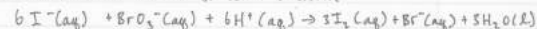
These data were obtained when this reaction was studied:

$[\text{CH}_3\text{COCH}_3]$ (M)	$[\text{I}_2]$ (M)	$[\text{H}^+]$ (M)	Relative Rate
0.010	0.010	0.010	1
0.020	0.010	0.010	2
0.020	0.020	0.010	2
0.020	0.010	0.020	4

What is the rate equation (differential) for this reaction?

Bromate ion

⑤ ~~Propanone~~ reacts with iodine in acid solution:



This data was obtained when this reaction was studied:

$[\text{I}^-]$ (M)	$[\text{BrO}_3^-]$ (M)	$[\text{H}^+]$ (M)	Rate (mol·L ⁻¹ ·s ⁻¹)
0.0010	0.0020	0.010	8.0×10^{-5}
0.0020	0.0020	0.010	1.6×10^{-4}
0.0020	0.0040	0.010	1.6×10^{-4}
0.0010	0.0040	0.020	1.6×10^{-4}

What are the units of the rate constant for this reaction?

- A. s⁻¹ C. L·mol⁻¹·s⁻¹
B. mol·L⁻¹·s⁻¹ D. L²·mol⁻¹·s⁻¹

⑥ For reaction $A \rightarrow B$, rate law is rate = $k[A]$ (first order).

If the reaction is 40.0% complete after 50.0 min, what is the rate constant, k ?

- A. $8.00 \times 10^{-3} \text{ min}^{-1}$ C. $1.39 \times 10^{-2} \text{ min}^{-1}$
B. $1.02 \times 10^{-2} \text{ min}^{-1}$ D. $1.83 \times 10^{-2} \text{ min}^{-1}$

⑦ CHALLENGE PROBLEM:

Given generic reaction:

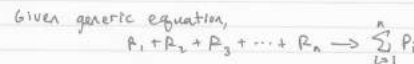


and experimental data:

$[A]$ (M)	$[B]$ (M)	Relative Rate
a	b	c
d	e	f

⑧ Derive a rate equation $k = [A]^m [B]^n$ for constants m and n written as functions of a, b, c, d, e , and/or f .

⑨ Let $R_n =$ reactants and $\sum_{i=1}^n P_i =$ all of the products
Let $m_n =$ order of reaction with respect to reactant R_n



how many unique experimental trials using unique initial reactant concentrations do you need to determine m_n for all R_n in this reaction?