

UNIT7-DAY5-LaB1230pm

Thursday, March 28, 2013
8:06 AM

Thinking Like a Chemist About Kinetics II

UNIT7 DAY5

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What are we going to learn today?

Investigating Integrated Rate Law

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IMPORTANT INFORMATION

HW9 due Tue 9 AM

LM 29... Question was killed

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Quiz: Clicker Question 1

The rate constant for a mystery reaction is $4.5 \times 10^{-3} \text{ M s}^{-1}$. By what order does this reaction proceed?

a) 0 order $\text{Rate } \left(\frac{\text{M}}{\text{s}}\right) = k [\text{A}]^x [\text{B}]^y$
 b) 1st order
 c) 2nd order
 d) 3rd order

\uparrow
 $\frac{\text{M}}{\text{s}}$ same as the rate!

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Kinetics – Review from Last time

Imagine the following reaction occurring in one elementary step:

$$\text{CH}_3\text{Br} + \text{OH}^- \longrightarrow \text{CH}_3\text{OH} + \text{Br}^-$$

<p>Macroscopic</p> $\frac{-\Delta[\text{CH}_3\text{Br}]}{\Delta t} = \frac{-d[\text{CH}_3\text{Br}]}{dt} = \text{RATE}$ <p>Measured in lab</p>	<p>Microscopic</p> $= k[\text{CH}_3\text{Br}]^x[\text{OH}^-]^y$ <p>Tells us about "how" The reaction occurs</p>
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rate law indicates how rate is dependent on concentration

- Affect Rate
- 1) Medium
 chunk vs solution
 vs crushed
 solid vs gas
 - 2) Concentration
 - 3) Temperature
 - 4) Catalyst
-] Next week!

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Integrated rate laws (the concentration as a function of time)

We need a situation in which either

1. The rate law depends on only one reactant

2) If. Only one reactant is changing much in concentrations, so effectively only one concentration is changing

the math and analysis for only one concentration is doable

Integrated Rate Law

First order.

The rate of the reaction is directly proportional to the concentration of one of reactant

For a generic reaction let's call that reactant "A"

$$\frac{-d[A]}{dt} = \text{RATE} = k[A]$$

Review from LM

Integrated Rate Law

First order.

Integrated Rate Law

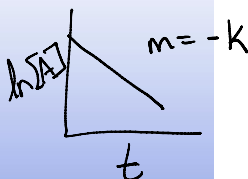
$$[A]_t = [A]_0 e^{-kt}$$

Half life:

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

$$y = mx + b$$

$$\ln[A] = -kt + \ln[A]_0$$



$$\ln \frac{[A]_t}{[A]_0} = -kt$$

Rearrange linear line on graph

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

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Rearrange depending on question

Fill out table on activity organize your understanding

TABLE 15.6 Summary of the Kinetics for Reactions of the Type $aA \rightarrow$ Products That Are Zero, First, or Second Order in $[A]$

	Order		
	Zero	First	Second
Rate law	Rate = k	Rate = $k[A]$	Rate = $k[A]^2$
Integrated rate law	$[A] = -kt + [A]_0$	$\ln[A] = -kt + \ln[A]_0$	$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$
Plot needed to give a straight line	$[A]$ versus t	$\ln[A]$ versus t	$\frac{1}{[A]}$ versus t
Relationship of rate constant to the slope of straight line	Slope = $-k$	Slope = $-k$	Slope = k
Half-life	$t_{1/2} = \frac{[A]_0}{2k}$	$t_{1/2} = \frac{0.693}{k}$	$t_{1/2} = \frac{1}{k[A]_0}$

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Poll: Clicker Question 2

Refer to Activity Q1. What is the concentration of N_2O after 100 ms?

- a) 0.34 M
- b) 0.24 M
- c) 0.14 M
- d) I have not mastered this skill and cannot get the answer without help.

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Poll: Clicker Question 3

Refer to Activity Q2: The value of the k could be determined:

- a) By using this data in the rate law equation applying the method of initial rates and solving for k
- b) By taking the natural log of all the values and then taking the difference between natural log and concentration at time, t
- c) By determining the slope of the line from a plot of $\ln[N_2O_5]$ versus time.
- d) By determining the slope of the line from a plot of $\ln[N_2O_5]$ versus time. The value of k would be the opposite of the

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Poll: Clicker Question 4

Refer to Activity Q3: How long will it take A to decrease to 1% of starting amount?

- a) 0 seconds
- b) 5 seconds
- c) 100 seconds
- d) I have not mastered this skill enough to figure out how to work this problem.

✓ $\ln\left(\frac{1}{10}\right) = -kt$

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Poll: Clicker Question 5

Refer to Activity Q4: How many years will it take the isotope to drop to 30% of original amounts?

- a) 24,000 yrs
- b) 36,200 yrs
- c) 41,660 yrs
- d) 43,580 yrs
- e) 48,000 yrs

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Poll: Clicker Question 6

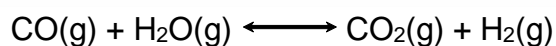
Refer to Activity Q5: How much time passes to reduce starting concentration to 20% of original amount?

- a) 41 seconds
- b) 82 seconds
- c) 160 seconds
- d) 202 seconds

Refer to Activity Q5: How much time passes to reduce starting concentration to 20% of original amount?

- a) 41 seconds
- b) 82 seconds
- c) 160 seconds
- d) 202 seconds
- e) I have not mastered this skill enough to solve this problem.

Do on your own

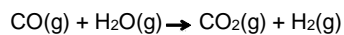


The rate law for this reaction is

$$\text{rate} = k[\text{H}_2\text{O}][\text{CO}]$$

it is first order in H₂O and first order in CO

Overall: 2nd order

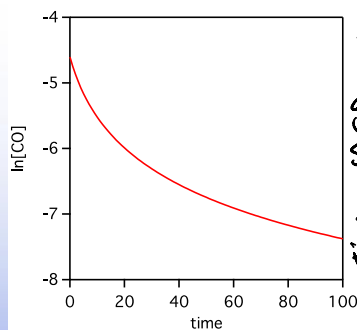


$$\text{rate} = k[\text{H}_2\text{O}][\text{CO}]$$

$$[\text{CO}]_0 = 0.01\text{M}$$

$$[\text{H}_2\text{O}]_0 = 0.01\text{M}$$

$$-\frac{d[\text{CO}]}{dt} = -\frac{d[\text{H}_2\text{O}]}{dt}$$



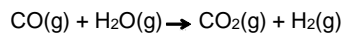
You only get a straight line if only 1 changes

Why is the plot of ln[CO] not a straight line?

- A. It is not 1st order in [CO]
- B. Both [CO] and [H₂O] are changing
- C. It is 2nd order in [CO]
- D. The [CO] is changing at a different rate than H₂O

Rates are the same Both concentrations change

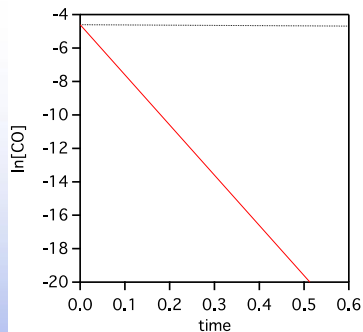
Poll: Clicker Question 7



$$\text{rate} = k[\text{H}_2\text{O}][\text{CO}]$$

$$[\text{CO}]_0 = 0.01\text{M}$$

$$[\text{H}_2\text{O}]_0 = 2.00\text{M}$$

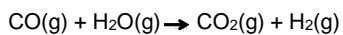


Why is the plot of $\ln[\text{CO}]$ now a steep straight line?

- A. $[\text{H}_2\text{O}]$ is nearly constant
 - B. $[\text{H}_2\text{O}]$ is changing faster than $[\text{CO}]$
 - C. The reaction is 2nd order in $[\text{CO}]$
 - D. The reaction is 0 order in $[\text{CO}]$
- Rate is the same*

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Poll: Clicker Question 8



For the initial conditions of

$$[\text{CO}]_0 = 0.01\text{M}$$

$$[\text{H}_2\text{O}]_0 = 2.00\text{M}$$

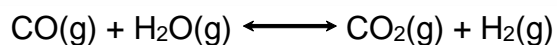
Limiting Reagent

What is the concentration of $[\text{H}_2\text{O}]$ at very long times (when the reaction has "gone to completion")

- A. 0.01 M
- B. 2.00 M
- C. 1.99 M
- D. $\ln(.01)$ M

Small

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What if we started with a whole lot of H_2O compared to CO ?

~~The $[\text{H}_2\text{O}] \sim \text{constant}$ (since there is so much of it)~~

Now we can combine the $[\text{H}_2\text{O}]$ with k (since both are constant)

~~and write the rate law as~~
~~rate = $k[\text{H}_2\text{O}][\text{CO}] = k'[\text{CO}]$~~ ~~$k' = k[\text{H}_2\text{O}]$~~

we now say the reaction is **pseudo-first order** in CO

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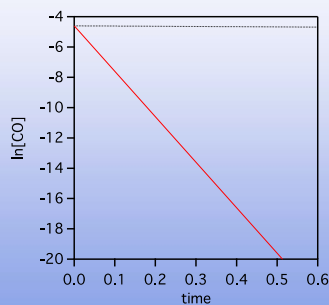


$$\text{rate} = k[\text{H}_2\text{O}][\text{CO}] = k'[\text{CO}]$$

we now say the reaction is **pseudo-first order** in CO

Determine k' from a plot of $\ln[\text{CO}]$ vs time

Determine k from k' since we know the $[\text{H}_2\text{O}]$



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Learning Outcomes

Apply integrated rate equations to solve for the concentration of chemical species during reaction of different orders.

Apply the concept of half life to kinetics problems

Understand and interpret pseudo first order kinetics data

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