UNIT7-DAY4-LaB1230

Monday, March 25, 2013
11:51 AM

Thinking Like a Chemist About Kinetics I

UNIT 7 DAY4

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What are we going to learn today?

Reaction Rates and the Rate Law

Method of Initial Rates

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IMPORTANT INFORMATION

LM28 & LM29 due Th 9AM

IMPORTANT INFORMATION

LM28 * & LM29 * due Th 9AM

Talk to LaB or VDB if you are interested in UGTA

application online!

HW 8 #34 withdrawn

↳ will be in HW9

Dr. McCord covered it already...

Piazza confusion ?

Quiz: Clicker Question 1

Assume electron

Hydrogen-3 (tritium, H-3) is sometimes formed in the primary coolant water of a nuclear reactor. Tritium is a beta emitter with a $t_{1/2}$ = 12. 3 years. For a given sample containing tritium, after how many years will only about 12% of the sample remain?

A)12.3 years
B)24.6 years
C)36.9 years
D)49.2 years
E)61.5 years

$100 \xrightarrow{t_{1/2}} 50 \xrightarrow{t_{1/2}} 25 \xrightarrow{t_{1/2}} 12.5$

$3 \times 12.3 = 36.9$ yr

Kinetics

Kinetics is about how fast chemical reactions occur.

Industry
medicine & more!

Measuring the rates of reactions (macroscopic) gives us insight into the way reactions are actually happening (microscopic)

mechanism of change

START ACTIVITY!

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Average, Instantaneous, Initial, Reaction Rate

$2NO_2(g) \rightarrow 2NO(g) + O_2(g)$

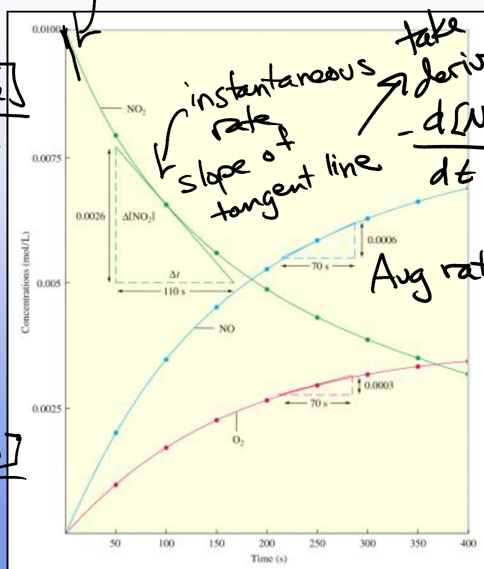
Rxn rate per mole Rxn $= -\frac{\Delta[NO_2]}{2\Delta t} = \frac{\Delta[NO]}{2\Delta t} = \frac{\Delta[O_2]}{\Delta t}$

2 mol NO_2 = 1 mol rxn

1 mol O_2 = 1 mol rxn

Divide by molar coefficient to normalize rates

Avg Rate $= \frac{[NO]_f - [NO]_i}{t_f - t_i} = \frac{\Delta[NO]}{\Delta t}$



instantaneous rate
slope of tangent line
take derivative $-\frac{d[NO_2]}{dt}$

Avg rate

Initial Rate at t = 0
Best to Define & compare
you can define concentrations with confidence

Check in

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Kinetics

Imagine the following reaction

$CH_3Cl + OH^- \longrightarrow CH_3OH + Cl^-$

Macroscopic | Microscopic

$$\frac{-\Delta[CH_3Cl]}{\Delta t} = \frac{-d[CH_3Cl]}{dt} = RATE = k[CH_3Cl]^1[OH^-]^1$$

Avg → (Δ) ; instant → (d)

Measured in lab

Tells us about "how" The reaction occurs

1st order in CH_3Cl ; 1st order in OH^-

OVERALL 1+1 = 2 ; 2nd order

Check at end of activity

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Similar but different reaction:

Imagine the following reaction

$(CH_3)_3CBr + OH^- \longrightarrow (CH_3)_3COH + Br^-$

Macroscopic | Microscopic

What order??

$$\frac{-\Delta[(CH_3)_3CBr]}{\Delta t} = \frac{-d[(CH3)_3CBr]}{dt} = RATE = k[(CH_3)_3Br]^x[OH^-]^y$$

NEED DATA

Avg → (Δ) ; instant → (d)

Measured in lab

Tells us about "how" The reaction occurs

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Poll: Clicker Question 2

Method of Initial Rates-Empirically Determine Rate Law

$(CH_3)_3CBr + OH^- \longrightarrow (CH_3)_3COH + Br^-$

What is the rate law for this reaction?

Experiment	$[(CH)_3CBr]_o$	$[OH^-]_o$	initial rate ($M\ s^{-1}$)
1	0.1M	0.1M	2.5×10^{-3}
2	0.2M	0.1M	5.0×10^{-3}
3	0.1M	0.2M	2.5×10^{-3}

2x 2x nothing

What is the rate law for this reaction?

Experiment	$[(CH)_3CBr]_o$	$[OH^-]_o$	initial rate ($M\ s^{-1}$)
1	0.1M	0.1M	2.5×10^{-3}
2	0.2M	0.1M	5.0×10^{-3}
3	0.1M	0.2M	2.5×10^{-3}

A. Rate = $k[(CH_3)_3CBr][OH^-]$
B. Rate = $k[(CH_3)_3CBr][OH^-]^2$
C. Rate = $k[(CH_3)_3CBr]^2[OH^-]$
D. Rate = $k[(CH_3)_3CBr]$
E. Rate = $k[OH^-]$

Poll: Clicker Question 3

Method of Initial Rates-Empirically Determine Rate Law

$$A + 2B \longrightarrow C$$

The reaction is what order in B?

Experiment	$[A]_o$	$[B]_o$	initial rate ($M\ s^{-1}$)
1	0.1M	0.1M	2.73
2	0.15M	0.1M	6.14
3	0.1M	0.2M	2.74

A. 0
B. 1
C. 1.5
D. 2
E. 3

Method of Initial Rates

Poll: Clicker Question 4

Method of Initial Rates-Empirically Determine Rate Law

$$A + 2B \longrightarrow C$$

The reaction is what order in A?

Experiment	$[A]_o$	$[B]_o$	initial rate ($M\ s^{-1}$)
1	0.1M	0.1M	2.73
2	0.15M	0.1M	6.14
3	0.1M	0.2M	2.74

A. 0
B. 1
C. 1.5
D. 2
E. 3

Exp2 $\frac{6.14}{2.73} = \frac{k[.15]^x[.1]^y}{k[.1]^x[.1]^y}$ Exp1

$2.245 = \left(\frac{0.15}{0.1}\right)^x = 1.5^x$

$\ln 2.245 = x \ln 1.5$

$x = 2$

usually small whole #s → guess & check

Method of Initial Rates

Method of Initial Rates

Principles of Chemistry II

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Poll: Clicker Question 5

what is k?

$$A + 2B \longrightarrow C$$

Experiment	$[A]_o$	$[B]_o$	initial rate ($M\ s^{-1}$)
1	0.1M	0.1M	2.73
2	0.15M	0.1M	6.14
3	0.1M	0.2M	2.74

$Rate = k[A]^x[B]^y$

$rate = k[A]^2$

$2.73 = k(0.1)^2$

A. 273 $M^{-1}\ s^{-1}$

B. 27.3 s^{-1}

C. 61.4 s^{-1}

D. 614 $M^{-1}\ s^{-1}$

E. 6.14 $M\ s^{-1}$

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Method of Initial Rates

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Reaction Order

The degree to which the reaction rate is dependent on concentrations of species.

Order of Each Species

Overall Reaction Order

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Poll: Clicker Question 6

The empirical rate law for the reaction

$$CO + H_2O \quad CO_2 + H_2$$

Is $rate = k[CO]^1[H_2O]^1$

This reaction is overall a

$1 + 1 = 2$

A. Zeroth order reaction

B. First order reaction

This reaction is overall a

A. Zeroth order reaction

B. First order reaction

C. Second order reaction

D. Third order reaction

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Poll: Clicker Question 7

The empirical rate law for the reaction

$CO + H_2O \qquad CO_2 + H_2$

Is rate = $k[CO][H_2O]$

This reaction is best described as

A. First order in CO and first order in H_2O

B. First order in CO only

C. Second order in CO

D. Second order in CO and second order in H_2O

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Poll: Clicker Question 8

The empirical rate law for the reaction

$CO + H_2O \quad CO_2 + H_2$

Is rate = $k[CO][H_2O]$

What units will the rate constants have?

A. $M\ s^{-1}$

B. s^{-1}

C. $M^{-1}\ s^{-1}$

D. s^{-2}

Learning Outcomes

Understand the concept of rate of change associated with chemical change, recognizing that the rate of change for a chemical reaction can be determined by experimentally by monitoring the change in concentration of a reactant or product with time.

Be able to identify the reaction order for a chemical change.

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