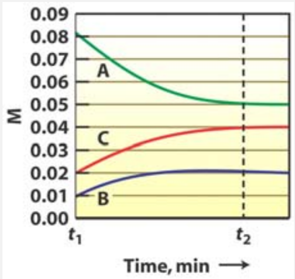


[TP] Chemical kinetics answers the question,

How long will the reaction take?

For the reaction A → B + C, the reaction takes time $t_2 - t_1$ to achieve equilibrium. This elapsed time is …

25% 1. 0.001 min
25% 2. 1 min
25% 3. 100 min
25% 4. Further information needed



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Response Counter

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Lecture 33 CH102 A1 (MWF 9:05 am)

Wednesday, April 18, 2018

Ch18: How long does a reaction take to reach equilibrium?

- The goal of kinetics
- Concentration versus time → $K = k_{for}/k_{rev}$
- Definition of "rate"

Next lecture: Rate vs concentration from experiment. Making sense of rate vs concentration: Reaction mechanism. Making sense of rate constants: The Arrhenius relation.

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The goal of kinetics: How long?

What direction are we going?

$$-T\Delta S_{tot} = \Delta G = RT\ln(Q/K)$$

How far will we go?

$$-T\Delta S°_{tot} = \Delta G° = -RT\ln(K) = \Delta H° - \Delta S°$$

How long to get there?

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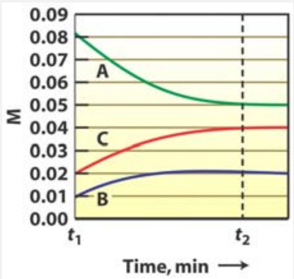

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$$-T\Delta S°_{\text{tot}} = \Delta G° = -RT\ln(K) = \Delta H° - \Delta S°$$

How long to get there?

Chemical Kinetics!

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Concentration vs time → $K = k_{\text{for}}/k_{\text{rev}}$

Consider the reaction A ⇄ B. Assume initially [A] = 1 M but [B] = 0.

How do you expect [A] to change with time?

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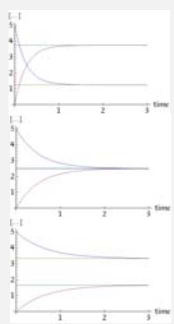
[TP] Consider three different chemical reactions,
reactants ⇄ products
For each reaction, initially [reactant] = 5 and [product] = 0.
Initially, which reaction consumes reactant fastest?



0% 1. Top
0% 2. Middle
0% 3. Bottom

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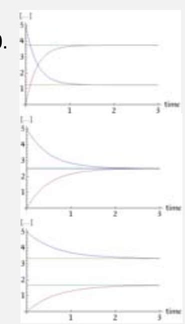
[TP] Consider three different chemical reactions,
reactants ⇄ products
For each reaction, initially [reactant] = 5 and [product] = 0.
Initially, which reaction consumes reactant slowest?



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0% 2. Middle
0% 3. Bottom

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[TP] Consider three different chemical reactions,

reactants ⇄ products

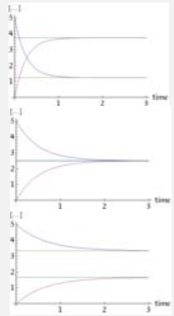
For each reaction, initially [reactant] = 5 and [product] = 0, and yet reactant is consumed at different rates.

This means that …

0% 1. Rate depends only on […]

0% 2. Rate is constant but different for each reaction.

0% 3. Rate depends on […] and something else.



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What does concentration vs time depend on?

The initial rate of a reaction like X → Y is …

$rate_{\text{for}} \propto [\text{X}] = k_{\text{for}}[\text{X}]$

The initial rate of its reverse reaction Y → X is …

$rate_{\text{rev}} \propto [\text{Y}] = k_{\text{rev}}[\text{Y}]$

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[TP] Consider three different chemical reactions,

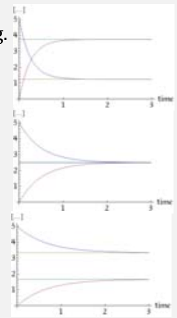
reactants ⇄ products

For each reaction, eventually concentrations stop changing. This means …

0% 1. Reactant is used up.

0% 2. Conversion of reactant to product stops.

0% 3. Something else.



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What does […] versus time depend on?

Concentrations stop changing when the rate of the forward and rate of the reverse reaction balance each other …

$rate_{\text{for}} = rate_{\text{rev}}$

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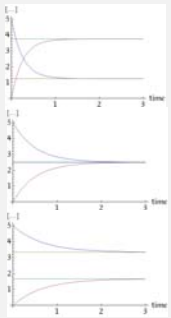
[TP] For X → Y, eventually concentrations stop changing.
This means that $rate_{\text{for}} = rate_{\text{rev}}$ and so that always ...

0% 1. $k_{\text{for}} = k_{\text{rev}}$
0% 2. [X] = [Y]
0% 3. $k_{\text{for}}[\text{X}] = k_{\text{rev}}[\text{Y}]$
0% 4. $k_{\text{for}}[\text{X}]_{\text{e}} = k_{\text{rev}}[\text{Y}]_{\text{e}}$
0% 5. None of these



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What does [...] versus time depend on?

Concentrations stop changing when the rate of the forward and rate of the reverse reaction balance each other ...

$$rate_{\text{for}} = rate_{\text{rev}}$$

Rates match at equilibrium, where concentrations have their equilibrium values.

So rates match when ...

$$k_{\text{for}}[\text{X}]_{\text{e}} = k_{\text{rev}}[\text{Y}]_{\text{e}}$$

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What does [...] versus time depend on?

Rates match at equilibrium, so then concentrations have their equilibrium values, and so at equilibrium

$$k_{\text{for}}[\text{X}]_{\text{e}} = k_{\text{rev}}[\text{Y}]_{\text{e}}$$

Express the equilibrium constant for X → Y in terms of its equilibrium concentrations ...

$$K = [\text{Y}]_{\text{e}} / [\text{X}]_{\text{e}}$$

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What does [...] versus time depend on?

Rates match at equilibrium, so then concentrations have their equilibrium values, and so at equilibrium

$$k_{\text{for}}[\text{X}]_{\text{e}} = k_{\text{rev}}[\text{Y}]_{\text{e}}$$

Express the equilibrium constant for X → Y in terms of its forward and reverse rate constants ...

$$K = k_{\text{for}} / k_{\text{rev}}$$

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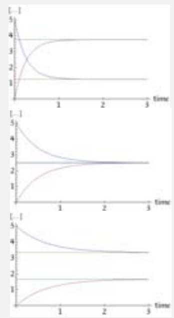
[TP] Consider three different chemical reactions,
reactants ⇄ products
For each reaction, initially [reactant] = 5 and [product] = 0.
Which reaction has the largest k_{for} relative to k_{rev}?

0% 1. Top
0% 2. Middle
0% 3. Bottom



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Lecture 33 CH102 A1 (MWF 9:05 am) Spring 2018

[TP] A ⇄ B has $k_{for} = 10k_{rev}$, C ⇄ D has $k_{for} = 100k_{rev}$, and E ⇄ F has $k_{for} = 0.01k_{rev}$. Which reaction will produce the greatest amount of products relative to reactants?

33% 1. A ⇄ B
33% 2. C ⇄ D
33% 3. E ⇄ F

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Lecture 33 CH102 A1 (MWF 9:05 am) Spring 2018

Definition of "rate"

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Lecture 33 CH102 A1 (MWF 9:05 am) Spring 2018

Definition of rate

"rate" is defined as change in concentration per unit time,

rate =Δ[…]/ Δtime

Think of the analogous quantity "speed" …

change in distance per unit time,

speed = Δdistance / Δtime

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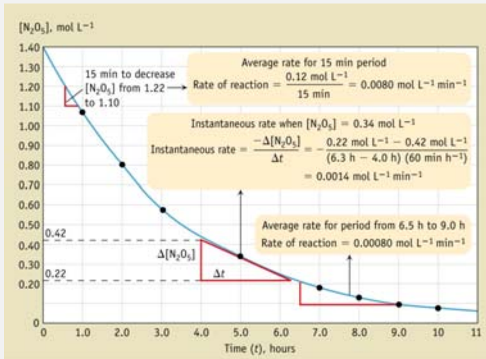
Lecture 33 CH102 A1 (MWF 9:05 am) Spring 2018

$2\ N_2O_5(aq) \rightarrow 4\ NO_2(aq) + O_2(g)$



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Lecture 33 CH102 A1 (MWF 9:05 am) Spring 2018

Definition of rate of reaction

a A + b B → c C ...

rate ...

= −(1/a) d[A] / d*t*

= −(1/b) d[B] / d*t*

= +(1/c) d[C] / d*t*

Rate of reaction = always positive

Rate always has units M/s

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Lecture 33 CH102 A1 (MWF 9:05 am) Spring 2018

[TP] For the reaction

3 A + 4 B → 2 D

at a certain time, [B] is decreasing at 0.012 M/s.

What is the rate of the reaction?

0% 1. 0.012 M/s

0% 2. −0.012 M/s

0% 3. Something else

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Lecture 33 CH102 A1 (MWF 9:05 am) Spring 2018

[Quiz] In the chemical reaction

2 A + 3 B → C

the initial rate of consumption of B is 0.15 M/s.

This means that the rate of the reaction is ...

0% 1. −0.15 M/s

0% 2. +0.15 M/s

0% 3. −0.10 M/s

0% 4. +0.050 M/s

0% 5. None of these

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