# Experiment 10
# Chemical Kinetics Discovery Lab

CH 204

Spring 2009

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# Last week in lab

Titration curves

Changing composition of a weak acid solution as strong base is added

pH meters, pH standards

Witnessed the awesome power of a buffer solution to resist changes in pH

# Thermo vs Kinetics

Thermodynamics is concerned only with where you start and where you finish.

Kinetics is all about how you get there: reaction rates and reaction mechanisms (the individual steps of a reaction).

# Reaction rate

How quickly a reactant disappears, or how quickly a product forms.

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = -\frac{d[A]}{dt}$$

How fast the reaction goes depends on the concentrations of the reactants.

This is expressed in an equation we call a *rate law*.

# Rate Laws

Rate laws tell you how the rate of a reaction (M/sec) depends on the concentrations.

For the reaction $A + B \rightarrow C$,
a typical rate law is

$$\text{Rate} = k[A][B]$$

Most rate laws are 1st or 2nd order. (Sum of the exponents equals 1 or 2.) This example is 1st order in A and B, and 2nd order overall.

# Reaction Mechanisms

The actual step-by-step chemical pathways that reactions take.

These often include intermediate products and catalysts that don't appear in the overall equation – but they might appear in the rate law.

# Catalysts and Intermediates

**catalysts** – consumed early in a reaction and regenerated in the same amount later. No net change in concentration.

**reaction intermediates** – produced early in a reaction and then consumed later.

Even though they are essential to the reaction pathway, neither of these show up anywhere in the overall reaction.

In the reaction

$$A + B \rightarrow C$$

A might not actually react with B at all, because the mechanism could be something like

$$A + catalyst \rightarrow Intermediate$$

$$Intermediate + B \rightarrow C + catalyst$$

In this case the rate law might include a catalyst that isn't in the overall reaction.

# Elementary Reactions

Each individual step in a reaction mechanism is called an *elementary reaction*.

There are no "hidden participants" in an elementary reaction, and the rate law is always exactly what you would expect:

For $aA + bB \rightarrow cC$, the rate law is

$$\text{Rate} = k[A]^a[B]^b$$

# Rate Laws for overall reactions

Generally speaking they are often exactly what you would expect, but there are enough exceptions out there that that's not a safe bet.

Rate laws can't be predicted from overall reaction equations, and are determined empirically.

# "All right, men...

...here's what we're gonna take and do."

125 mL of unknown solution
2.5 g of unknown solid
2 drops of methylene blue indicator

Mix 'em up and watch the reaction go.

# Your mission, if you decide to accept it...

Determine the mechanism of the reaction.

Break the overall reaction into individual elementary reactions.

Identify the role of the unknown solid and any other reactants, catalysts, and intermediates in the system. (The unknown liquid does NOT play a role.)

# Things to watch for

Rates of reactions – what happens quickly? What happens slowly?

How does doubling the concentration of a reactant affect the rate of the reaction?

Which changes in the reactants result in the formation of more product? How do you know when you've formed more product?

What is the limiting reagent in the reaction?

# "My brain hurts!"

The answers aren't in the lab manual, and your TA won't just hand them to you either.

You've got to noodle your way through to the answer on this one.

Make sure you understand the mechanism before you leave the lab. Your TA will not answer questions about the mechanism once lab is over.

# In your notebook

Record all your data and observations.

Part 15 – simple graphs. Two or three points is enough. No need for Excel, just draw a simple graph in your lab notebook.

Record all observations directly into your lab notebook.

# Before you leave the lab

Look over the discussion questions and make sure you know the answers.

# Well, that lecture wasn't very helpful, was it?

No, it wasn't.

# Special Announcements

NO LECTURE NEXT WEEK

NO QUIZ NEXT WEEK

Check out of your drawer at the end of lab today.

Experiment 10 reports are due by the beginning of lab time next week.

If you are doing a make-up lab today, bring your TA evaluation to the stockroom so they can get it in the right envelope.

# More Special Announcements

IF YOU HAVE A MAKE-UP LAB

Go directly to lab at your normal lab time next week. I will post make-up lab room assignments on the course web page and on signs posted outside the labs. Everyone will work in rooms 4.116 and 4.124.

# One Final Announcement

IF YOU ARE NOT HERE TODAY

Let me know as soon as possible so we can get you on the make-up schedule.

# One Final Final

Part nein of nein of the final exam
und then you are done.