Experiment 10
Chemical Kinetics Discovery Lab

CH 204

Spring 2006

Dr. Brian Anderson

Previous week in lab

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

pH meters

pH standards

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.

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

The relationship between concentration and reaction rate is expressed in the form of a *rate law*.

Rate Laws

Rate laws summarize the concentration dependence of the rate of the reaction.

For the reaction $A + B \rightarrow C + D$,
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 intermediaries and catalysts that don't appear in the overall equation – but they might appear in the rate law.

In the reaction

$$A + C \rightarrow Products$$

A might not necessarily react directly with C, because the mechanism might be something like

$$A + \text{catalyst} \rightarrow Intermediary\ B$$

$$Intermediary\ B + C \rightarrow Products$$

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 exactly what you would expect:

For $aA + bB \rightarrow cC + dD$, 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 reaction equations, and are determined empirically.

"All right, men...

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

150 mL of unknown solution
2.5 g of unknown solid
1 or 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 down into individual elementary reactions.

Identify the role of the unknown solid and any other reactants, catalysts, and intermediaries 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 reaction?

Which changes in the reactants result in the formation of more product? How do you know?

What is the limiting reagent in the reaction?

"My brain hurts!"

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

You've got to work 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 to these before you leave the lab.

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

No, it wasn't.