Inspiring Greatness

INDEPENDENCE SCHOOL DISTRICT

High School Science Virtual Learning

College Chemistry
Kinetics Equilibria Virtual Lab

May 13, 2020

High School College Chemistry
Lesson: May 6, 2020

Objective/Learning Target:
Students will complete lab activities to learn about kinetics.

Let’s Get Started:

1. What is a titration?

2. What is a pH indicator?

Let's Get Started: Answer Key

1. Titration is the slow addition of one solution of a known concentration (called a titrant) to a known volume of another solution of unknown concentration until the reaction reaches neutralization, which is often indicated by a color change

2. A pH indicator is a halochromic chemical compound added in small amounts to a solution so the pH (acidity or basicity) of the solution can be determined visually.

Lesson Activity:

- Just like the lessons from earlier this week, this activity will be split between two days.
- Today you will watch the lab video and complete the lab worksheet. There are some new concepts, so there are some additional notes added after the lab.
- Tomorrow you will check your answers and watch a deeper explanation of the lab.

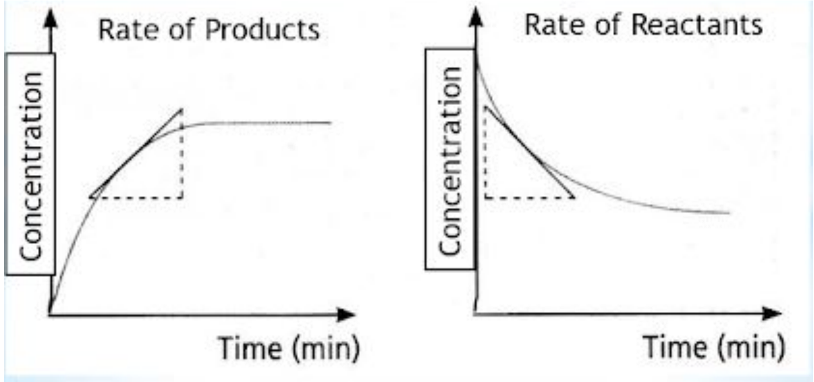
Lesson Activity:

Directions

- Watch this video.
- Answer the questions on your lab worksheet.
- The data for the lab worksheet can be found here.

NOTES:

- What is a kinetics?
  - It is a description of how chemical reactions occur.
  - Most reactions occur over time. The loss of reactants to create products.
  - This change over time is called a Rate of Reaction and is defined as the rate of change in concentration over time
  - Rate Units = 1/time = 1/s or s^{-1}



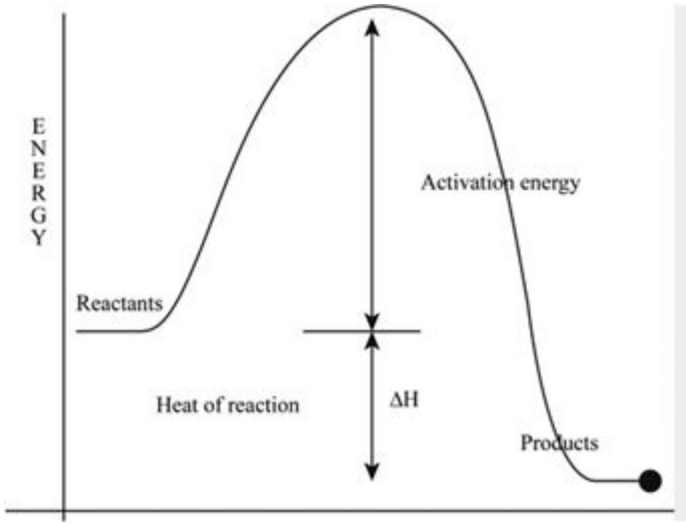
NOTES:

- Requirements for a Chemical Reaction to Occur
  - As seen in the video, reactions that occur instantaneously are fast and reactions that do not occur instantaneously, but do happen are considered slow.
  - Since we are talking about movement of molecules (breaking and making bonds), scientists constructed a mathematical association of what occurs.
  - These are based on a molecules kinetic energy (energy that a molecule uses as it is in motion)

NOTES:

- Requirements for a Chemical Reaction to Occur Continued
  - Since all reactions are not equivalent due to a variety of properties (like solid, liquids, gases, and aqueous solutions), most starting calculations are done with ideal gases and are based on Collision Theory.

- Collision Theory
  - Collision theory states that gas atoms, ions, and molecules can react to form products when they collide, break, and form bonds, if they have enough kinetic energy called Activation Energy.
  - Activation energy
    - The minimum amount of energy that particles must have in order to react
    - Serves as a barrier for reactions
    - If they do not have enough kinetic energy; they will “bounce apart” instead.



NOTES:

- Rate Law
  - An equation that relates the rate of a reaction to the concentrations of reactants (and catalysts) raised to various powers
  - $A + B \rightarrow \text{products}$
  - $\text{Rate} = k[A]^m[B]^n$

NOTES:

- Determining Powers in Rate Law:

Change in [A]	Change in rate of zero-order reaction (power = 0)	Change in rate of first-order reaction (power = 1)	Change in rate of second-order reaction (power = 2)
[A] doubles	No change	Rate doubles (2x)	Rate x 4

NOTES:

- Reaction Mechanism
  - Most reactions occur in a series of measurable short steps, and is known as a reaction mechanism
  - Each individual step is called an elementary step
  - Most elementary steps are not seen – occur too quickly to see a distinction
  - Compounds which are made in one step and used in the following step are called intermediates
  - Some elementary steps do take a noticeable amount of time
  - The step which is the slowest step is called the rate-determining step.

NOTES:

- Reaction Mechanism Continued
  - A rate law or equation can be created from the rate determining step. Where the coefficients are the powers.

Step 1: $NO_2(g) + NO_2(g) \rightarrow NO(g) + NO_3(g)$ Slow

Step 2: $NO_3(g) + CO(g) \rightarrow NO_2(g) + CO_2(g)$ Fast

Overall Reaction: $NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$

Rate law:

Rate = $k[NO_2]^2$

NOTES:

- Kinetics Video
    - To better understand the process of kinetics please watch this Crash Course Video. Make sure to take detailed notes and write down his example problems.

Practice

Complete the following questions using the information you learned during the lesson activity.

Questions:

1. Use the following data to determine the rate law for the equation:

$$NH_4^+(aq) + NO_2^-(aq) \rightarrow N_2(g) + 2H_2O()$$

Experiment	$[NH_4^+]$ (*M*)	$[NO_2^-]$ (*M*)	*Rate* (*M*/s)
1	0.2500	0.2500	1.25×10^{-3}
2	0.5000	0.2500	2.50×10^{-3}
3	0.2500	0.1250	6.25×10^{-4}

a. $k[NH_4^+][NO_2^-]$
b. $k[NH_4^+]^2[NO_2^-]$
c. $k[NH_4^+][NO_2^-]^{1/2}$
d. $k[NH_4^+]^{1/2}[NO_2^-]^2$
e. $k[NH_4^+][NO_2^-]^2$

Questions:

2. Use the following data to determine the rate law for the equation:

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

Experiment	[NO] (*M*)	[Cl_2] (*M*)	*Rate* (*M*/s)
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

a. Rate = $k[NO][Cl_2]$

b. Rate = $k[NO][Cl_2]^2$

c. Rate = $k[NO]^2[Cl_2]$

d. Rate = $k[NO]^2[Cl_2]^2$

e. Rate = $k[NO][Cl_2]^{1/2}$

Questions:

3. Use the following data to determine the rate law for the equation:

$$2A + 2B + 2C \rightarrow \text{Products}$$

Initial [A]	Initial [B]	Initial [C]	rate
0.273	0.763	0.400	3.0
0.819	0.763	0.400	9.0
0.273	1.526	0.400	12.0
0.273	0.763	0.800	6.0

a. rate = $k[A][B][C]$
b. rate = $k[A][B]^2[C]$
c. rate = $k[A]^3[B]^4[C]^2$
d. rate = $k[A]^2[B]^2[C]^2$

Answer Key:

1. A
2. C
3. B