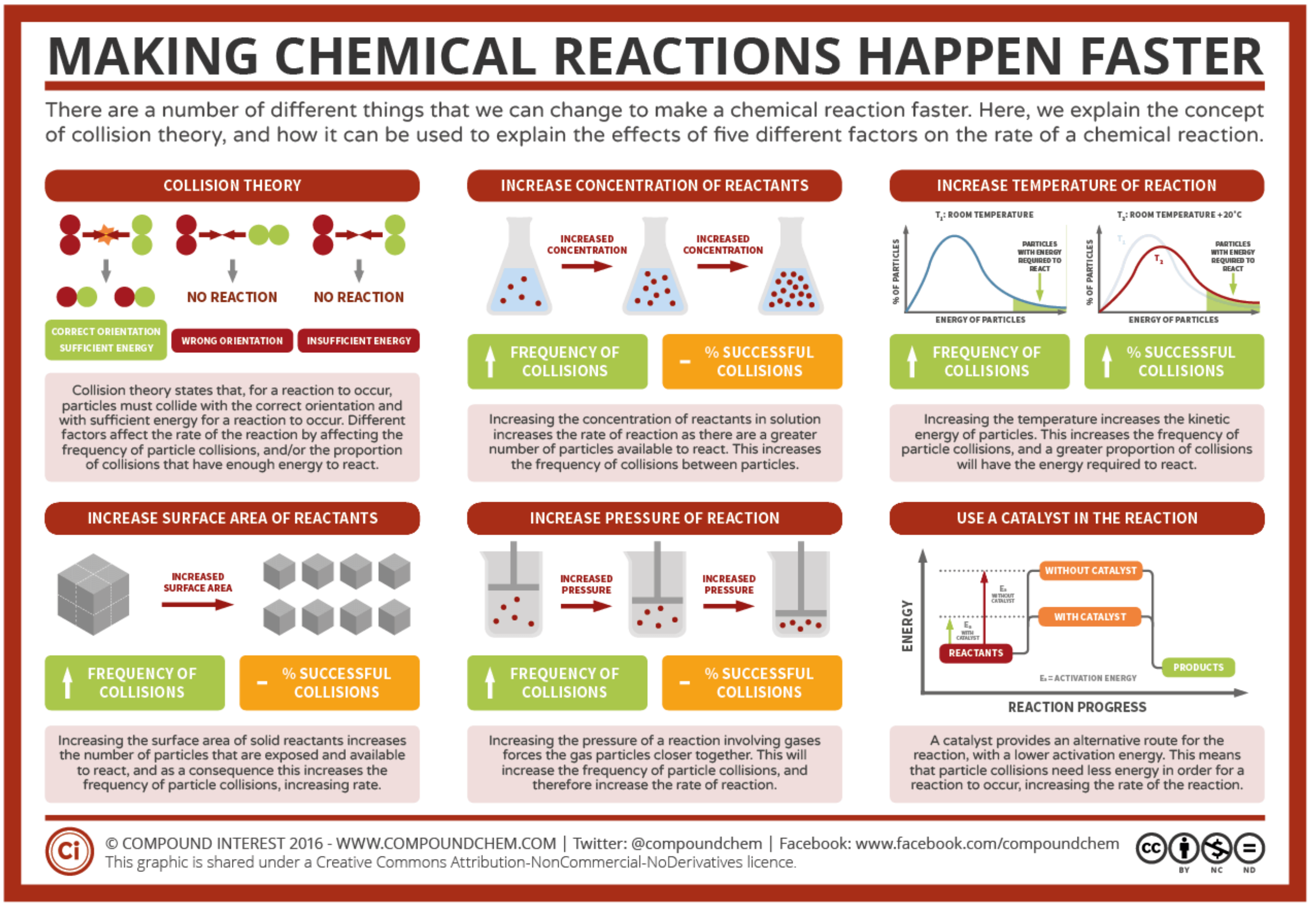
Lab 12.1
Factors Affecting Reaction Rates

Background
The quick boom and flashes of fireworks and the slow rusting of iron and corrosion of copper are all chemical reactions. The study of chemical kinetics centers on the reason for the different rates at which chemical reactions occur. The primary theory behind chemical kinetics is the collision theory. According to this theory, reactant molecules must collide with enough force to achieve activation energy before a reaction can occur. Activation energy is the minimum amount of energy needed to break the chemical bonds of reactant molecules such that they form new products. While molecules collide continuously (according to the kinetic molecular theory), only those that meet or exceed their activation energy **and** collide in a favorable orientation will form new products with new bonds.



In the data tables for this lab, you may use the standard symbol "gtt" for drop(s) from the Latin *guttae* (drops). The symbol may indicate singular or plural drops. "gtts" is an also a common symbol for plural drops. While a drop is not a precise, inform amount it is considered to be 1/20th of a mL (0.05mL).

Safety

- Hydrochloric acid (HCl), though dilute in this lab, is corrosive to skin and eyes.
- $CuSO_4$ and $Na_2S_2O_3$ are slightly toxic by ingestion.
- Hydrogen peroxide is a weak oxidizer and irritating to skin and eyes.
- Spills should be neutralized and cleaned up immediately. Any solutions that contact skin should be rinsed off with plenty of water.
- Exercise caution when using the hot plate and when handling objects that have been heated.
- Goggles and aprons must be worn.

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AP Chemistry

I. PURPOSE

The rate of chemical reactions can be influenced by different factors. The purpose of this lab is to investigate and learn what factors affect reaction rates.

II. MATERIALS

1. Baking Soda ($NaHCO_3$)
2. 0.05 M potassium iodide
3. 0.10 M hydrochloric acid
4. 0.01 M sodium thiosulfate
5. 0.001 M copper (II) sulfate
6. 1% starch
7. 3% hydrogen peroxide
8. Potassium iodide solid
9. Weigh boats/weigh paper
10. 24-well micro plates
11. 1 mL syringe
12. Stop watch (stop watch app)
13. Labeled pipettes
14. Hot plate
15. Ice
16. Thermometer
17. Mortar and pestle
18. 150 mL beakers for baths
19. Scoopulas
20. Balance (±0.001g)
21. Test tube tongs
22. Test tubes (13x100)
23. 10 mL graduates
24. DI or distilled water
25. Test Tube rack

III. PROCEDURES

Part A – Calibration Procedure

1. In the top left well of the well plate, place 8 drops of KI, 2 drops of HCl, 4 drops of $Na_2S_2O_3$, and 4 drops of starch to the well. Swirl gently to mix.
2. Draw 0.4mL of hydrogen peroxide into the syringe.
3. Add the hydrogen peroxide to the well, starting the timer as soon as the solutions touch.
4. Swirl the plate and monitor the color. Record the amount of time it takes for the entire solution to turn a dark blue-black color.
5. If the solution takes **more** than approximately 20 seconds to turn, repeat above but this time with only 3 drops of $Na_2S_2O_3$ rather than 4. Continue trials reducing the $Na_2S_2O_3$ by 1 drop each time until it takes 20 seconds to turn.
6. If the solution took **less** than approximately 20 seconds to turn, repeat above but this time with 6 drops of $Na_2S_2O_3$ rather than 4. Continue trials increasing the $Na_2S_2O_3$ by 2 drops each time until it takes 20 seconds to turn.
7. Once you hit approximately 20 seconds, no more trials are necessary.
8. Record the number of drops of $Na_2S_2O_3$ used to achieve the time. This number will be used in all subsequent experiments *(hereafter abbreviated CD)*.

Part B – Effect of KI Concentration

1. In the leftmost well of an empty row of your well plate place: 8 drops KI, 2 drops HCl, *CD* $Na_2S_2O_3$, and 4 drops starch.
2. Swirl the solution by moving the plate in small circles on the table.
3. Draw 0.4mL of hydrogen peroxide into the syringe.
4. Add the hydrogen peroxide to the well, starting the timer as soon as the solutions touch.
5. Swirl the plate and monitor the color. Record the amount of time it takes for the entire solution to turn a dark blue-black color.
6. Repeat steps 1-5 for trials 2-4 (one trial at a time) using amounts found in the data table.

Part C – Effect of Temperature

1. Prepare three water baths as follows (share baths with the group across from you)
   a. Cold water bath – half fill a beaker with ice then add tap so water that it is at least 20°C below room temperature.
   b. Room-temperature water bath (warm) – put tap into a 150 mL beaker.
   c. Hot water bath – heat water so that it is at least 20°C above room temperature.
2. In each of the 3 labeled test tubes (cold, warm, hot) place: 8 drops KI, 2 drops HCl, *CD* $Na_2S_2O_3$, and 4 drops starch.
3. Swirl to mix well and place in test tube rack
4. With the syringe put 0.4 mL hydrogen peroxide in each of the three test tubes pre-labeled H_2O_2.
5. Place in each of the three prepared water baths one test tube containing the mixture of solutions and one test tube containing the hydrogen peroxide. All baths should contain a pair of your test tubes.
6. Allow the solutions to remain for at least 5 minutes in the baths (start preparing Part D while waiting).
7. Remove the tests tubes from the room temp bath. Be sure to record the temperature of the bath right before you remove the tube. Pour the hydrogen peroxide into the tube containing the mixture and begin timing.
8. Swirl the test tube and monitor the color. Record the amount of time it takes for the entire solution to turn a dark blue-black color.

9. Repeat the process for the test tubes in the hot and the cold baths as well. (Use test tube tongs as needed and be sure to get the temperature right before you remove the test tube.)

Part D – Effect of Surface Area

1. In each of the unlabeled test tubes place: 4 drops HCl, **3mL** $Na_2S_2O_3$, 5 drops starch, and 0.8mL H_2O_2.
2. Swirl each tube well to mix and place in test tube rack.
3. Weigh out 0.02 g of the crushed powdered KI from the mortar and pestle into test tube labeled "crushed".
4. Weigh out 0.02 g of the KI original crystals from the bottle into a test tube labeled "crystals".
5. Pour one of the mixtures into the tube with the powdered crystals and DO NOT SWIRL. Start the timer.
6. Record the time it takes for the solution to turn black.
7. Repeat steps 5 and 6 with the whole original crystals.

Part E – Effect of Adding $CuSO_4$

1. In the leftmost well of an empty row of your well plate place: 8 drops KI, 2 drops HCl, *CD* $Na_2S_2O_3$, 4 drops starch, and 2 drops distilled water *(see Data Table E for clarification)*.
2. Swirl the solution to mix it by moving the plate in circles on the table.
3. Draw 0.4mL of hydrogen peroxide into the syringe.
4. Add the hydrogen peroxide to the well, starting the timer as soon as the solutions touch.
5. Swirl the plate and monitor the color. Record the amount of time it takes for the entire solution to turn a dark blue-black color.
6. Repeat 1 – 5 using 2 drops of copper sulfate instead of water *(see Data Table E for clarification)*.

IV. PRE-LAB QUESTIONS

1. What is activation energy?
2. As described in the above introduction, what are the TWO requirements for a reaction to take place?
3. What are some examples of reactions that people may wish to speed up or slow down?
4. In each of the following three examples, make drawings (and label drawings) to explain how the molecules differ in the two items described:
   a. Water at 70°C and water at 40°C
   b. 5 M glucose and 6 M glucose
   c. a 64 cm^3 cube of sugar and a 2 x 8 x 4 cm prism of sugar

V. DATA & CALCULATIONS

A. DATA

Part A: Drops of $Na_2S_2O_3$ Required for Calibration: _______________

("CD" = Drops of $Na_2S_2O_3$ Required for Calibration in following tables.)

Part B Data Table

Trial	KI (gtt)	H_2O (gtt)	HCl (gtt)	$Na_2S_2O_3$ (gtt)	Starch (gtt)	H_2O_2	Time (s)
1	8	0	2	*(CD)*	4	0.4 mL	
2	6	2	2	*(CD)*	4	0.4 mL	
3	4	4	2	*(CD)*	4	0.4 mL	
4	2	6	2	*(CD)*	4	0.4 mL	

Part C Data Table

Water Bath	Temperature (°C)	Reaction Time (s)
Room temp		
Hot		
Cold		

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Part D Data Table	
KI Form (0.02 g)	Reaction Time (s)
Powdered KI	
Original KI crystals	

Part E Data Table								
Trial	KI (gtt)	HCl (gtt)	$Na_2S_2O_3$ (gtt)	Starch (gtt)	Water (gtt)	$CuSO_4$ (gtt)	H_2O_2	Time (s)
1	8	2	*(CD)*	4	2	0	0.4 mL	
2	8	2	*(CD)*	4	0	2	0.4 mL	

B. <u>CALCULATIONS</u>
None

VI. POST-LAB QUESTIONS & DISCUSSION OF ERROR

A. <u>QUESTIONS</u>

1. What was changed about the experiment from trial to trial in Part B?
2. Make a general concluding statement regarding how the “factor” changed in Part B will affect any reaction rate. (i.e. When you increase _______________, rates of reactions ____________)
3. What was changed about the experiment from trial to trial in Part C?
4. Make a general concluding statement regarding how the “factor” changed in Part C will affect any reaction rate.
5. What was changed about the experiment from trial to trial in Part D?
6. Make a general concluding statement regarding how the “factor” changed in Part D will affect any reaction rate.
7. How did the addition of the copper (II) sulfate affect the reaction rate in Part E?
8. What is the most probable role of the copper (II) sulfate?
9. Make a general concluding statement regarding how the “factor” added in Part E will affect any reaction rate.
10. Many fast–acting medications are sold as powders, sometimes in soluble capsules. Why?
11. Recap! What are the 4 factors that can affect reaction rate?

B. <u>DISCUSSION OF ERROR</u>

VII. CONCLUSION