**Reactions and Rates weblab**

10 questions, 100 points possible.

Name and date submitted (3 pts): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Instructions: Open the PhET “Reactions and Rates” lab:

<https://phet.colorado.edu/en/simulation/legacy/reactions-and-rates>

At the time of writing, there are both Java and browser-compatible versions.

**Chemical Kinetics**

Reactions require 3 things to occur:

1. Collisions must occur
2. Collisions must have the proper orientation
3. Collisions must have sufficient speed (kinetic energy)

Assuming you have the above three, there are 4 factors that affect the rate of a reaction:

1. Concentration

We measure concentration in moles/L.

* More molecules = more collisions, therefore faster reaction.
* Collisions are necessary for reactions
1. Physical State

Smaller and better mixed = more collisions, therefore faster reaction.

* Solids can be ground and pulverized to increase surface area
* Liquids can be stirred
1. Temperature

Higher temperature increases the kinetic energy of molecules

Higher kinetic energy of reactants = more collisions, and more forceful collisions, therefore faster reaction.

* Need sufficient energy to react (known as Activation Energy)
1. Catalysts

Catalysts lower the activation energy of reactions

Lower activation energy = more molecules have sufficient kinetic energy to react, therefore faster reaction.

* Lower activation “hump” means more molecules can react

Single Collision Tab

\*\*\*Hypothesis: collisions must have sufficient speed\*\*\*

1. Pull back and release the knob. What happened? (Discuss)

Click the “Reload Launcher” button and expand the two windows on the right side of the program by clicking the “+” button for the Separation View and the Energy View. Now release the knob from various distances.

1. Draw a horizontal line on the graph below to indicate the potential energy at which the reaction proceeds.

**Potential Energy**

**Reaction Coordinate**



Now click the **Angled Shot** option in the top right corner. Try several angle-shots.

\*\*\*Hypothesis: collisions must have the proper orientation\*\*\*

1. Does the reaction proceed as easily as before?
2. Why do you think this was the outcome despite having enough energy for the reaction to proceed?

\*\*\*Hypothesis: Energy is conserved in a reaction. Potential energy contained within chemical bonds is converted into kinetic energy and vice versa\*\*\*

Set the *Choose a reaction* option to the last preset chemical reaction that isn’t **Design your own**. (exothermic with no activation energy hump)

Now Change the *Launcher Options* back to **Straight Shot** and release the knob. Hit “reload launcher” to observe several times.

1. Compare the speed of the lone atoms ‘A’ and ‘C’, and the molecules ‘AB’ and ‘BC’, as the reaction goes forwards and backwards. Explain what is going on.
	1. Which ones move faster/slower?
	2. Why do AB and BC move more slowly?
	3. Why do A and C move more quickly?
	4. Is the potential energy in the bonds converted into kinetic energy and then back again?

Rate Experiments Tab

\*\*\*Hypothesis: Increasing the initial concentration of reactants increases the speed of reaction\*\*\*

Click on the “Rate Experiments” tab. Make sure “Select a Reaction” is set to the first reaction (endothermic with activation energy hump). Set *Options* (bottom right corner) to **Strip**. Increase the *Initial Temperature* until the Average Energy (green bar) is equal to the potential energy of the products.



In *Initial Conditions*, set ‘A’ and ‘BC’ to 1. Click on **Begin Experiment**.

1. How much time does it take to react?

If no reaction occurred in 3000 seconds in the *Current Amounts* window (a couple minutes in real time), hit **End Experiment** and increase ‘A’ and ‘BC’ by 1 each. Repeat until the reaction occurs within a couple minutes real time.

1. How many reactants had to be used?
2. Recall that your “total average energy” for the reactants was set below the activation energy (the hump). How did this reaction take place with the total average energy set below the activation energy? Explain.

Now start out with 5 of each reactant. Record how long in seconds (as shown in the *Current Amounts* window) it takes for 1 reaction to take place. Use **End Experiment** and **Begin Experiment** as needed.

**5 Reactants Each**

Run 1:

Run 2:

Run 3:

Average time in seconds:

Repeat this process for 10 reactants each and 15 reactants each.

**10 Reactants Each**

Run 1:

Run 2:

Run 3:

Average time in seconds:

**15 Reactants Each**

Run 1:

Run 2:

Run 3:

Average time in seconds:

1. How did the *beginning concentration of reactants* affect the rate of the reaction? Be specific, and use the numbers in your explanation.
2. Now that you see how it works, set up your own experiment on the simulator to test how temperature affects the rate of a reaction.
	1. State your hypothesis.
	2. How did you design your experiment?
	3. What tab(s) did you use?
	4. What reaction, or reactions?
	5. Exothermic, or endothermic?
	6. How many atoms and molecules are involved in this reaction?
	7. What temperatures, and when, and how long?
	8. What was your *total average energy* set to?
	9. What were the other settings?
	10. What were the results, numerically? Discuss.
	11. Did the results support your hypothesis? Discuss.