The Tech Museum of Innovation
201 S. Market St.
San Jose CA. 95113
1-408-294-8324
thetech.org

Reaction Rate Races

Lab Related Activity: *Chemicals of Innovation*

This activity is meant to extend your students' knowledge of the topics covered in our Chemicals of Innovation lab. Through this activity, students will learn how energy affects molecules and the rate of chemical reactions.

Grades 5-8
Estimated time: 45-60 minutes

Student Outcomes:
1. Students will be able to model particle motion in relation to changes in temperature.
2. Students will be able to identify temperature as a variable of reaction rates.

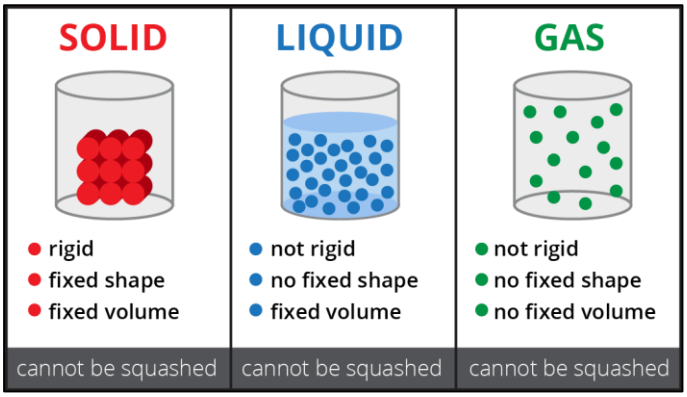
Next Generation Science Standards
Grade 5: 5-PS1-1, 5-PS1-4
Grades 6-8: MS-PS1-4, 6-PS3-4, 6-PS3-5
Common Core ELA Standards
Grade 5: *Speaking and Listening* 5.SL.1b-d
Grades 6-12: Writing W.7; *Speaking and Listening* SL.1b-e

California State Science Standards
Physical Sciences/Chemistry
Grade 5: 5.1.b; **Grade 6:** 6.3.a, c
Grade 8: 8.3.a, b, d, e; 8.5.c-d
Investigation and Experimentation:
Grade 5: 5.6.a-d, g-h; **Grade 6:** 6.7.a-b, d-e;
Grade 7: 7.7.a, c, e; **Grade 8:** 8.9.a;

Vocabulary:
Familiarity with these terms and concepts will enhance students' experience in the activity
- Chemiluminescence: The production of light from a chemical reaction.
- Endothermic: Refers to a reaction or process that is accompanied by or requiring the absorption of heat.
- Exothermic: Refers to the reaction or process that is accompanied by the release of heat.

Materials (One set per team of 4 students):
- 3 Alka-Seltzer Tablets
- 3 Glow Sticks (same color)
- 2 400mL Beakers or Clear Heat Tolerant Clear Cups
- ~700 mL Hot Water (but not too hot so as to melt the plastic)
- ~700 mL Ice Water
- ~700 mL Room Temperature Water
- 2 Thermometers
- 1 Stopwatch

Procedure:
1. Students will work in groups of 4 for this activity. Each group should have one set of the above materials.
2. **Discussion:** Review molecule movement and energy. Some teaching points are below.
   - All molecules are in constant motion. An object's state of matter (solid, liquid, or gas) is determined by the motion of molecules.
     - Molecules in a solid are tightly packed, typically in a regular pattern, and vibrate. Molecules in a liquid are irregularly arranged close together and slide past each other as they vibrate. Molecules in a gas are widely separated without any regular arrangement and move past each other freely at high speeds.
       - To model molecular movement in various phases, use a small clear box filled with a varying amount of marbles. Fill the box entirely



*Molecular arrangements of the three phases of matter

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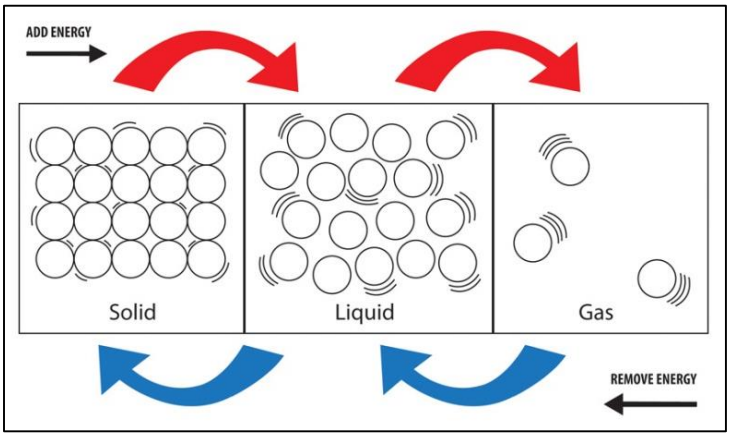

*Image shows change in molecular vibration in the three phases of matter as temperatures increase and decrease.

for solids, remove half for liquid, and remove most for gas. Shake the box side to side to put the molecules in motion.

- Molecular motion is also essential for chemical reactions to take place. In order for a chemical reaction to take place, the molecules of two reactants must collide, breaking and forming new chemical bonds.
  - A video is available to model this interaction through the American Chemical Society's (ACS) education website:

www.middleschoolchemistry.com/multimedia/chapter6/lesson4

- Molecular motion is also highly dependent on temperature. Ask students if they think molecules move faster or slower at colder temperatures and at warmer temperatures
  - At lower temperatures, molecules generally move and vibrate slower than those at higher temperatures.
  - How do you think molecular temperature affects physical changes? How does temperature affect molecular collisions (chemical reactions)?
- Energy comes in many forms (light, heat, mechanical, chemical, etc.) and cannot be created or destroyed. When chemical bonds are created or destroyed (chemical reactions), the process gives off and absorbs different types of energy.
  - Exothermic and Endothermic classifies reactions based on thermal energy released or absorbed as bonds are broken and formed.
  - Chemiluminescence is when light energy is released from a chemical reaction. Light is emitted due to excited atoms (increased energy). When atoms become excited the electrons rise to higher energy levels and when they return to their normal level (decrease in energy), release energy in the form of light.

3. **Experiment:** Each team will have their set of materials at their station. The two cups will be utilized for three different experiments and will need to be rinsed in between. Students should make hypotheses regarding the reaction rates at different temperatures, record data and observations, and draw conclusions.
   a. *What type of reaction?* Fill the two cups with equal amounts of room temperature water. Place one thermometer in each cup and record the starting temperature. At the same time drop the Alka-Seltzer tablet in one cup and place the just-activated light stick in the other cup. As soon as the reactions begin, start the stop watch and measure and record the temperatures at 30 second intervals until both temperatures equalize (no more than 5 minutes). Record the time mark when the Alka-Seltzer tablet is completely dissolved. Label the reactions as endothermic, exothermic, and/or chemiluminescent and how you came to that conclusion.
   b. *Which will dissolve faster?* Label the two cups "hot" and "cold" and fill with respective temperature water. Measure and record the starting temperatures. At the same time, place one Alka-Seltzer tablet in each cup and start the stop watch. Record how long it takes the tablet to completely dissolve. Which temperature water dissolved the tablet faster? Why?
   c. *Which will be brighter?* Rinse the cups and repeat step b for the light sticks. Record observations regarding the light stick over time (5 minutes). Which temperature light stick glowed brighter? Why?
4. **Wrap up:** Have teams share their observations. Were their hypotheses validated? Which of the two reactions – hot or cold – reached completion more quickly? Why did the reaction reach completion more quickly? Did it matter if the reaction was endothermic, exothermic, or chemiluminescent? What visual cues did you use to determine the reaction was complete?

Post-Visit Activity

The Tech Science Labs: *Chemicals of Innovation*

Data Collection Sheet

Experiment A

1. *Hypothesis:* What type of reaction do you think the two products are going to produce (endothermic, exothermic, chemiluminescent, or a combination)? Why?

   Glow Stick: _____

   Alka-Seltzer: _____

Data Table for Experiment A

	Start Temp.	30 sec.	1 min.	1 min. 30 sec	2 min.	2 min. 30 sec.	3 min.	3 min. 30 sec.	4 min.	4 min. 30 sec.	5 min.	**Type of Reaction**
Glow Stick												
Alka-Seltzer												

2. What was the reaction type for the two products? How do you know?

   _____

   _____

Experiment B

3. *Hypothesis:* Which temperature water do you think will dissolve the Alka-Seltzer tablet fastest? Why?

   _____

Data Table for Experiment B

	Time for tablet to dissolve
Hot Water	
Cold Water	

a. Which temperature water dissolved the tablet the fastest? Why do you think that temperature made it dissolve faster? _____

_____

Post-Visit Activity

The Tech Science Labs: *Chemicals of Innovation*

4. If you needed to take Alka-Seltzer for an upset stomach, which temperature water would you use and why?

_____

_____

Experiment C

5. *Hypothesis:* How do you think the water temperature will affect the glow sticks?

Data Table for Experiment C

	Observations
Hot Water	
Cold Water	

6. What did you observe? What do you think caused this?

_____

_____

7. If you wanted to save and use the same glow stick for several days, how would you store it so that it keeps glowing? Why?

_____

_____