Science Unit: ***Matter***

Lesson 15: ***Heat and Rates of Reaction***

Summary:	In this lesson, students participate in two activities. In the first activity, they carefully observe the **chemical reaction** in a **light stick** and compare the **rate of reaction** when their stick is submerged in cold water to the rate in warm water. In the second activity, they observe **dry ice** as it **sublimes** (changes from solid to gas), and compare the rate of change in the air at room temperature to the **rate of change** in warm water.
Science skills:	Close observation, exploration, curiosity, inferring, concluding.
School Year:	2013/2014
Developed for:	Champlain Heights Annex Elementary School, Vancouver School District
Developed by:	Ingrid Sulston (scientist); Mona Francis and Ramona Smith (teachers)
Grade level:	Presented to grades 2/3; appropriate for grades 1 – 7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes
Notes:	• The first activity in this lesson requires a room that can be darkened. • Students should never touch or handle dry ice. Dry ice can burn the skin so thick, protective gloves must be worn by the adult.

Objectives

Students will be able to:

Observe a familiar chemical reaction and learn what is happening at the molecular level.

Experiment with how heat and cold change the rate of a chemical reaction.

Observe a dramatic state change with dry ice.

Background Information

There are some fun and dramatic examples of state changes and chemical reactions that are well suited to a final lesson on states of matter and chemistry. In this lesson, dry ice is used as a dramatic example of a state change, and light sticks provide a fun exploration into the effect of temperature on a chemical reaction.

Vocabulary

Molecules and atoms:	Tiny particles that make up everything around us. Molecules and atoms are too small to see individually, but with enough of them together they make objects we can see.
Heat:	A form of energy that moves through matter. Molecules move faster and collide more often as they gain heat energy.
Chemical reaction:	A chemical reaction occurs when molecules break apart and their atoms rearrange to make new molecules.
Rate of chemical reaction:	How fast a chemical reaction proceeds, therefore how fast new molecules are made.
Sublimation:	Changing state directly from a solid to a gas.

Materials

- light stick for each student
- tub of cold water (about 5ºC) for each group of three or four students
- dry ice in styrofoam box
- tub of warm water (about 45ºC) for each group of three or four students
- ice cubes to keep the water cold in the tubs
- thick glove to handle dry ice
- kettle to provide hot water, to keep water warm
- thermometer to check the water temperature of the tubs
- optional: bubble mix and bubble maker. See ref. 1.

In the Classroom

Introductory Discussion

Introduce or review the concept of heat at the molecular level (a form of energy that makes molecules move around faster). Tell students that the following activities will investigate heat.

Processes of science that the students will focus on: close observation, exploration, curiosity, inferring, concluding.

Brief description of safety guidelines:

- Boiling water must be handled with care, especially around the students.
- When the lights are out, students should stay in one place, to avoid tripping in the dark.
- Dry ice must not be touched with bare hands, as it will burn the skin. Always handle with thick gloves.

Science Activities

(1) Activity Title: Glow Sticks and Heat

Purpose of Activity: Watch the rate of a chemical reaction change with more or less heat.

Methods and Instructions:
Set-up prior to experiment: Set up one stations for each group of two or three students. Each station needs one tub of warm water and one tub of cold water.

1. Distribute one light stick to each student. Explain that inside the plastic cover of the light stick is a glass rod. One chemical is inside the glass rod and another is outside. When you snap the glass rod by bending the light stick, the chemicals mix together, and the chemical reaction produces a new molecule that glows.
2. Turn the lights out and instruct students to snap their sticks all at the same time. Ask students to look closely at the light stick as the chemicals mix. They should be able to see a swirl of colour as the chemicals react and new glowing molecules are made.
3. Turn the lights back on. Ask students to take their light sticks to the warm/cold water stations. Instruct students to stay at their station while the lights are out.
4. Turn the lights out. Ask students to observe how heat and cold affect the rate of the chemical reaction in their light sticks by dipping them in both the warm and cold water tubs.
5. Once the students have had some time to investigate, turn the lights on and regroup to discuss what they found:
    - They should have observed that the light stick glows more intensely in the warm water. This is because the heat energy in the warm water causes the molecules in the light stick to move around faster, hence collide more often with each other. Colliding causes the chemicals to *react* (reorganize) and make more of the glowing molecules.
    - The light stick dipped in cold water should become dim. Heat energy always moves from warm to cold. The heat energy leaves the light stick and moves into the cold water, hence the molecules in the light stick have *less* energy and move around less. The cooler molecules collide less frequently and so undergo fewer chemical reactions and fewer glowing molecules are made.
    - Students may see something different, possibly due to the intensity of the glow stick affecting the sensitivity of our eyes in the darkness. These are real results and should be welcomed. However, the main goal of the discussion is to determine what the majority of the students observed.
8. Allow students to return to their stations for further investigations. Once everyone is safely back at the water stations, turn the lights off again. This activity is a good opportunity for students to spend some time observing, experimenting and sharing ideas with other students. (The warm water may need replenishing with boiling water to keep it warm, and the cold water may need more ice to keep it cold.)

(2) Activity Title: Dry Ice and State Changes

Purpose of Activity: Observation of a dramatic state change from solid to gas.

Methods and Instructions:
Set-up prior to experiment: warm tubs of water, distributed around the room - use the same tubs as for activity (1).
Students work in groups of three or four.

1. Show students a chunk of dry ice (only hold with thick gloves, as it will give cold burns to skin). Dry ice is carbon dioxide in its solid state. It is very cold (- 80ºC)!

   The solid carbon dioxide does not stay solid very long in a warm room, but instead of turning to a liquid then a gas, it turns straight into a gas - a process called “sublimation”. The gaseous carbon dioxide can be seen as white clouds surrounding the solid chunk of dry ice.

2. Ask groups to each gather around a tub of warm water. Drop a few nuggets of dry ice into each tub while students watch. **The students must not touch the dry ice.**

   The warm water will dramatically speed up the state change from solid carbon dioxide to gas: large bubbles of carbon dioxide gas form in the water, and clouds of the gas spill over the top of the container. Sometimes small pieces of dry ice zoom around on the top of the water, like a hovercraft. (If the reaction slows before the dry ice is used up replace the water with more warm water.)

3. For a final activity, add dry ice to bubble mix to make bubbles filled with carbon dioxide gas. These bubbles are heavier than normal bubbles as carbon dioxide is heavier than air. A funnel contraption can be made as described in ref. 1 to make large bubbles.

Closure Discussion

Review the chemistry of the lesson:

- The light sticks glow because a chemical reaction that makes a new glowing molecule. The rate of this chemical reaction can be sped up by dipping the light stick in warm water, or slowed down by dipping it in cold water.
- Dry ice sublimes at room temperature, making clouds of carbon dioxide gas in the air, and violently bubbles as the gas is rapidly formed in warm water.

References

<www.stevespanglerscience.com/lab/experiments/boo-bubbles-dry-ice-science#> Steve Spangler Science. “Boo bubbles”. Accessed May 13, 2014.