UTAH OFFICE OF
ENERGY DEVELOPMENT

Transporting Natural Gas

Grade/Subject: 8th Integrated Science

Strand/Standard 8.1.7 Design, construct, and test a device that can affect the rate of a phase change. Compare and identify the best characteristics of competing devices and modify them based on data analysis to improve the device to better meet the criteria for success. (PS1.B, PS3.A, ETS1.A, ETS1.B,ETS1.C)

Lesson Performance Expectations:

- Students will investigate to determine the optimum conditions for phase change, using water as a model for natural gas.

Materials: Each group will need

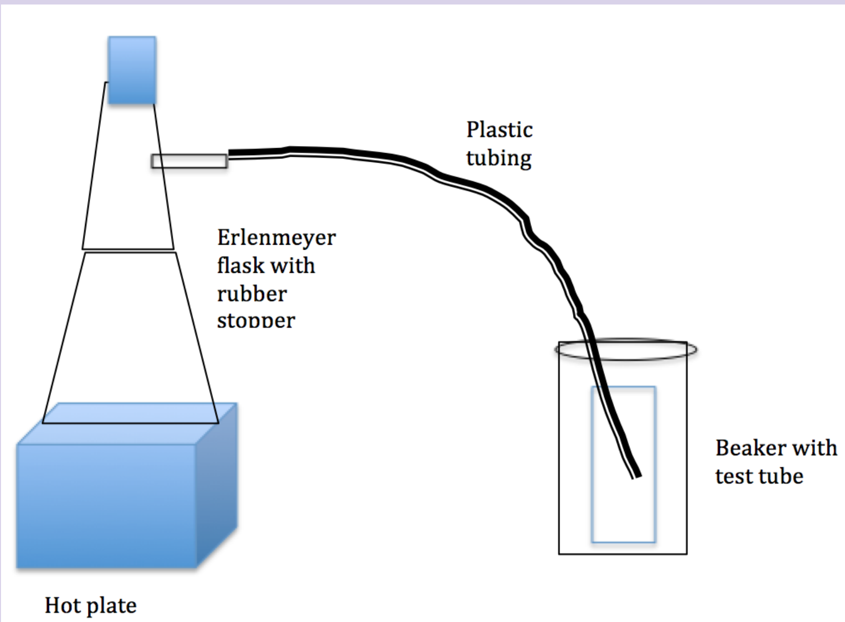
- A Student hot plate
- 250 mL Erlenmeyer flask with a solid rubber stopper
- Plastic tubing in various lengths
- Beakers of various sizes
- Test tubes of various sizes

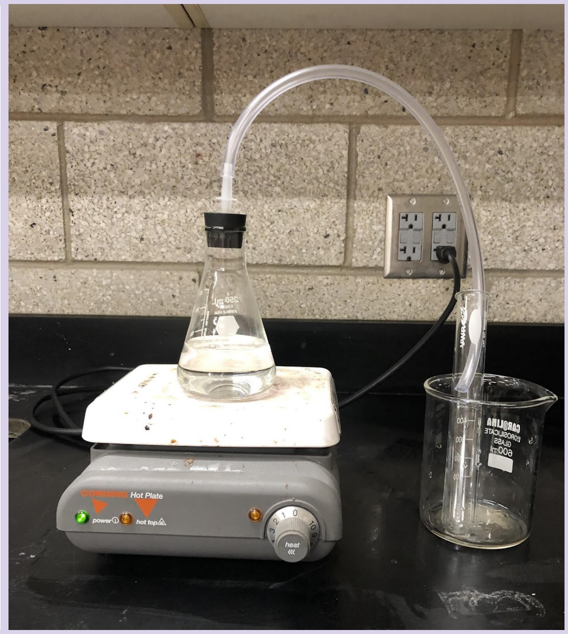
Time: 2 - 60-minute periods

Teacher Background Information:

- Natural gas comes from the ground as a mixture of a variety of gases. The largest component of natural gas is methane, a compound with one carbon atom and four hydrogen atoms (CH4). Natural gas also contains smaller amounts of hydrocarbon gas liquids (HGL) and non-hydrocarbon gases, such as carbon dioxide and water vapor.
- Natural gas forms similarly to other fossil fuels and often with oil or coal. It is found in porous rock or trapped under nonporous layers of rock. Natural gas is a gas in its original state but may be liquefied by changes in temperature or pressure. While most natural gas is delivered in its gaseous form via pipeline in the United States, the growth in the international market for natural gas has given rise to the use of natural gas in a liquefied state, or LNG (EIA).
- Liquefied natural gas must be cooled to about - 160°C for shipping and storage. The volume of natural gas in its liquid state is about 600 times smaller than its volume in its gaseous state in a pipeline. This *liquefaction* process, developed in the 19th century, makes it possible to transport natural gas to places pipelines do not reach and to use natural gas as a transportation fuel (EIA).

- Liquid water exists between 0° C and 100° C. Above 100° C, water exists as a gas under normal pressures. This lesson uses water as a model for the change from liquid to gas and back.
- Water can be "distilled" or changed from a liquid to a gas to a liquid again using an apparatus like this:





There are many versions of this, and the students will need to alter the basic model to see who can get the greatest amount of water distilled.

Safety Warning: Do not place a stopper in the test tube. It will create a closed system and blow up when heated.

Student Background Knowledge:

- Students understand that matter exists in three phases or states of matter.
- Students know the Engineering Design Process.

Teacher Step by Step: A 3-D lesson should insist that students think deeply. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Introduce Phenomenon and develop problem statement:**
    a. Have students write questions about the phenomenon on their student sheet.
    b. Discuss student questions and guide them to the focus question: *How does the Natural Gas-liquid become a gas?*
2. **Design a Solution**
    a. Students will design a distilling apparatus that will return the greatest amount of water from liquid to gas to liquid again.
    b. Review the Engineering Design Process.
        i. *Ask: How can we move water from a liquid to gas to liquid again without loss using the distilling apparatus? Discuss Criteria and Constraints of the Design:*
            1. *Criteria - Given 50 mL of water, change it to gas and see how much you get back.*

2. *Constraints - 1) made from the materials provided, 2)reusable, 3) does not take more than 1 class period to set up and run.*

ii. *Research: Students may use the internet to research solutions.*

iii. *Brainstorm: Students discuss their ideas in groups.*

iv. *Plan:* Students decide on a final idea for their design and draw it.

v. *Create:* Students will create apparatus according to their plan and test it. The amount of water produced in the test tube is their result.

vi. *Improve:* Students will make improvements to their design and test their results again.

Assessment of Student Learning. Students will successfully fill out the Engineering Design Sheet and test a distilling apparatus.

Standardized Test Preparation: Transporting Natural Gas

1. What is the challenge faced when transporting liquid Natural Gas?
   a. It changes to a gas slowly.
   b. It liquefies at a very cold temperature.*
   c. It turns into a different substance under pressure.
   d. It forms an immovable solid when heated.

2. What are the criteria for a design to transport Utah's natural gas to Utah homes?
   a. It must be contained in secure pipelines.*
   b. It must be the same mass at its destination.
   c. It must be liquified before transport.
   d. It must be made non-flammable.

3. What is the advantage of liquefying natural gas?
   a. It takes up much less space.*
   b. It requires less energy.
   c. It makes the gas burn cleaner.
   d. It allows the gas to move through a pipeline.

4. What should the distillation design do to achieve the best result?
   a. Prevent evaporation*
   b. Heat the crude oil.
   c. Prevent heat exchange.
   d. Allows oil to solidify.

Extension of lesson: Visit the website of your local electricity or natural gas provider to learn more about the home energy audits or energy services that they might provide. Rocky Mountain Power Dominion Energy. Have students ask their parents to see a natural gas bill or visit the school furnace.

Career Connections: Have students research various career opportunities in Utah relating to natural gas and other natural resources. Find information about careers in the natural gas industry here.

Transporting Natural Gas

Name____________________________________

Background: Natural gas is an important source of energy for modern society. It burns cleaner than other fossil fuels and is abundant. It forms similarly to other fossil fuels and often with oil or coal. It is a gas in its original state but may be liquefied by changes in temperature or pressure. Most natural gas is delivered in its gas state by pipeline in the United States. To get the gas to the international market, the development of technology to liquefy the gas has grown. Liquefied gas is 600 times smaller in volume than the same amount of gas! Liquefied natural gas must be cooled to about -260° Fahrenheit for shipping and storage. The liquefaction process makes it possible to transport natural gas to places pipelines do not reach and to use as a transportation fuel.

The problem: Natural gas must be changed from a gas to a liquid and then back to a gas to be transported and used. Here is a ship that carries natural gas.

https://www.energy.gov/fe/science-innovation/oil-gas/liquefied-natural-gas

Write down three questions about this design:

1.

2.

3.

Natural gas is too flammable to handle in a classroom setting, so water will be used as a model of this technology. How does water change from one phase to another?

Listen as your teacher describes the process of water distillation.

There are many ways to alter the distillation process. Work on a design that will most effectively transmit 100 mL of water from one beaker to another with your group. Your success will be measured by transforming the water from liquid to gas to liquid again and the amount of water you get in the second tube.

1st design:

Results: Trial 1: ___________mL in test tube

2nd design:

Trial 2: ___________mL in test tube

Observe the class results and data. Using evidence from your investigation, write an explanation for why there may be differences in the data. Also, identify similarities and differences between your group's design and others.