UTAH GOVERNOR'S OFFICE OF
ENERGY DEVELOPMENT

Physical Change with Matter and Heat

Grade/Subject: 5th Science

Strand/Standard 5.2.4 Use mathematics and computational thinking to provide evidence that regardless of the type of change that occurs when heating, cooling, or combining substances, the total weight of matter is conserved. Examples could include melting an ice cube, dissolving salt in water, and combining baking soda and vinegar in a closed bag. (PS1.A, PS1.B)

Lesson Performance Expectations:

- Identify different states of matter focusing on liquid changing to a solid
- Identify the conservation of mass with phase change.
- Make observations of energy/heat loss when during a physical change in matter

Materials: Students groups of 3

- Crockpot (preferably an old one, as it will be melting wax, a liner may be used)
- Paraffin wax (2 - 4 liquid oz. per group -- Can be found at any craft store or Amazon)
- Candle dye (Optional) for students to see the wax better
- 8-oz plastic drink cups (enough for each group to have 4 - 5 cups)
- Tablespoon-- .5 oz. ladle
- Thermometer (one for each group)
- Scale that measures in grams

Time: 40 - 60 mins

Teacher Background Information:

- **Conservation of Mass:** Substances undergoing chemical or physical changes do not change mass as long as nothing is added or taken away.
- **Heat** is a form of energy associated with the movement of atoms and molecules in any material. The higher the temperature of something is the faster the atoms move and the more energy is present. Atoms move more slowly (less freely) when matter is in a solid state. When the temperature rises, the atoms move more freely; eventually the atoms move fast enough to change the state from a solid to a liquid (**melting point**), or from a liquid to a gas (**boiling point**). The opposite is also true. When heat is removed (when an object cools), the movement of the atoms slows down; eventually the gas becomes a liquid, which will then become a solid (**freezing point**) with enough heat loss.
- The concept of phase change is demonstrated when some of Utah's petroleum is extracted. We use petroleum to fuel our cars and produce many other products, like plastics. Oil can be found in many parts of Utah. In locations like Uinta Basin (Duchesne, Uintah, Grand and Carbon counties) and Paradox Basin (San Juan County), petroleum is not the liquid oily substance that we typically think of. Instead of being a black liquid, it is a waxy substance called waxy crude that hardens when it loses heat and its temperature decreases. When it is below the earth, this oil is hot enough to remain in liquid form, but as soon as it reaches the surface, it begins to cool, and if it is not kept warm using some kind of insulator, it will harden like wax.
- Waxy crude is found in two colors: yellow and black. The difference in color is attributed to the organic material that it is derived from, along with the maturity of the crude. Yellow wax was formed during the time period when Utah was covered by freshwater, whereas the black wax was formed when parts of Utah were covered by salt water. While waxy crude is a resource to add to Utah's fossil fuel portfolio, transporting it before it hardens remains a challenge. Engineers had to find a way to keep the crude warm below its freezing point while it is

transported to the refineries. The most cost efficient way to do this is through insulated containers that hold the petroleum.

Student Background Knowledge:

Students need to know the differences between the physical changes of matter (solid liquid and gas). The teacher or students can learn more from this simulation. Focus on the energy or heat loss during the transition of a liquid to a solid. https://phet.colorado.edu/en/simulation/states-of-matter-basics

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

Prep before lesson

1. The teacher will melt paraffin wax in a crockpot. This can take anywhere from 1-2 hours, depending on how much wax you have, so time accordingly so the wax is melted before class. If you want to make it a little easier on the students, get some candle dye so it will be easier to see in the cups (this is completely optional). You can also use a crock pot liner to make clean up easier.

2. Divide the students into groups of 3 - 4.

Lesson

3. **Introduce the phenomenon:** *One of Utah's natural resources is waxy crude oil. Oil is found in many parts of the state. In locations like Uinta Basin (Duchesne, Uintah, Grand, Carbon counties) and Paradox Basin (San Juan County) the oil looks a lot different than you may think. Utah's oil is in a liquid form when it's underground.* As soon as it reaches the surface, it begins to cool, and if it is not kept warm using some kind of insulator, it will harden like wax.

Waxy Crude Oil Before Hardening

Waxy Crude Oil After Hardening

Together with your group, write down 3 questions you may have about the liquid oil hardening into a solid waxy state. What math tools would you use to determine the physical change in the crude oil?

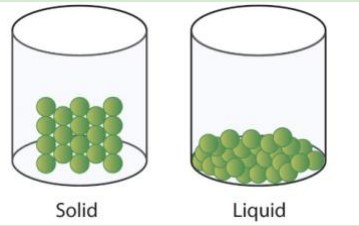
4. Give time for the students to decide which responsibility each student will perform and record the names on their observation sheet. These responsibilities can be rotated throughout the experiment if you would like.
5. The teacher will take the temperature of the melted wax in the crockpot (make sure the thermometer is in the middle of the wax and not touching the side or bottom of the crockpot). Students should record this temperature on their sheets.
6. The teacher will give each group a 2-oz. cup with 1 TBSP of melted wax. Plastic cups may melt a little when the wax sits in them.
7. Upon receiving their cups, each group will place their cup on a scale and take the weight. They will observe their cup to see what the changes the wax makes in the cup. They students will need to leave their cups on the scales until the experiment is over. Students will begin to see solidification around the sides and on the bottom almost immediately.

They should record their observations and continue to observe what happens. The next observation recorded will be when the top layer solidifies.
8. Students will record the time, temperature and mass in the row for cup #1.
9. Once a group has recorded their observations on their student sheet, they will return to the teacher to get another cup of wax.
10. The teacher will give the groups a second cup with 1 TBSP of wax.
11. Each group will repeat steps 6 through 8 for cup #2
12. The teacher will give the groups a third cup with 1 TBSP of wax.
13. Each group will repeat steps 6 through 8 for cup #3
14. Average the mass and temperature readings.
15. **Answers to questions:**

1. How did the wax look when it was a liquid? *Clear, runny*

Solid? *Not clear, cloudy, hard*

2. What was the temperature difference from liquid to solid? *Somewhere between 10-30 degrees depending on how long they let it cool.*
3. Why did we average temperatures and masses? *Averaging is a way to see how well data agree.*
4. What happens as the wax hardens? Draw a picture of what the molecules are during the liquid state and the



solid state.

5. How did math help us understand the experiment? *Math showed us how much change occurred and what the average was.*
6. Did the mass of the wax change when it changed forms? *No* Why? *No matter was added or taken away.*

Assessment of Student Learning. Students should claim that mass is conserved during a physical reaction. The evidence is that the three experiments showed mass as unchanging when wax changed from a liquid to a solid. The reasoning may include the mathematical averaging that helped support the claim or they could very correctly discuss that not enough data was collected in this experiment to prove it.

Standardized Test Preparation:

Physical Change with Matter and Heat

Use this information to answer the questions. A cube of ice was put in a cup and massed. The ice was allowed to melt and the cup was massed again.

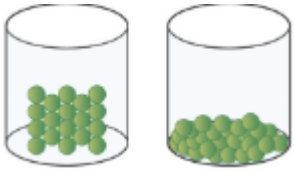
Cup	Starting Mass	Ending Mass	Difference
A	**15.1 g**	**15.0**	**-.1**
B	**16.3**	**16.3**	**0**
C	**14.7**	**14.8**	**+.1**
Average			**0**

1. How did the ice in the cups change? Choose all that apply.
   a. The ice changed from a solid to a liquid.*
   b. The ice changed from a liquid to a gas.
   c. The ice changed in atomic structure.
   d. The ice changed its molecular motion.*

2. The results indicate that mass was conserved in this experiment. What does that mean?
   a. The cups all started at the same mass.
   b. The cups all finished with the same mass.
   c. The mass did not change.*
   d. The mass showed a physical change occurred.

3. If students had added two ice cubes to cup B, would the average be any different?
   a. Yes, the number would be higher.
   a. Yes, the number would be lower.
   b. No, the number would stay at zero.*
   c. No, the cups could no longer be compared.

Containers of waxy crude oil.



X Y

4. How is the wax in container X different than in container Y? Choose all that apply.
   a. The molecules in X are moving slower.*
   b. The molecules in X are moving faster.
   c. The molecules in X are a liquid form.
   d. The molecules in X are a solid form.*

5. Why was an average taken of the differences? Choose all that apply.
   a. To show that, mathematically, there was no change.*
   b. To show that each experiment was identical.
   c. To help understand the meaning of the data.*
   d. To delete data that did not agree with other data.

Extension of lesson and Career Connections: Allow the students to view examples of waxy crude oil. Here is some suggestions
https://utahpetroleum.org/production/
Crude Oil Extraction (1:23 mins)
Yellow Waxy Crude Oil -- (3:30) mins This video shows what crude oil looks like and how it can stick inside containers.