Name: _____ Packet Due Date:_____

Science

Module 2	**Phase Change**
Chapter 2	**Investigating Energy and Phase Change** *What could cause liquid methane to change phase?* *(NGSS Performance Expectations: MS-PS1-1; MS-PS1-4; MS-PS3-4; MS-PS3-5; MS-ESS1-3; MS-ESS2-4)*



Lessons & Objectives

Lesson 7: Causing Freedom of Movement Changes
- ❑ I can use a simulator to determine what causes a molecules' freedom of movement to change.

Lesson 8: Understanding Energy Transfers
- ❑ I can explain how transferring kinetic energy in and out of a substance can cause a molecules' freedom of movement to change.

Lesson 9: Evaluating Evidence and Claims
- ❑ I can construct a scientific argument to explain what happened to the lake on Titan.

Packet Completion Rubric

4	3	2	1	0
Nothing in packet is missing. Responses consistently meet ALL of the criteria for high quality work. Exemplary effort is evident throughout entire packet.	Packet is 75-100% complete/accurate. Work/effort misses the criterion for high quality consistently.	Packet is 50-75% complete/accurate. Work/effort has evidence of quality but not consistently.	More than 50% of the packet is incomplete or incorrect. Work does not meet the expected level of quality.	Packet is entirely incomplete or not turned in.

Grading Breakdown: 0 - 1.9 = F 2 - 2.4 = D 2.5 - 2.9 = C 3 - 3.4 = B 3.5 - 4 = A

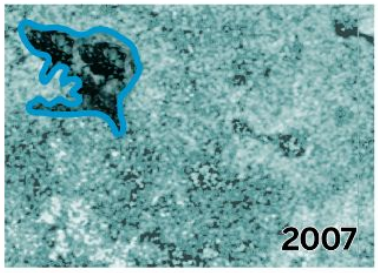
Lesson 7: Causing Freedom of Movement Changes

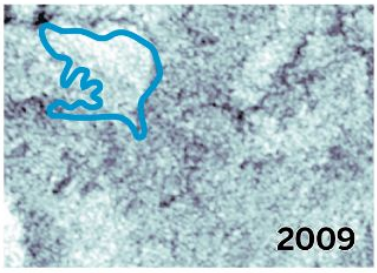
Objective: I can use a simulator to determine what causes a molecules' freedom of movement to change.

Lesson 7 DO NOW	*In two to three complete sentences, explain what you think happened to the lake on Titan!* Please make sure to use scientific language from Chapter 1. _____ _____ _____ _____ _____ _____ _____

Do Now Recap

We know that sometime between 2007 and 2009 the methane molecules' *freedom of movement* changed. We don't know what made this happen nor do we know if the phase change involved was freezing or evaporation.





Unit Question:

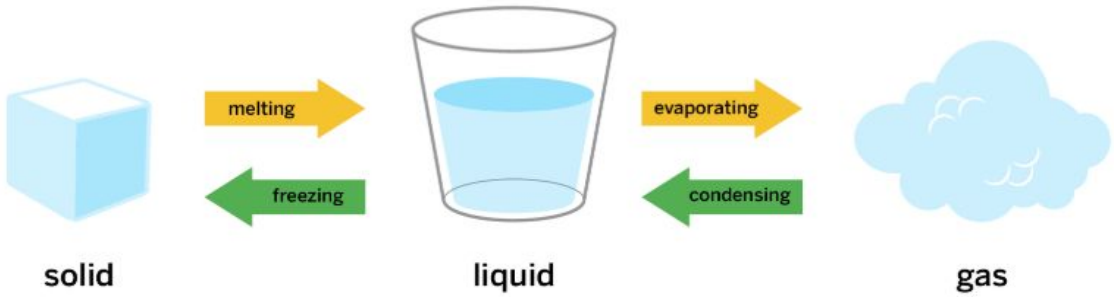
How can the appearance of a substance change without it becoming a different substance?

Chapter 2 Question:

What could cause liquid methane to change?

To better answer this question we need to first learn more about a molecule's _____!

In Chapter 1, you read "*Weird Water Events*" to learn more about the phase change on a molecular scale. Now, you are going to focus in on what events affect the ***freedom of movement of molecules*** in each of the four articles. The excerpts for each article are below. ***Please annotate each excerpt while looking for freedom of movement between phase changes.***



Old Faithful Geyser

"Old Faithful lies in Yellowstone National Park, an area where an ancient volcano still heats up rock close to the surface. This hot rock heats up water that trickles down through cracks. The water is able to trickle because of the behavior of its molecules. Molecules in liquid water are free to move around each other and flow down into a container–in this case, underground spaces made by cracks in the rock.

Inside its rock container, the water becomes extremely hot, causing some of the water at the bottom to change phase. The liquid water changes into a gas called water vapor. The molecules in a gas have more freedom of movement than molecules in a liquid. Molecules in gas are free to move away from each other, so gas can expand to fill its container."

Flash Floods in Slot Canyons

"Even in the desert, there is water vapor in the air—molecules of water in the gas phase. These molecules have a lot of freedom of movement and can move apart from each other, so water vapor is invisible. Even though you can't see it, the water vapor is still there. When conditions are right, hot air forces this water vapor upward, high above the desert floor, where temperatures are cooler. As the water vapor cools, it changes phase and condenses into droplets of liquid water. These droplets gather to form huge storm clouds. Soon, big drops of rain fall on the dry desert. The hard, dry desert ground can't absorb all the water, so the water flows quickly across the desert floor, becoming a flash flood."

Glacier Caves of Iceland

"In the ice walls of the cave, the water molecules have very little freedom of movement. Since the molecules of water are held in place, the ice is rigid and keeps its shape. These hard, shiny walls of ice sparkle in the light from visitors' flashlights. In spots where this ice meets hot rock, the ice changes phase. As the solid ice melts into liquid water, its molecules gain more freedom to move around. The molecules of liquid water become free to slide around each other. Because of what's happening on the molecular level, the liquid water is able to flow, forming streams and cutting tunnels through the ice."

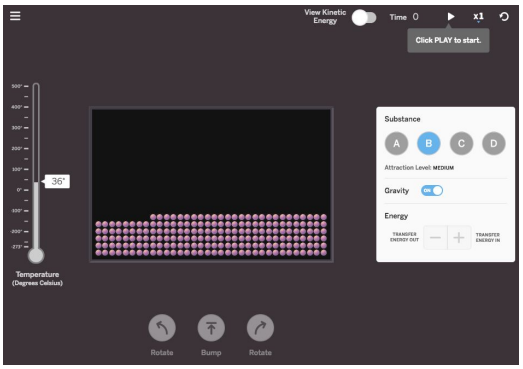
Frozen Niagara Falls

"The cold weather causes a phase change. Niagara Falls freezes—not completely, but large parts of it. The spectacle of the partially frozen falls is thanks to the behavior of water molecules. When it gets cold enough, the water changes phase from liquid to solid. The molecules lose some of their freedom of movement, becoming stuck in place. They still move back and forth a little, but they can't move around each other. Because of what's happening on the molecular scale, the flowing liquid freezes into solid ice. It forms huge icicles, ice columns, and a shelf of ice at the base of the falls. The frozen falls may look like sculpted rock, but they are still made up of water molecules. As warmer weather arrives, the ice melts into liquid water and the falls flow freely again."

Using the SIM to explore *Freedom of Movement*

1.Each group member (groups of 4) should choose the substance (A, B, C, or D) that matches the starting phase of the water described in your text. Start with:

a. gas for "Flash Floods in Slot Canyons."
b. solid for "Glacier Caves of Iceland."
c. liquid for "Frozen Niagara Falls."
d. liquid for "Old Faithful Geyser.



2.Make the molecules' ***freedom of movement*** change for that substance. The change should match the phase change that occurred in your article.
3. When finished recreating the phase change in the Sim, follow the instructions for completing the table in your packet!

SIM Freedom of Movement Tool

Referring to the text annotations and your observations in the sim, complete the row for the article you were assigned. When instructed by your teacher, share your observations with your group. Complete the table as each group member shares. Use the word bank to help you incorporate important scientific language.

condensation	evaporation	transferred energy out of the liquid	melting
the water became hotter	the water became colder	transferred energy into the liquid	freezing

	Type of phase change	What caused the water to change phase in the article?	How did you cause the phase change in the Sim?
Slot Canyons			
Glacier Caves			
Niagara Falls			
Old Faithful			

SIM Discussion

Discuss the following questions with your group:

1. What were the **similarities** between the phase changes each member of your group explored?

_____

_____

_____

What were the **differences** between the phase changes each member of your group explored?

_____

_____

_____

Based on these observations, answer the Investigative question for Chapter 2:

What can cause molecules' freedom of movement to change?

_____

_____

_____

SIM Discussion

What Can Cause Molecules' Freedom of Movement to Change?

freezing | condensing

The substance

- cools down.
- gets colder.

Energy is transferred out of the substance.

evaporating | melting

The substance

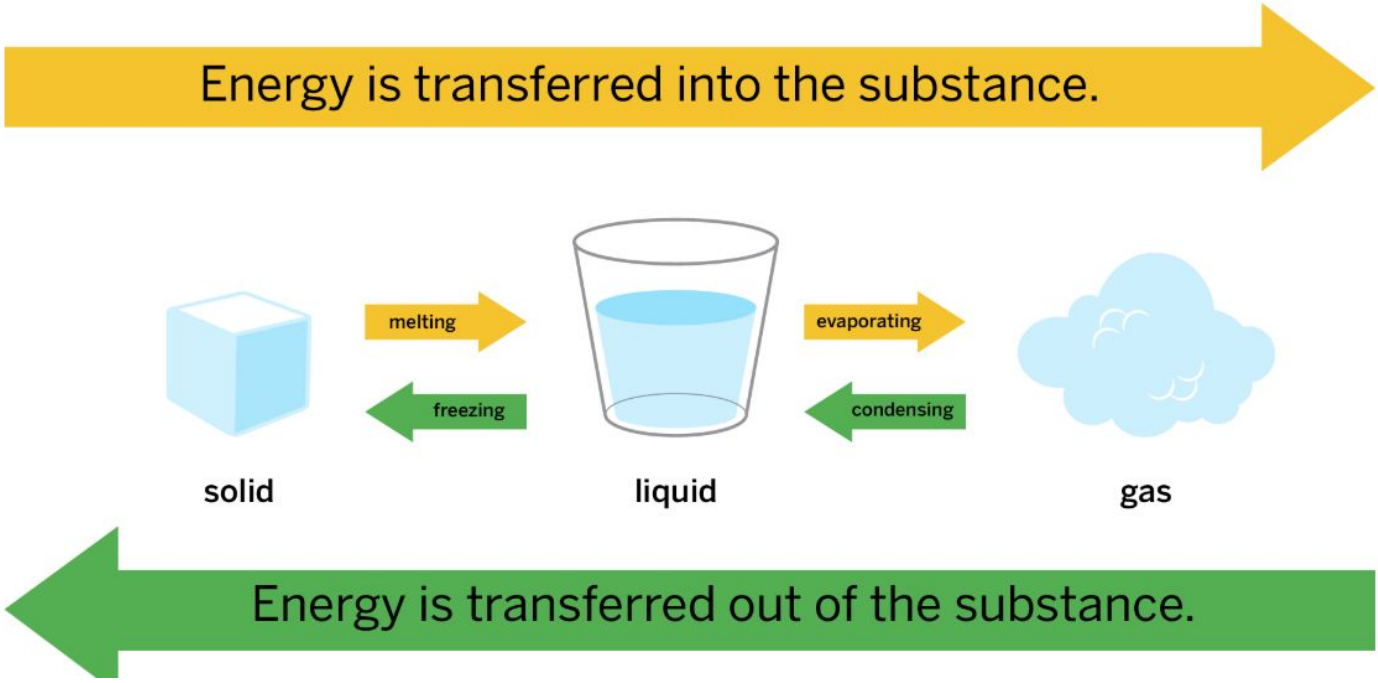
- heats up.
- gets hotter or warmer.

Energy is transferred into the substance.

Key Concept

When energy is transferred to or from a substance, it can change the molecules' freedom of movement.

What Can Cause Molecules' Freedom of Movement to Change?



The Solid, Liquid & Gas Phases of Matter

By Hayley Ames; Updated April 25, 2017

Materials have a solid, liquid and gas form. Each of these forms is known as a phase of matter. In each of its phases the particles of a substance behave very differently. A substance can change from one phase to another through what is known as a phase transition. These phase transitions are mainly the result of temperature changes.

Solid

When a material is in its solid phase, molecules are bound together tightly. The shape and volume of a solid is usually fixed. The forces that attract particles to one another are particularly strong in solids, keeping them close together in specific positions. This helps to prevent a solid from breaking apart or being compressed. The density of solid material increases at lower temperatures. The colder the temperature, the weaker the vibrations of particles, making them pack together even tighter. Solids can be classified as crystalline, with particles arranged tightly in geometric patterns, or they may be classed as amorphous solids. The crystals in amorphous solids, such as clay, are arranged more loosely and randomly, allowing the shape of the material to be altered.

Liquid

In its liquid phase, the particles that make up a substance have more freedom of movement. This movement is achieved through the particles gaining thermal energy. The shape of a liquid is determined by the shape of its container. Although the particles in a liquid are not bound together as tightly as those in a solid, liquid substances cannot be compressed. Liquid particles are more energetic than solid particles and can move around but only within a certain distance from other particles. There is still a force of attraction holding them together loosely. Because particles are further apart in a liquid, the volume of a substance in its liquid phase is greater than its volume in a solid phase.

Gas

The shape and volume of a gas is determined by the shape and volume of its container. However, unlike a solid, a gas will escape if there is no lid on its container. The particles in a gas have a great deal of freedom of movement and do not have an ordered arrangement. This is because the forces that attract these particles to each other are weak or absent in the gas phase. Gas particles have a great deal of kinetic energy, which is continually passed around between particles as they move around and bump into each other.

Please read and annotate the following article for your exit slip. Please **circle** all occurrences of the ***freedom of movement*** of molecules in the article.

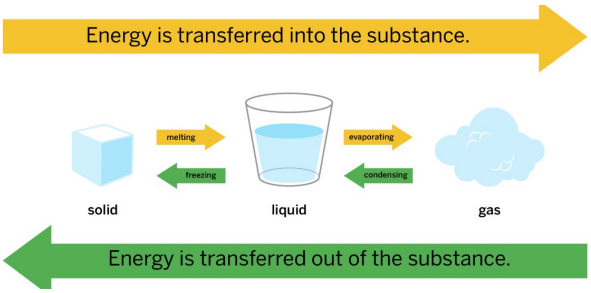
Transition

Phase transitions take place due to changes in temperature, although they are also influenced by atmospheric pressure. A solid becomes a liquid when it is heated to its melting point, where heat gives the particles enough energy to loosen their structure and become a liquid. At boiling point, heat gives particles in a liquid enough energy for those on the surface of a liquid to escape the structure and vaporize, moving into the air as a gas. Low atmospheric pressure allows liquids to boil at a lower temperature. For gas to become a liquid, it must cool enough for particles to lose energy and condense; forming bonds tight enough to hold a liquid form. For a liquid to become a solid, it must freeze so that particles have very little energy and are drawn together by very tight bonds.

Lesson 7 EXIT SLIP	Please read and annotate the article on pg.6 for your exit slip. Please **circle** all occurrences of the ***freedom of movement*** of molecules in the article.

Lesson 8: Understanding Energy Transfers

Objective: I can explain how transferring kinetic energy in and out of a substance can cause a molecules' freedom of movement to change.

Lesson 8 DO NOW	*You decide to place a chocolate bar in a hot pan at home. The chocolate began to flow and it took the shape of the pan.* *Explain what changed in the chocolate's freedom of movement. Use the diagram provided from last lesson to help you with your response.*  _____ _____ _____ _____ _____ _____

Using the SIM to explore *Freedom of Movement*

We know that transferring energy can cause a change in molecules' freedom of movement. Another way to say this is that transferring energy into or out of a substance can cause a phase change. Today, we will take a deeper look at what happens to molecules when energy is added or removed.

Kinetic Energy Key

Our new investigation question for this lesson is:
Why can transferring energy into or out of a substance change molecules' freedom of movement?

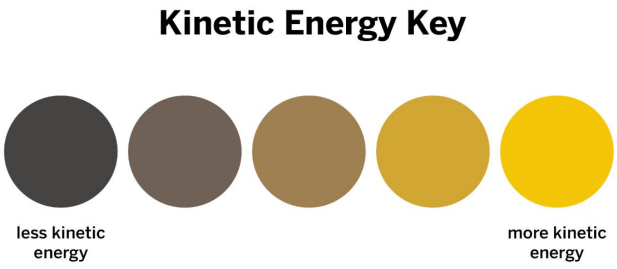
We can further build on our Chapter 2 question:
"What could cause liquid methane to change phase"?

The SIM

Launch the Simulation. Consider the following question as you work: ***Why can transferring energy into or out of a substance change molecules' freedom of movement?***

1. You have caused phase changes in the Sim before. Before you start this new activity, think about how you created these phase changes in the past.
2. Begin with substance A.
3. Turn on the kinetic energy and **press the play** button to start the Sim.
4. Transfer energy into the substance.
5. Observe what happens to the molecules. Pay particular attention to the molecules' kinetic energy.
6. ***Answer the first question.***
7. Once the highest energy possible has been reached, begin to transfer energy out of the substance. Pay particular attention to the molecules' kinetic energy.
8. ***Answer the remaining questions.***

Questions to answer as you use the SIM



1. Describe how transferring energy into the substance affected the speed of the molecules.

_____

_____

_____

_____

2. As the speed changed, what did you notice about the molecules' ***freedom of movement***?

_____

_____

_____

_____

3. Do you believe changes in the speed of molecules, kinetic energy, and freedom of movement might have an effect on the temperature of the substance? Why or why not?

_____

_____

_____

_____

Video Notes: "Zooming In On Phase Change" and "Breaking and Forming Bonds"

Developing Our Claims

What are the three concepts we have discussed that change when transferring energy into, or out of a substance?

_____ _____ _____

All 3 of these ideas have an effect on the molecules':

_____

Developing Our Claims

Investigation Question:

Why can transferring energy into or out of a substance change molecules' freedom of movement?

Claim 1: Transferring energy into or out of a substance changes _____

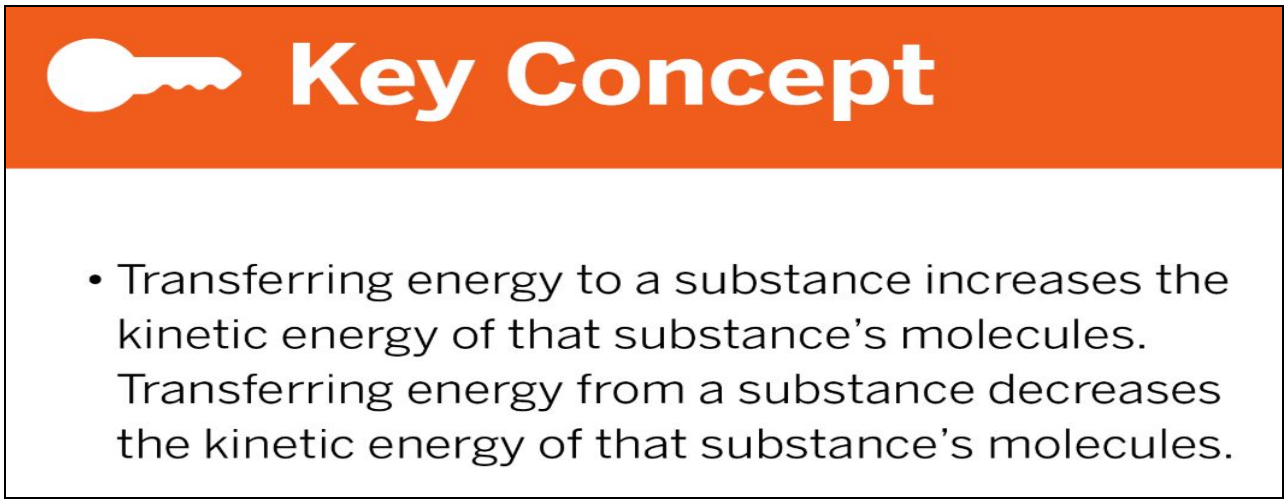
_____

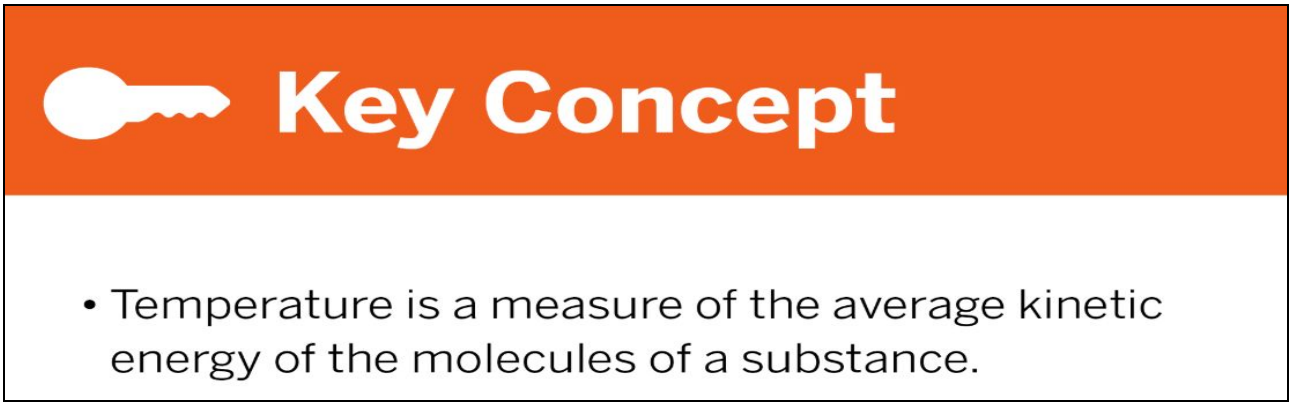
Claim 2: Transferring energy into or out of a substance changes _____

_____

Claim 3: Transferring energy into or out of a substance changes _____

_____





What Burns? What Melts?

Imagine this: You're camping with your family. It's a beautiful night, just perfect for sitting around the campfire and making s'mores under the stars. You layer a graham cracker, a piece of chocolate, a marshmallow you've toasted over the fire, and another graham cracker—a sweet, sticky treat! You might even leave your whole s'more sitting near the fire to help melt the chocolate. In that moment, the campfire is transferring energy to the wood in the fire and to the chocolate, but they're responding in very different ways. The wood is burning, while the chocolate in the s'more is melting. What's the deal?

Melting is a phase change from the solid phase to the liquid phase. The molecules in a solid chocolate bar are packed tightly together and can only move in place. When energy is added to the solid chocolate—like thermal energy from a fire—the molecules gain energy and begin to move around more. When they have enough energy and freedom of movement to flow around each other, the chocolate becomes a liquid. It's important to remember that melting doesn't change substances into other substances. The molecules that make up your chocolate bar haven't changed; they're just moving around more. It's even possible to make liquid chocolate back into solid chocolate by removing energy—also known as letting the chocolate cool.

The wood in your campfire is also receiving energy from the fire, but it definitely isn't melting into a liquid. Instead, it's burning.

Combustion is caused when some materials reach a certain temperature and their molecules react with oxygen.

Sometimes transferring energy to a substance causes it to burn, and sometimes it causes it to melt. Why is that?

Read and annotate the article "What Burns? What Melts?" and then answer the questions in your packet!

Burning, also known as combustion, is a chemical reaction that happens when some materials reach a certain temperature and their molecules react with oxygen. The fire transfers energy to the wood, raising its temperature. When the wood reaches about 150°C (302°F), its molecules begin to break down. Some change into the gas phase and escape into the air; others react with oxygen in the air and give off light and heat. Some parts of the wood don't burn and are left behind as ash. The combustion reaction keeps repeating itself until it runs out of fuel (like wood) to burn, until its supply of oxygen is cut off, or until its temperature is no longer hot enough to keep breaking down the molecules in the wood. That's why the fire goes out a little while after you stop adding new logs. Without fuel to burn, the reaction that causes the fire can't continue.

So the chocolate on your s'more melts, while the wood in the campfire burns. But why? Every material has a different temperature at which it melts (its melting point) and a temperature at which it burns (its flash point). How the material reacts to heat depends on which of those temperatures is lower. If a material's flash point is lower than its melting point, that material will burn before it melts. If a material's melting point is lower than its flash point, it will melt before it burns. Wood's flash point is lower than its melting point, so it burns. Chocolate's melting point is lower than its flash point, so it melts.

Lesson 8

EXIT SLIP

1. Is burning a phase change? Explain.

2. What determines whether a material melts or burns when heated?

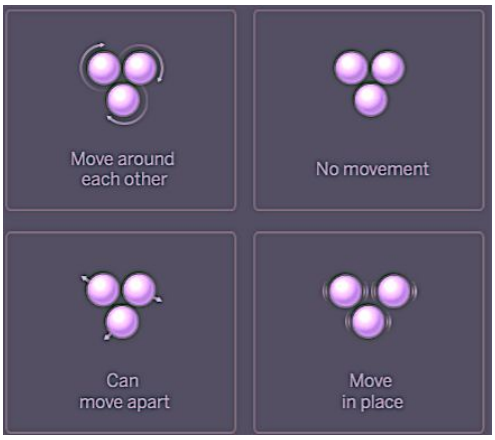
Lesson 9: Evaluating Evidence and Claims

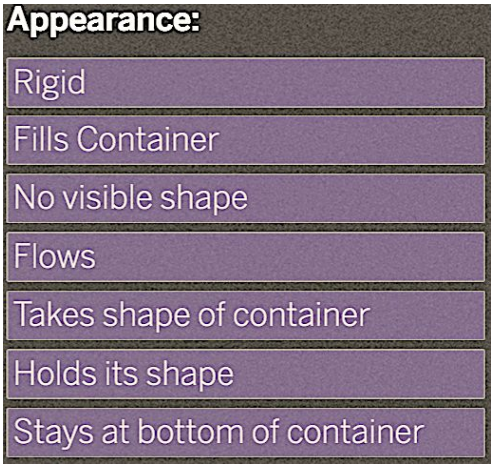
Objective:I can construct a scientific argument to explain what happened to the lake on Titan.

Lesson 9

DO NOW

You are freezing juice to make your own popsicles. Create a model in the space provided that shows what happens on a molecular level as the juice freezes. Include a selection of the following terms in the boxes provided.





To: Student Chemists
From: Dr. Daniela Flores, Lead Chemist at the Universal Space Agency
Subject: Request for Final Scientific Argument

UNIVERSAL SPACE AGENCY

Based on your investigations, we are closer to determining what happened to the lake on Titan. We have collected additional evidence, which I am now sending to you. After you analyze the new evidence, please send me a written scientific argument about which claim you think this new evidence best supports. Remember to explain your reasoning.

Preparing Your Final Explanation

Use the evidence cards provided by your teacher to either support or refute either claim.

	Claim 1. The lake froze.	***Claim 2. The lake evaporated.***
The evidence cards that *support* the claim...		
The evidence cards that *refute* the claim...		

Reasoning Tool

In order to prepare your final explanation to Dr. Flores, please complete the reasoning tool to compile all your evidence from this chapter. Remember, we want to address the Chapter 2 question: "***What could cause liquid methane to change phase?"***

Evidence (Describe the most convincing evidence card.)	**This matters because . . .** (How does this evidence support or refute the claim?)	**Therefore, . . .** (claim)
Quotation from *Weird Water Events:* "No matter what phase water is in, the water molecules stay the same; they just move differently."	If water molecules always stay the same, they cannot disappear when water changes phase.	Therefore, the evidence refutes the claim that "molecules in a substance disappear or no longer exist when a substance changes phase."
		This evidence supports the claim that the lake evaporated.
		This evidence refutes the claim that the lake froze.

Additional Notes:

Final Explanation

Dr. Flores would like an update on your research about what happened to the lake on Titan. Did the lake on Titan evaporate or freeze? After you clearly state your claim, explain how the evidence connects to the claim to support your argument. Remember to explain what happened at both the macro and molecular scale.

CER Writing Assessment Rubric - Adapted for Science					
Rubric Categories	**4**	**3**	**2**	**1**	**0**
CLAIM **TOTAL /4**	Writes a one-sentence claim that is clearly communicated, uses the language from the question, and accurately responds to the writing prompt. **Does not contain an "I" statement.**	Writes a correct one sentence claim that accurately responds to the writing prompt but **does not fully use the language from the writing prompt.**	Writes a claim sentence that **somewhat** responds to the writing prompt, but is **incomplete or disorganized.**	Writes a claim sentence that **does not respond to the writing prompt.** Claim may be **confusing, unclear, or inaccurate.**	*Claim is missing entirely.*
EVIDENCE **TOTAL /4**	Selects multiple pieces of scientific evidence (facts, concepts, theories) or evidence from the prompt to **strongly** support the claim. The source of **each** piece of evidence is provided.	Selects multiple pieces of scientific evidence (facts, concepts, theories) or evidence from the prompt to **adequately** support the claim. The source of **most** pieces of evidence is provided.	Selects scientific evidence (facts, concepts, theories) or evidence from the prompt that **incompletely or vaguely** supports the claim. **Some evidence might be incorrect or inappropriate for the claim.** The source of evidence is **rarely provided or missing entirely.**	Selects evidence that **does not support** the claim.	*Evidence is missing entirely.*
REASONING **TOTAL /4**	**Clearly** explains the main idea of **each** piece of evidence in your own words using **precise** scientific language. **Clearly** explains how **each** piece of evidence supports the claim.	Explains the main idea of **each** piece of evidence in your own words using **scientific language.** Explains how **each** piece of evidence supports the claim.	Explains the main idea of **some** pieces of evidence in your own words. **Weakly** explains how **some** evidence supports the claim.	Reasoning is **unclear or confusing.** Reasoning **does not discuss the connection to the claim.**	*Reasoning is missing entirely.*
CONVENTIONS **TOTAL /2**	X	X	**Adequate use** of correct sentence formation, organization, punctuation, capitalization, grammar usage, and spelling	**Limited use** of correct sentence formation, organization, punctuation, capitalization, grammar usage, and spelling	*CER is missing entirely.*
TOTAL /14					