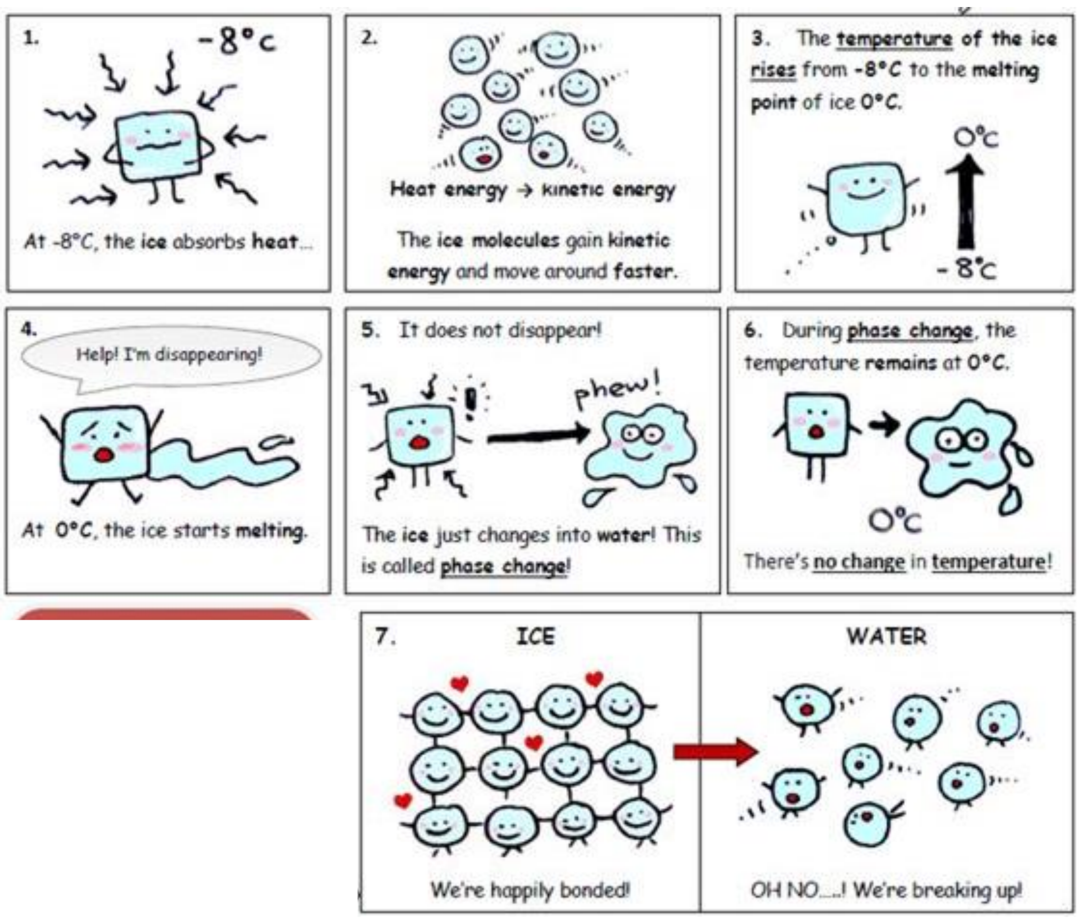
Matter & Its Interactions

Chapter II

Phase Changes & Thermal Energy



Name:	
Hour:	

Phase Changes & Thermal Energy

STANDARD MS-PS1: Matter and Its Interactions	
Performance Expectations: **MS.PS1-4.** Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	
Dimension	**Name**
Science and Engineering Practices	**Developing and Using Models** Develop a model to predict and/or describe phenomena.
Disciplinary Core Idea	**PS1.A: Structure and Properties of Matter** Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
Crosscutting Concept	**Scale, Proportion, and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

STANDARD MS-PS3: Energy	
Performance Expectations: **MS.PS3-4.** Plan an investigation to determine the relationships, amount of energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.	
Dimension	**Name**
Science and Engineering Practices	**Planning and Carrying Out Investigations** Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
Disciplinary Core Idea	**PS3.A: Definitions of Energy** Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B: Conservation of Energy and Energy Transfer** The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
Crosscutting Concept	**Scale, Proportion, and Quantity** Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes

Phase Changes & Thermal Energy 

	The chemicals, reactants and products, involved in a chemical reaction.
	The container, air and any other substances in direct contact with the ‘system’ in a reaction
	When a solid substance turns into a gas without first becoming liquid
	A reaction or process accompanied by the EXITING of heat from a substance
	When a gaseous phase of matter turns directly to a solid without passing through the liquid phase
	When matter in a gaseous phase loses energy and becomes a liquid
	When matter in a liquid phase gains energy and becomes a gas - sometimes referred to as ‘boiling’
	A measure of the average kinetic energy of the particles in a sample of matter
	To take in or soak up
	The internal energy of an object due to the kinetic energy of its atoms and/or molecules
	A reaction or process accompanied by the ENTERING of heat into a substance
	The scale of temperature in which water freezes at 0° and boils at 100° under standard conditions

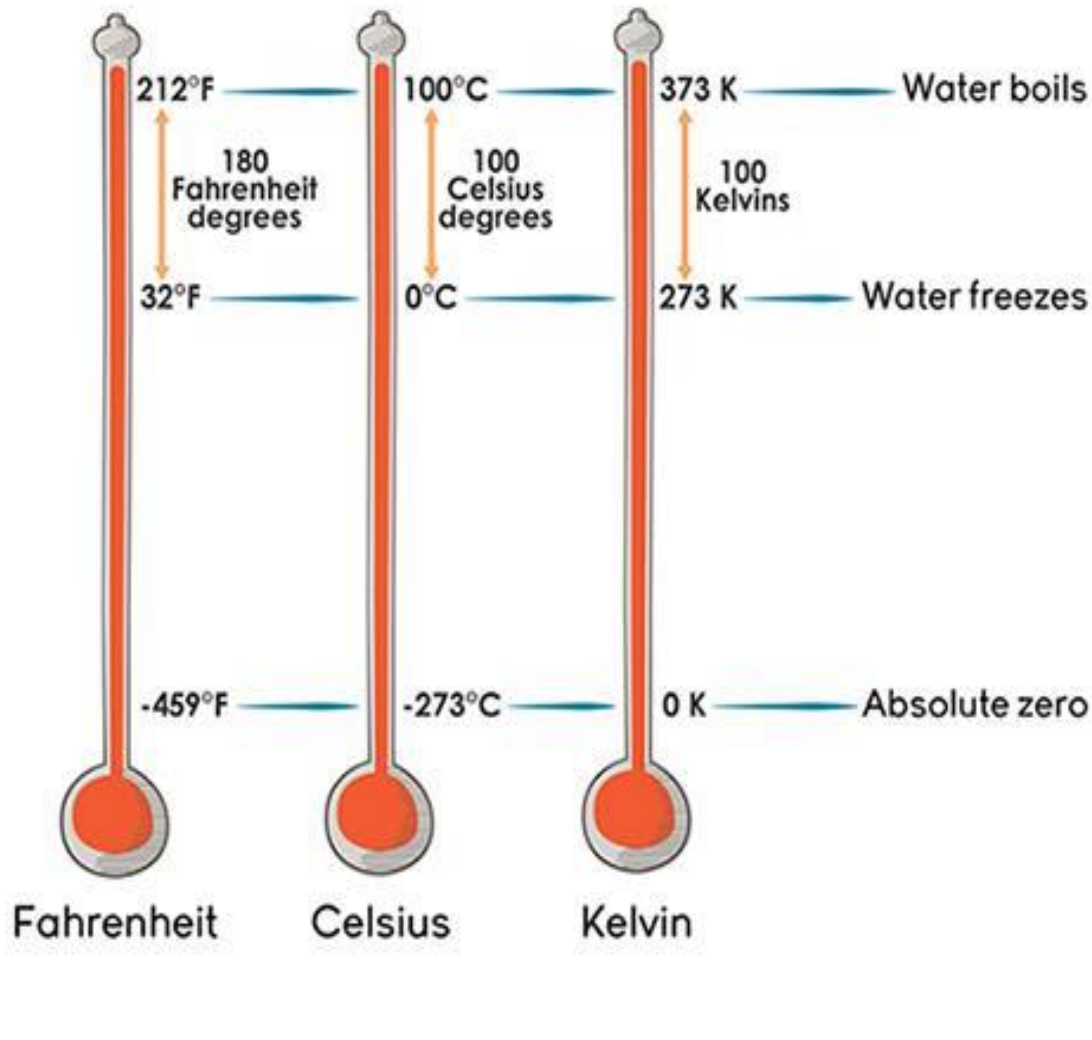
The(can)Crusher

1. Start by rinsing out the soda cans to remove any leftover soda goo.	
2. Fill the bowl with cold water (the colder the better).	
3. Add 1 generous tablespoon of water to the empty soda can (just enough to cover the bottom of the can).	
4. Place the can directly on the burner of the stove while it is in the "OFF" position. It's time for that adult to turn on the burner to heat the water. Soon you'll hear the bubbling sound of the water boiling and you'll see the water vapor rising out from the can. Continue heating the can for one more minute.	
5. It's important to think through this next part before you do it. Here's what's going to happen: you're going to use the tongs to lift the can off the burner, turn it upside down, and plunge the mouth of the can down into the bowl of water. Get a good grip on the can near its bottom with the tongs, and hold the tongs so that your hand is in the palm up position. Using one swift motion, lift the can off the burner, turn it upside down, and plunge it into the cold water. Don't hesitate . . . just do it!	

Observations	Sketches
• • • •	

Possible Explanation

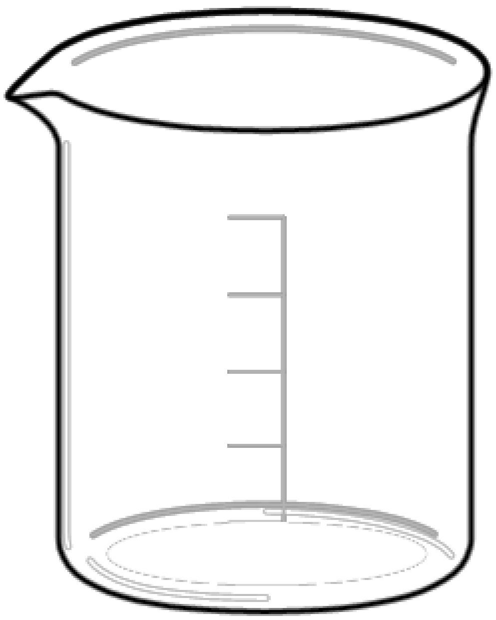
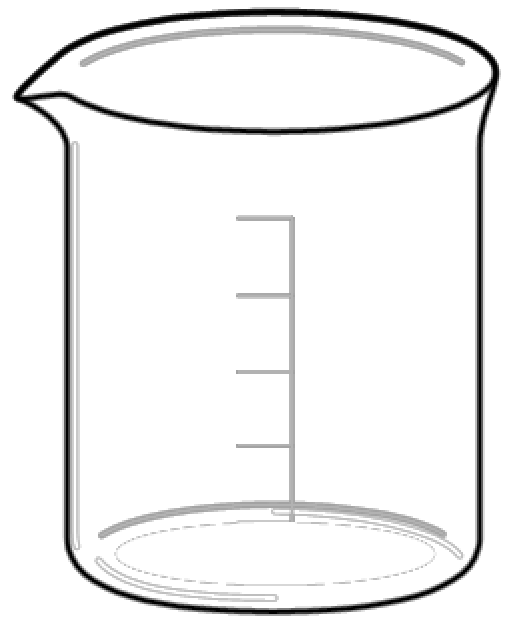
Temperature Comparisons
Conversions: C to F



Moving **M**olecules   **Dying to Meet You!?**

As you conduct the cold water, warm water diffusion activity, sketch both a **macro** and **micro** drawing for each. Use key vocabulary from our sorting activity (and word wall if available) to label and explain your work.

Macro Model

 ***Cold Water***	 ***Warm Water***
Cold Notes • • • •	***Warm Notes*** • • • •

Comparisons Between Cold and Hot Macro Observations:

Moving **M**olecules

Dying to Meet You!

<table>
<tr><th colspan="2">Micro Model</th></tr>
<tr><td>Cold Water</td><td>Warm Water</td></tr>
<tr><td>Cold Notes</td><td>Warm Notes</td></tr>
<tr><td colspan="2">Comparisons Between Cold and Hot Micro Observations</td></tr>
</table>

Thermal Energy

Kinetic-Molecular Theory of Matter

The Kinetic-Molecular Theory of Matter states that all matter is made out of very small particles which are constantly in motion. These particles are called atoms or molecules (atoms joined together). These particles have kinetic energy, or energy of motion that we perceive as temperature, so if there is an increase in temperature, the particles will move faster (they have more kinetic energy). When the particles collide, they exchange energy. This theory helps us explain why substances exist in different states of matter and how they can change states.

Summarize the Kinetic Molecular Theory of Matter:

Heat vs. Temperature

Is there more heat in an ice cube or in a candle flame?

Heat and temperature are not the same thing, they in fact mean two different things;

- Temperature is related to how fast the atoms within a substance are moving.
- Heat is a measure of how many atoms there are in a substance multiplied by how much energy each atom possesses.

There is more heat in an ice cube than in a flame. Why? Because although the atoms in an ice cube are moving about three times slower than the atoms in a flame, there are around 1000 times more atoms in an ice cube than in a flame!

HEAT

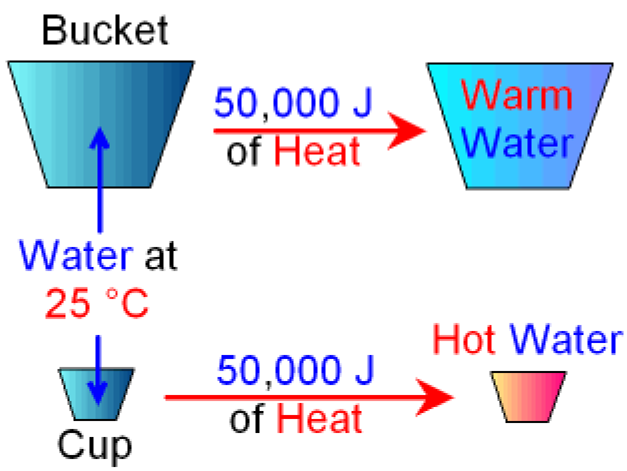
Heat is a measurement of energy – it is measured in Joules. Heat and thermal energy mean the same thing. All molecules contain some amount of kinetic energy, as they are constantly in motion – stated in the Kinetic-Molecular Theory of Matter. The hotter an object is, the faster the motion of the molecules inside it. Thus, the heat of an object is the total energy of all the molecular motion inside that object. However, even things that are cold can have quite a bit of heat energy (the molecules are still moving). If you removed ALL of the heat energy from an object, the molecules would stop moving. This would mean the temperature of the object is at ABSOLUTE ZERO.
Summarize what you know about heat:

Temperature

Temperature is a measure of the average kinetic energy of the molecules in a substance. It is measured in Celsius, Fahrenheit, or Kelvin. The faster the particles move, the hotter they are. When we say an object has a temperature of 100 degrees C, for example, we do not mean that every single molecule has that exact thermal energy. In any substance, molecules are moving with a range of energies, and interacting with each other as well, which changes their energies, but if we average the motion (kinetic) energies of all the molecules together, we can calculate an object's temperature.

Remember the idea about absolute zero? So, even an ice cube at 0^0 Celsius is actually relatively "hot!" In fact, compared to absolute zero, everything around us is hot. The molecules are moving, and the object has at least some heat energy.

Temperature does not depend on mass or how many particles there are. The amount of heat DOES depend on mass. If you double mass, you must double the heat energy in order to get the sample to the same temperature. An object's temperature does not tell us how much heat energy it has! Think of ice cubes compared to icebergs. Both are at the same approximate temperature, but because the iceberg has more mass than the ice cube meaning it contains more molecules and more heat energy.



Imagine you have a bucket full of water and a cup full of water both at 25 °C. If you add the same amount of heat energy (for example 50,000J) to both, you would find the temperature of the cup of water increases by more than the temperature of the bucket of water.

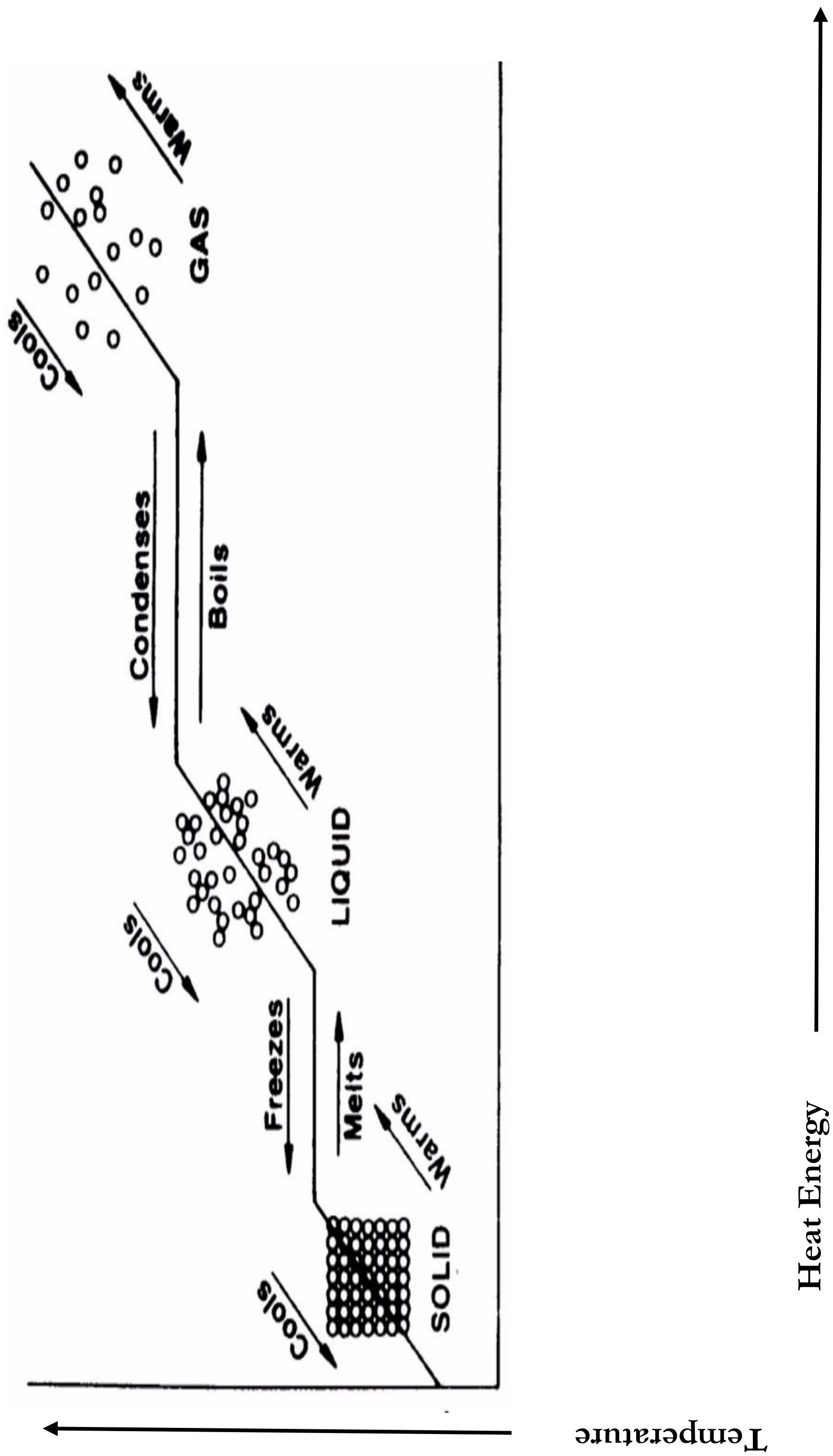
Summarize what you know about temperature:

RESOURCES:

http://askascientist.co.uk/physics/whats-the-difference-between-heat-and-temperature/
http://www.spitzer.caltech.edu/uploaded_files/other_files/0000/4597/TheDifferenceBetween.pdf
http://www.gcsescience.com/pen3-heat-temperature.htm
http://www.explainthatstuff.com/heat.html

Phased Out

MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.



Phased Out

Question: How do individual water molecules behave as more energy (heat) is added?

Materials:

- Thermometer (Temperature Probe)
- Ring Stand
- Hot Plate / Pot Equipment – Bunsen Burners if hot plate / pot n/a
- Large Beaker
- Appropriate safety gear

Procedure

Work with your group to develop a procedure and roles in order to design this activity to gather data to support the ideas of molecular motion. Good luck!

Safety Notes: *If you are working with Bunsen burners. Remember Bunsen burner safety rules! Is your hair and any baggy clothing tied back, jewelry removed? Goggles on??*

Data

Time (Mins)	Temp (C°)	Physical State/ Observations	Time (Mins)	Temp (C°)	Physical State/ Observations	Time (Mins)	Temp (C°)	Physical State/ Observations
0			5:30			11:00		
:30			6:00			11:30		
1:00			6:30			12:00		
1:30			7:00			12:30		
2:00			7:30			13:00		
2:30			8:00			13:30		
3:00			8:30			14:00		
3:30			9:00			14:30		
4:00			9:30			15:00		
4:30			10:00			15:30		
5:00			10:30			16:00		

Graph the data from the table, using Time (minutes) as the horizontal axis and Temperature (C) as the vertical axis. ***Don't forget to label axes and title the graph***.

TITLE: ____

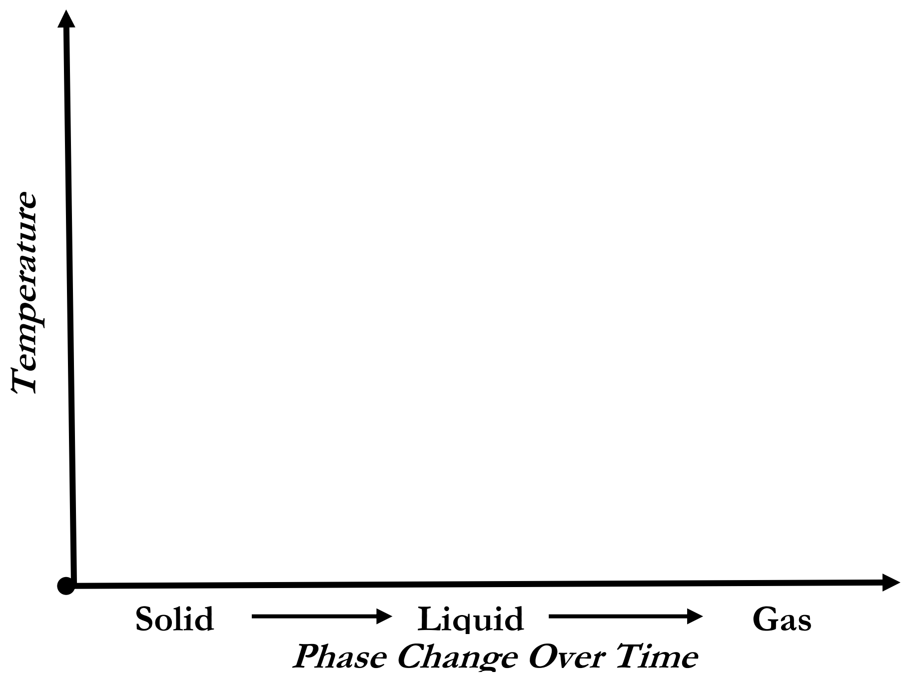
Evaluate: Answer the following questions to evaluate your data.

1. On your graph, label where the substance is changing states from liquid to gas
   How did you know to label there? ______________________________
2. What happened to the temperature of the water as the water boiled? Why do you think that happened?
3. As boiling occurred, bubbles were created in the water. What do you believe was in the bubbles? Explain!

4. **Checkpoint Question:** If the temperature wasn't getting hotter although the burner was providing heat energy, where do you think that the energy from the burner was going?

Communicate: Based on your accumulated knowledge, complete the following graph:
Imagine you started with a beaker of solid ice instead of water. Draw a graph showing how the temperature would change as the ice melts and changes from a solid to liquid water and then finally to water vapor. Don't forget to TITLE this graph!

TITLE:___________________________

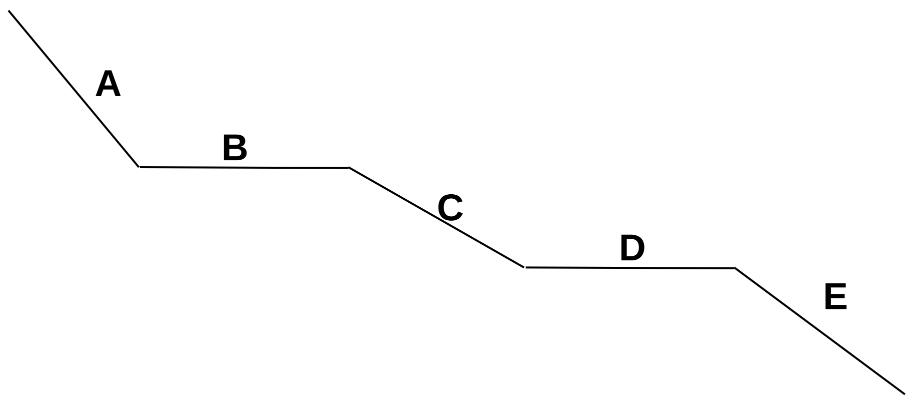


1. Look at your graph. **DURING** a change of state, what do you notice happens to the temperature while it is changing states?

2. How could there be a change in heat during a phase change without a change in temperature? If you are continuously adding heat, why isn't it getting hotter during the phase change? What is the energy doing instead if it isn't making the temperature rise?

Phase Change: Follow-Up Discussion

For your last question, you must apply your new knowledge to answer it. Use the following diagram of a **GAS** turning into a **SOLID** to answer questions a-d.



1. Is heat being added or removed from this substance? Explain how you determined this.

2. What is the substance doing along section B?

3. What is happening during segment A, C, and E?

4. Which segment of the graph represents the point during which the liquid is turning into a solid? What is this process called?

Just a Phase: Building a Model

MS-PS 1-2

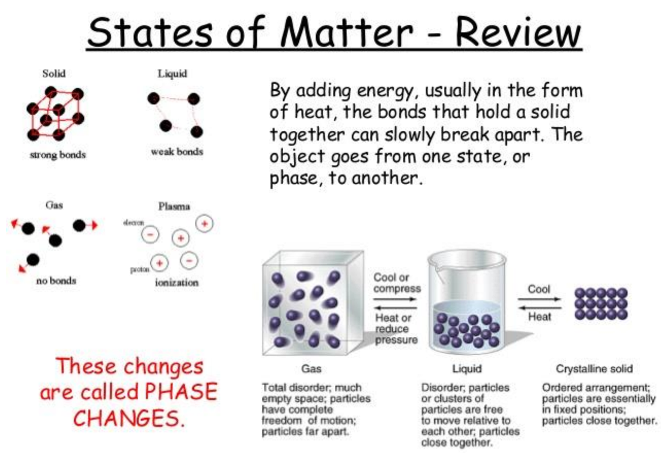
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal (heat) energy is added or removed.

Use your accumulatedknowledge to **create** and **annotate** a model demonstrating your understanding of this standard.

*Be sure to have a specific annotation about heat during the phase change as opposed to during a phase.

Word Bank

• Solid • Liquid • Gas • Thermal Energy (Heat) • Temperature (Celsius) • Heating • Cooling • Phase Change • Heat during Phase Change	• Freezing • Melting • Condensing • Boiling • Molecules • Spacing • Kinetic Energy • Spacing



MS-PS1A: Structure and Properties of Matter			
Advanced 10 pts.	**Proficient 9 pts**	**Developing 8 or 7 pts**	**Beginning <7 pts**
Proficient PLUS: Feature 'sublimation and/or deposition' as the phase change **Optional: Vary presentation format**	**Graph and explanation accurately show and describe the relationship between changes in temperature, state, and particle behavior when adding heat energy over time. Must**	**Minor mistakes, though shows a general understanding of the relationship between changes in temperature and state of matter as heat energy is added.**	**Several mistakes show lack of understanding of the relationship between changes in temperature, and state of matter as heat energy is added.**

Phase Changes, Heat, & Temperature Review

Use the suggested links on SOAS to help here. Check with your teacher.

Heat vs. Temperature Summary

1. Why are heat and temperature easily confused?

2. What is the relationship between **temperature** and **energy**? Give an example.

3. What is the relationship between **heat** and **energy**?

4. Describe, in detail, the TWO possible outcomes on the molecules of a substance when heat is added. Be able to **draw molecular models** to support your answer.

Outcome #1:	Outcome #2:
Molecular Model Drawing:	Molecular Model Drawing:

Change of Phase, Heat, and Temperature

- Name and describe each phase change, including a description of the changes in heat, temperature, and molecule behavior in each.

Change of Phase	Description of Molecule Behavior	Heat Changes	Temp Changes

- How is it possible for there to be a change in heat without a change in temperature? Be able to use the terms: heat energy, kinetic energy, temperature, molecules.

Molecular Motion, Heat, and Temperature

- Describe the relationship between temperature, speed, and kinetic energy. Be able to draw molecular models to support your answer.

	Molecular Model:

Word Bank:
Condensation
Deposition
Freezing
Melting
Sublimation
Vaporization