**Lesson 2.2: Physical Properties and Changes**

| Task | Page(s) | Learning Target |
|---|---|---|
| 1 | 2-3 | I can describe physical properties and changes of matter. |
| 2 | 4 | I can draw a model that predicts and describes changes in the phase of water when thermal energy is added or removed to create a solid, liquid and gas. |
| 3 | 5 | I can use evidence from text and a digital model to describe what happens to the molecules of a substance when it changes phase. |
| 4 | 6 | I can use a physical and digital model to describe how energy transfer affects molecules' freedom of movement. |
| 5 | 7 | I can model a phase change of water using a digital simulator. **Select one of the two Scenarios to Model: |
| 6 | 8 | I can follow a multistep procedure that will enable me to describe how kinetic energy of a substance must overcome the molecular attraction of that substances' molecules in order for a phase change to occur. |
| 7 | 9 | I can draw a model that predicts and describes changes in the phase of water when thermal energy is added or removed to create a solid, liquid and gas. |
| 8 | 10 | I can determine properties of cube samples in order to predict how they would behave if they were placed in water. |
| 9 | 11 | I can use a SIM to test *how molecular attraction affects whether or not a phase change will occur.* |

**Task 1 Learning Target:** I can describe physical properties and changes of matter.

Video Links:

https://www.brainpop.com/science/matterandchemistry/propertychanges/

https://www.youtube.com/watch?v=Z5L2NOMEWT0

https://www.youtube.com/watch?v=x49BtB5dOwg

https://www.youtube.com/watch?v=BOr76Zx48QM

https://www.brainpop.com/science/matterandchemistry/matterchangingstates/

https://www.brainpop.com/science/matterandchemistry/statesofmatter/

**1. Physical**

A. Physical properties:

a. Examples:

B. Physical changes:

a. Examples:

C. **States of Matter**

*Read and take notes on the following:

Phase" describes a physical state of matter. The key word to notice is physical. Things only move from one phase to another by physical means. If energy is added (like increasing the temperature) or if energy is taken away (like freezing something), you have created a physical change.

When molecules move from one phase to another, they are still the same substance. There is water **vapor** above a pot of boiling water. That vapor (or gas) can **condense** and become a drop of water in the cooler air. If you put that liquid drop in the freezer, it would become a solid piece of ice. No matter what physical state it was in, it was always water. It always had the same chemical properties.

On the other hand, a chemical change would build or break the chemical bonds in the water molecules. If you added a carbon (C) atom, you would have formaldehyde ($H_2CO$). If you added an oxygen (O) atom, you would create hydrogen peroxide ($H_2O_2$). Neither new compound is anything like the original water molecule. Generally, changes in the physical state do not lead to any chemical change in molecules.

*****The melting and boiling points are not the same for all substances. How might these physical properties help to identify an unknown substance?***

## D. Measuring Matter

Suggested Videos:
https://www.brainpop.com/science/matterandchemistry/measuringmatter/
https://www.youtube.com/watch?v=FfuBO3-K8AQ

| | Mass | Volume | Density |
|---|---|---|---|
| **Definition** | | | |
| **Tool/ Instrument** | | | |
| **Formula** | | | |
| **Units** | | | |
| **Q&A** | 1. What is the difference between mass and weight?<br><br>2. Which object has a higher mass: a 20-gram brick or a 20-gram bag of feathers? | 1. How could you use a ruler and/or a graduated cylinder to measure the volume of a cube?<br><br>2. Which object has a higher volume: a 20-gram brick or a 20-gram bag of feathers? | 1. Which object has a higher density: a 20-gram brick or a 20-gram bag of feathers?<br><br>2. If the mass of a brick is 20 grams and the volume of a brick is 20 $cm^3$. What is the density?<br><br>3. If I cut the same brick in half, what is the mass, volume, and density? Did the density of the brick change even though the mass and volume changed? |

**Task 2 Learning Target:** I can draw a model that predicts and describes changes in the phase of water when thermal energy is added or removed to create a solid, liquid and gas.

**Initial Ideas:**

1. *What happens to the molecules of a substance when it changes phase?*

☐ Claim 1: I think that molecules in a substance disappear or no longer exist when a substance changes phase. I think this because when a substance goes from liquid to gas, I can no longer see it.

☐ Claim 2: I think that molecules in a substance move differently when a substance changes phase. I think this because a liquid, gas, and solid do not move in the same way when you tilt the container they are in.

☐ Claim 3: I think that the molecules in a substance change into a new kind of molecule during a phase change. I think this because, when you tilt the container they are in, a liquid, gas, and solid do not move in the same way.

2. *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 its temperature, which changes the molecules' freedom of movement.

☐ Claim 2: Transferring energy into or out of a substance changes the molecules' kinetic energy, which changes their freedom of movement.

☐ Claim 3: Transferring energy into or out of a substance changes the molecules' speed, which changes their freedom of movement.

3. Develop a model that predicts and describes changes in the phase (state) of water when thermal energy is added or removed to create a solid, liquid and gas. Describe changes in particle motion, temperature, energy, density, and annotate your model with the terms "melting point" and "boiling point."

Use the following checklist to help evaluate your model:

___ Movement/Particle Motion is described
___ Energy is described
___ Melting Point is labeled
___ The spacing of molecules is correct
___ Temperature is described
___ Density is described
___ Boiling Point is labeled

**Task 3 Learning Target**: I can use evidence from text and a digital model to describe what happens to the molecules of a substance when it changes phase.

Water is amazing stuff, and it does some amazing things: It flows, it sparkles like diamonds, and it seems to appear and disappear like magic. These are all large-scale observations of water's appearance that we can make with the human eye. We can also think about water, and all substances, on another scale that we cannot usually see: the molecular scale. Molecules are too tiny to see, but they are very important. Water is made of molecules, and so is almost everything else on Earth. The appearance of water is determined by the way the water molecules are moving.

You might think of water as a liquid, but water can actually exist in three different phases: liquid water, solid ice, and a gas called water vapor. No matter what phase water is in, the water is still made of the same molecules; they just move differently.

In the solid phase (known as ice), water molecules are tightly packed and can move only in place. In the liquid phase, water molecules have greater freedom of movement. They're able to move around and flow from one place to another. However, they still stick together, which is why liquid water forms little beads on a car windshield when it rains. In the gas phase (known as water vapor), water molecules move around a lot—and they don't stay right next to each other at all. Water vapor doesn't stay where you put it!

1. Launch the Phase Change Simulation and observe what happens to the molecules of a substance when it changes phase. (Hint: Track one or two molecules by pressing on them, then observe them. Once you select a molecule to track, the molecule will be highlighted red or green, and dotted lines will appear that represent the molecule's path of motion.) https://apps.learning.amplify.com/phasechange/

2. Complete the data table by describing each phase using text descriptions and a visual model.

| Phase | Text Description | Diagram Model Visual |
|---|---|---|
| **Gas** | | |
| **Liquid** | | |
| **Solid** | | |

*Rigid and keeps its shape*
*Flows, stays at the bottom of the container, and takes shape of container*
*Fills container and has no visible shape*

3. *What happens to the molecules of a substance when it changes phase?*
   Select and explain a quotation from the article and an observation from the Sim as evidence to support one of the three claims below.

☐ Claim 1: I think that molecules in a substance disappear or no longer exist when a substance changes phase. I think this because when a substance goes from liquid to gas, I can no longer see it.

☐ Claim 2: I think that molecules in a substance move differently when a substance changes phase. I think this because a liquid, gas, and solid do not move in the same way when you tilt the container they are in.

☐ Claim 3: I think that the molecules in a substance change into a new kind of molecule during a phase change. I think this because, when you tilt the container they are in, a liquid, gas, and solid do not move in the same way.

**Task 4 Learning Target**: I can use a physical and digital model to describe how energy transfer affects molecules' freedom of movement.

**Part 1: Observe Energy Transfer in a real-world scenario:**

Consider the following question as you work:

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

1. Observe the magnetic marbles which represent molecules. https://sites.google.com/a/ps207tigers.org/207sci/marblemolecules
2. Add a small amount of energy to the marbles by shaking the closed container gently. Observe the marbles. Consider the effect adding energy to a substance has on the molecules.
3. Experiment by adding different amounts of energy to the container (or by letting the container rest). Observe what happens to the marbles.

a. Describe how transferring energy into the container affected the speed of the marbles.
b. As the speed changed, what did you notice about the marbles' freedom of movement?

**Part 2: Observe Energy Transfer in the Sim:**

Consider the following question as you work:

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

1. Launch the Simulation: https://apps.learning.amplify.com/phasechange/
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. Once the highest energy possible has been reached, begin to transfer energy out of the substance. Pay particular attention to the molecules' kinetic energy.

c. Complete the following prompts:

1. When you transfer energy into a substance, the temperature
   ☐ increases ☐ decreases ☐ stays the same
2. When you transfer energy into a substance, the molecules' kinetic energy
   ☐ increases ☐ decreases ☐ stays the same
3. When the above happens, the molecules are moving
   ☐ faster ☐ slower ☐ the same speed

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

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

f. Consider the three claims about why transferring energy into or out of a substance can change molecules' freedom of movement. Select the true statement(s):

☐ Claim 1: Transferring energy into or out of a substance changes its temperature, which changes the molecules' freedom of movement.

☐ Claim 2: Transferring energy into or out of a substance changes the molecules' kinetic energy, which changes their freedom of movement.

☐ Claim 3: Transferring energy into or out of a substance changes the molecules' speed, which changes their freedom of movement.

**Task 5 Learning Target**: I can model a phase change of water using a digital simulator.

**Select one of the two Scenarios to Model:

**Scenario 1: Modeling Water on the Stove**

1. Open the Phase Change Modeling Tool activity: Water on Stove
https://apps.learning.amplify.com/modelingtool/#/tool/145/level/Water_on_Stove_id_2039

Goal: James put a pot of liquid water on the hot stove. When he came back the liquid was gone. Show why the water changed phase.

What to Do:

- Drag out two Substance Descriptions and describe water before and after.
- Move the Substance Descriptions up or down to show when the water had higher or lower energy.
- Drag out an arrow. Start the arrow at the Substance Description Before and move it to show energy transferring in or out.
- Label the arrow using a red hexagon.

  **a.Copy your work**

  **b.Explain how your model illustrates water on the stove. Be sure to include the words kinetic energy, temperature, and freedom of movement in your response.**

  **c.Do all energy transfers lead to a phase change?**

Tips:

- The lines point to the kinetic energy of the substance.
- The arrowhead can touch a line but doesn't need to.

**Scenario 2: Modeling Water in the Freezer**

1. Open the Phase Change Modeling Tool activity: Water in Freezer
https://apps.learning.amplify.com/modelingtool/#/tool/145/level/Water_in_Freezer_id_2038

Goal: Hillary left a cup of water in the freezer. When she came back it was rigid and kept its shape. Show why the water changed phase.

What to Do:

- Drag out two Substance Descriptions and describe water before and after.
- Move the Substance Descriptions up or down to show when the water had higher or lower energy.
- Drag out an arrow. Start the arrow at the Substance Description Before and move it to show energy transferring in or out.
- Label the arrow using a red hexagon.

  **a.Copy your work**

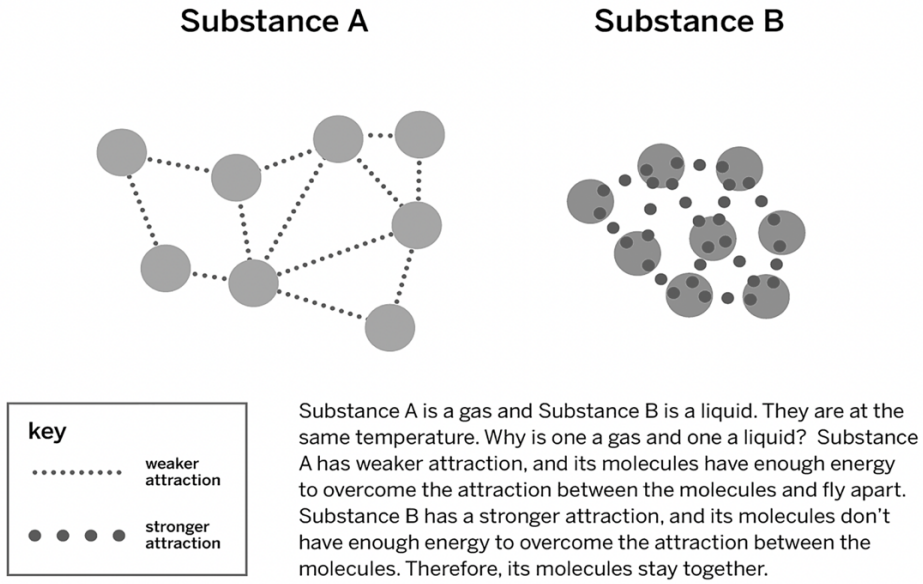
  **b.Explain how your model illustrates water in the freezer. Be sure to include the words kinetic energy, temperature, and freedom of movement in your response.**

  **c.Do all energy transfers lead to a phase change?**

Tips:

- The lines point to the kinetic energy of the substance.
- The arrowhead can touch a line but doesn't need to.

**Task 6 Learning Target**: I can follow a multistep procedure that will enable me to describe how kinetic energy of a substance must overcome the molecular attraction of that substances' molecules in order for a phase change to occur.




Substance A is a gas and Substance B is a liquid. They are at the same temperature. Why is one a gas and one a liquid? Substance A has weaker attraction, and its molecules have enough energy to overcome the attraction between the molecules and fly apart. Substance B has a stronger attraction, and its molecules don't have enough energy to overcome the attraction between the molecules. Therefore, its molecules stay together.

## Observing the Evaporation of Isopropanol Versus Water

Why does an energy transfer not always result in phase change? You observed that a substance needs a certain amount of energy transferred in or out before a phase change will occur.
Now you will observe two different liquids and note whether or not the same transfer of energy will cause them to evaporate. Note: The same amount of energy will be transferred into each liquid from the air.

| |
|---|
| **Safety Note:** The chemical isopropanol, also known as rubbing alcohol, is a flammable liquid and vapor. Avoid eye contact and do not inhale. If you suspect exposure, alert your teacher immediately. |

**Procedure**:

1. On the left side of the paper towel, write "water." On the right side, write "isopropanol."
2. Place two drops of liquid water below the water label and two drops of isopropanol below the isopropanol label.
3. Draw a circle around each drop in order to indicate where the drop was before it began to evaporate.
4. Given that the energy transferred in from the air will be the same for both liquids, write a hypothesis about whether both drops or only one drop will evaporate within five minutes.
5. After about five minutes, record your observations by completing the questions below.

| **Water** | **Isopropanol** |
|---|---|
| a.Did the liquid water evaporate after five minutes?<br>b.Did this fit with your hypothesis? | c.Did the isopropanol evaporate after five minutes?<br>d.Did this fit with your hypothesis? |

## Explaining Attraction

e. Based on this evidence, which substance has a stronger molecular attraction? Explain.

**Task 7 Learning Target**: I can draw a model that predicts and describes changes in the phase of water when thermal energy is added or removed to create a solid, liquid and gas.

1. Recreate or revise a model that predicts and describes changes in the phase (state) of water when thermal energy is added or removed to create a solid, liquid and gas. Describe changes in particle motion, temperature, energy, density, and annotate your model with the terms "melting point" and "boiling point."

Use the following checklist to help evaluate your model:

___ Movement/Particle Motion is described
___ Energy is described
___ Melting Point is labeled
___ The spacing of molecules is correct
___ Temperature is described
___ Density is described
___ Boiling Point is labeled

2. Visit the following links and then respond to the statement:
   *Solid molecules are more tightly packed than liquid or gas molecules.*

https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html

https://www.khanacademy.org/science/biology/water-acids-and-bases/water-as-a-solid-liquid-and-gas/v/liquid-water-denser-than-solid-water-ice

**Task 8 Learning Target**: I can determine properties of cube samples in order to predict how they would behave if they were placed in water.

**Facts:**

Volume = Length x Width x Height

Density = Mass/Volume

The density of water is 1.0g/cm$^3$.

Use the data table below to record your data for the given cubes. Based on your calculations, determine if the cube would sink or float in water.

| Cube | Mass (g) *to the nearest tenth | Volume (cm$^3$) *to the nearest 0.1 cm | Density (g/cm$^3$) *to the nearest 0.1g/cm$^3$ | Sink or Float |
|---|---|---|---|---|
| A | 37.0 g | 50.7cm$^3$ | 0.7 g/cm$^3$ | |
| B | | | | |
| C | | | | |
| D | | | | |
| E | | | | |
| F | | | | |
| G | | | | |
| H | | | | |
| I | | | | |

**Analyze Data to Draw Conclusions:**

1. Notice that the density of Cube A has been provided in the data table (0.7 g/cm$^3$). Assume block A was placed into the water. Draw a diagram that shows where you predict Cube A would be located in the container of water.
2. Which cubes are made of the same material? Explain how you know.
3. Which cubes seem to be made of the same material although are probably not?
4. **Enrichment**: Identify the material that makes the bolt.

**Task 9 Learning Target**: I can use a SIM to test *how molecular attraction affects whether or not a phase change will occur.*

**Test 1**

Complete the below steps for substances B and C. The first partner should test substance B and the second should test substance C. When you are finished, compare your results.
Note: Substance B has a medium molecular attraction while substance C has a low molecular attraction.

1. Before starting, make a prediction: If substances B and C are both in the gas phase and are at the same energy level, which of the two substances will need to have more energy transferred out in order to change to the liquid phase? Substance B or substance C? Explain your answer.

2. Transfer in energy to reach the highest amount of kinetic energy for both substance B and C.

3. Slowly transfer out energy from each substance. Note the temperature at which each substance changes phase.
-Substance B changed to a liquid at _____ °C. -Substance C changed to a liquid at _____ °C.

4. Based on your observations above, which substance needed a greater decrease in kinetic energy in order to change phase?
☐ The substance with low attraction needed more energy transferred out in order to change phase.
☐ The substance with medium attraction needed more energy transferred out in order to change phase.

**Test 2**

Complete the below steps for substances A and B. The first partner should test substance A and the second should test substance B. When you are finished, compare your results.
Note: Substance A has a high molecular attraction while substance B has a medium molecular attraction.

1. Before starting, make a prediction: If substances A and B are both in the solid phase and are at the same energy level, which of the two substances will need to have more energy transferred in in order to change to the liquid phase? Substance A or substance B? Explain your answer.

2. Transfer out energy to reach the lowest amount of kinetic energy for both substance A and B.

3. Slowly transfer in energy to each substance. Note the temperature at which each substance changes phase.
-Substance A changed to a liquid at _____ °C. -Substance B changed to a liquid at _____ °C.

4.Based on your observations above, which substance needed a greater increase in kinetic energy in order to change phase?
☐ The substance with medium attraction needed more energy transferred in in order to change phase.
☐ The substance with high attraction needed more energy transferred in in order to change phase.

Reflect on what you have learned about attraction, energy transfer, and phase change.
You have observed isopropanol and water drops on a paper towel. Even though the same amount of energy was transferred into both substances from the air, the isopropanol evaporated while the water did not. Why do you think the isopropanol changed phase, but the liquid water did not?