CaSTL Center

Molecular Interactions

NSF Center for Chemical Innovation
Chemistry at the Space Time Limit (CaSTL)
https://www.castl.uci.edu/

Essential Question: How do atomic and molecular interactions explain the properties of matter that we see and feel?

NGSS Performance Expectation:
MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]

NGSS Science Practice:
Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Develop a model to predict and/or describe phenomena. (MS-PS1-1)

Disciplinary Core Ideas:
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. (MS-PS1-1)

Cross-Cutting Concepts:
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. (MS-PS1-1)

Content Learning Objective:
Students will engage in the phenomenon of surface tension and will develop a model to explain the intermolecular forces present between the water molecules. They will engage in the Bond Breaker Classroom Edition game (https://testtubegames.com/bondbreaker3.html) to learn about van der Waals forces and will revise their model after exploring these forces through investigating properties of water.

Cooperative Groups:
Teacher will have already set norms for working in groups:

- Take turns
- Everyone shares
- Look at the speaker

- Actively listen
    - Nodding
    - Asking questions for clarification
- Respect others' thinking
- Think before speaking
  (from Ferris, S. (2015, July). Making talk productive. *Science and Children, 52*(9), 67 – 73.)

This is a multiple day lesson.

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5E Lesson Planner

ENGAGE: ***Anchoring phenomena and central question, relating lesson to phenomena found in students' everyday lives or phenomena that are potentially intriguing, students come up with ideas or hypotheses that may help answer the central question, students construct an initial model*** **Estimated time: 20 minutes** **Description of Engage: Students will watch the first minute of a YouTube video showing water striders walking on water: https://www.youtube.com/watch?v=XYdWxP8YTL8. They will get into groups of 3 or 4 and will construct a conceptual model of their initial ideas about why this happens. They will draw their initial model on chart paper.**		
Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Developing a model	I am going to show you a video and I want you to watch it without talking to your group. After I show the video two times, I want you to then talk to your group to share your ideas about what happened and why it happened. The question we are trying to answer is: **How do atomic and molecular**	Students talk in their groups and share their ideas. They get chart paper and markers and draw what happened and attempt to explain what happened.

	interactions explain the properties of matter that we see and feel? Be sure to label the components in your drawing. The teacher will walk around the room and probe for understanding.	Groups put their models aside for later. They will add to these models after the investigation.

EXPLORE: ***Students conduct a set of empirical investigations about the phenomena, investigations provide evidence that might be useful for addressing the central question and for revising the students' model, students make observations***

Estimated time: 40 minutes

Description of Explore: Students will investigate properties of water by dropping drops of water and drops of alcohol on pennies, putting pennies into a cup of water, dragging drops of water along a ruler, putting a strip of paper into a small amount of water in a cup and watching the water climb up the paper, and putting a small paper clip onto water in a cup. Students will collect data and use this evidence to address the central question and to revise their model.

Teacher may have two sets of each exploration set on each side of the room for a total of 10 stations. This will allow groups to move efficiently through the investigations.
This will also allow for small groups of 3 – 4 students.

Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Asking questions Developing a model	Teacher introduces the exploration and tells the students that they will collect data that will help them to explain the water strider phenomenon. The teacher gives instructions that they are to stay at the station until the teacher gives the signal to switch.	

	Teacher gives the students the worksheet with the directions and the data tables for each investigation. Students predict what they think will happen before they conduct the investigations. They make their predictions in small groups at their desks. Teacher monitors this and when everyone has a prediction for each exploration, the teacher gives students the signal to go to their first station. Each group begins at a different station. Once students are sent to their first station, the teacher will walk around the room and will ask questions to probe for understanding. Teacher gives a signal every 7 minutes to tell students to move to the next investigation. Possible teacher questions: *What do you notice?* *What might be going on here that we can't see?* *What do you think causes the water to behave this*	Students work in groups to make predictions. Groups collect data at every station. *"The drops of water collected on the penny but the alcohol just ran off."* *"There was a little mound of water on the penny."* *"We put more pennies into the cup than we expected."* *"We were able to make the drop of water longer. The water stuck to itself."* *"The water molecules stick to each other."* *"Maybe the water strider sticks to the water?"*

	way? *Can you explain what is happening in terms of the water strider we observed in the video?* Teacher monitors students' conversations and answers to questions to plan which groups will report out in the Explain. The teacher selects groups purposefully and decides how to sequence ideas shared to build conceptual understanding.	*"The water stuck to the paper. Maybe it sticks to the water strider in the same way?"*
EXPLAIN: ***Students identify and analyze the patterns they find, explain the result, and reflect the results in relation to their model*** **Estimated time: 30 minutes** **Description of Explain: Students talk in their groups about the data and the patterns that they observe. They try to explain what happened in the investigation and try to apply their explanations to the water strider and their model. Teacher also asks questions related to the central question that arose from the phenomenon.**		
Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Analyzing and Interpreting Data Creating an explanation Drawing a conclusion from evidence	Teacher tells students to talk in their groups to be sure everyone has an explanation for the patterns they observed in the investigation. Teacher asks questions and chooses groups to reply based on the monitoring done in the Explore. Teacher is strategic in choosing groups that had productive conversations that will help the whole class understand why the water strider can walk on water.	*"Water sticks to itself and it sticks to other things too."*

	"What did you find in your investigation?" *"What patterns did you see in the data?"* *"How is what we did in this activity like or unlike the water strider we observed?"* *"What does this help us understand about how water molecules interact?"*	*"When we put the paper clip onto the water, it floated. But we had to open it a little bit to make it spread out a little bit more, just like the water strider."* *"Water molecules have some invisible attraction for other water molecules."*
EVALUATE: ***Students evaluate their initial model with empirical findings and revise their model*** **Estimated time: 20 minutes** **Description of Evaluate: Students return to their models and revise their models based on their new information from their investigation. They refine their explanations based on their evidence.**		
Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Developing a model Arguing from evidence Communicating information	Teacher directs students to take out their models and add to their drawing, labels, and explanations based on any new evidence their collected in the investigation. Teacher walks around and monitors student work to assess whether students are changing their ideas and adding to their explanations.	Students work productively to change or add to their models and explanations.
EXPLORE: ***Students investigate fundamental scientific concepts, ideas, and theories related to the phenomena or model that they cannot access through empirical investigations—through text, the teacher or computer simulations*** **Estimated time: 30 minutes**		

Description of Explore: Teacher gives the students the link to TestTube Games: Bond Breaker Classroom Edition https://testtubegames.com/bondbreaker3.html Students can work independently or with one partner to play levels 6 - 12 of the game. These levels will give the students more information about attraction and repulsion of molecules. Students could access the game in class or on their own time since the game can be accessed by their phones or by their tablets if they are in a one-to-one district. Teacher will tell students to read the "Tap to Learn More" links as they successfully open the gates to grab the stars. They should write down important information that they think could help them revise their models.

Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Drawing a conclusion from evidence Obtaining information Communicating information	When students have completed levels 6 - 12, students share with each other what they learned in the game that they think can help them with their model. Teacher brings them together to ask questions about molecules interacting with each other. *"When did the molecules in the game attract each other?"* *"What information in the game will help you in revising your model?"*	*"When they were close to each other."* *"When they were stable."* *"The molecules attract each other because of van der Waals forces."*

EVALUATE: *Students evaluate and revise their model using scientific ideas to which they have been introduced*

Estimated time: 15 minutes

Description of Evaluate: Students return to their models one more time to add more information from the game. Students then visit each other's posters to see what others have done with the intent of adding to their own poster. While they look at the posters, they carry post it notes with them to ask clarifying questions, agree with the information they see on the posters, disagree with the information they see, or add on to the information. Each group then returns to its poster and reads the post its that were left. The students make one last revision to the model.

Science Practice	**Teacher's Role and**	**Students' Role and Expected**

	Teacher Questions	Student Answers to Teacher Questions
Developing a model Creating an explanation Arguing from evidence Communicating information	Teacher tells students to add information to their poster based on the class discussion. Teacher then gives directions on how students will ask clarifying questions, agree with the information they see on the posters, disagree with the information they see, or add on to the information. Students then visit each other's posters to observe what others have done. They leave feedback on the posters with post it notes.	Students work productively to make more revisions. Students then walk around and leave productive comments on post its as feedback to classmates.

EXTEND/ELABORATE: ***Students construct a consensus model either within a small group or as a whole class, using the strengths of each individual's model, students use the consensus model to predict or explain other related phenomena, students determine strengths and limitations of their model for further revision***

Estimated Time: 20 minutes

Description of Extend/Elaborate: Teacher leads the students to look at their group models and creates a consensus model from each group's contribution.

Science Practice	Teacher's Role and Teacher Questions	Students' Role and Expected Student Answers to Teacher Questions
Arguing from evidence Communicating information	Teacher facilitates a whole class discussion. Teacher asks students if their models have enough information to explain the water strider phenomenon. What is their evidence? Teacher then asks students	Students will look at their model and decide if they can explain the phenomenon based on what they put on their posters. They need to support their statements with evidence from their model.

	to write three sentences that explain the patterns of interactions they observed in the water strider phenomenon.	Students should write about: How water molecules can attract each other How van der Waals forces help explain the attraction water molecules have for each other How water molecules can attract other molecules

Tools, Materials, & Resources

Equipment needs:	gallon of water, 150 ml rubbing alcohol, 200 pennies, 10 plastic 9 oz cups, 10 droppers, 10 pieces of wax paper, cut up strips of coffee filters 2 inches wide by 6 inches high, and 10 small paper clips, 5 rolls of paper towels.
Safety requirements	Students should use the water only as prescribed in the exploration. No squirting water on each other!
Visual aids, Powerpoint slides, handouts.	**YouTube video:** **https://www.youtube.com/watch?v=XYdWxP8YTL8** **Stated Clearly: What is an Atom and How Do We Know?** **https://youtu.be/LhveTGblGHY** **Stated Clearly: What Are Atoms Made Of?** **https://youtu.be/ooWfzpUIoNM** **TestTube Games: Bond Breaker Classroom Edition** **https://testtubegames.com/bondbreaker3.html** **TestTube Games: Bond Breaker 2.0 (full game)** **http://www.testtubegames.com/bondbreaker.html**

Molecular Interactions
Student Worksheet

Station 1:
In this investigation, you will drop water on a penny and compare that to drops of rubbing alcohol on a different penny.

Question:
Will a penny hold more drops of water or alcohol before it overflows?

Prediction:
I think that a penny will hold more drops of _____ before it overflows

because _____.

Be sure to hold the dropper in the same way when you drop the liquids onto the pennies.

Data Table.

Trial	Number of Drops of Water	Number of Drops of Alcohol
1		
2		
3		

Discussion Questions: Notice how I have asked the questions below.
Which liquid held more drops on the penny and why do you think this liquid held more drops on the penny?

Which liquid do you think holds its molecules together the strongest?

_____

What did you observe that could be considered evidence for your explanation?

Station 2.
In this investigation, you will put pennies one at a time into a full cup of water until the water overflows.

Question:
How many pennies can fit into a full cup of water before it overflows?

Prediction:
I think that a full cup of water will hold_____ pennies before it overflows because

_____.

Data Table.

Trial	Number of Pennies
1 **Notice the shape of the water at the top of the cup as you put more and more pennies into the cup**	
2 **Notice the shape of the water at the top of the cup as you put more and more pennies into the cup**	
3 **Notice the shape of the water at the top of the cup as you put more and more pennies into the cup**	

Discussion Questions:
Did you notice the shape of the water at the top of the cup as you put more and more pennies into the cup? Draw that shape here.

Why do you think that the full cup of water could hold so many pennies before it overflowed?

Station 3.
In this investigation, you will pull a drop of water along a ruler.

Question:
How far can you stretch a drop of water before it breaks into smaller droplets?

Prediction:

I think that I can stretch a drop of water _____.

Put a sheet of wax paper over the ruler to keep the ruler dry.

Data Table.

Trial	Inches I Could Stretch the Drop of Water
1	
2	
3	

Discussion Question:

Why do you think that you could stretch the drop of water so far?

Station 4.
In this investigation, you will place a strip of paper into a small amount of water in a cup.

Question:
What do you think will happen to the water when you place the strip of paper into the water?

Prediction:
I think that the water will _____

because _____

_____.

Observation:

What happens to the water?

Discussion Question:

Why do you think this happens?

Can you think of anything you know about that is like this?

Station 5.
In this investigation, you will try to put a small paper clip on the water in a cup.

Question.
How can you make a paper clip float on water?

Prediction:
I think that the paper clip will float if I _____

Try it!

Discussion Question:

What did you have to do to get the paper clip to float?

What kept the paperclip floating?

If the paper clip breaks the surface of the water, what happens?

How is this like the water strider?