CaSTL Center

Breaking Up Is Hard to Do

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

Essential Question: How do substances combine or change (react) to make new substances?

Content Standard Addressed:
MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

NGSS Practice Standard:
Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)

Disciplinary Core Idea:
PS1.A: Structure and Properties of Matter
Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2)

PS1.B: Chemical Reactions
Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
(MS-PS1-2)

Cross-Cutting Concept:
Patterns
Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

Content Learning Objective:
After the teacher shows students different examples of physical change and chemical change (melting butter, adding food coloring to water, melting an ice cube, tearing a piece of paper, burning a match, burning sugar, ripening bananas, moldy strawberries), students will conduct an investigation mixing baking soda and vinegar and will decide whether this is an example of a physical change or a chemical change. Students will give evidence to support their statement.

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.)

Group Roles

(adapted from similar work by Jeremy Hansuvadha, math teacher for Orange County School of the Arts)

♣ **Emperor** ♣

In charge of:

- Making official decisions
- Reading materials to the rest of the group
- Coordinating presentations
- Filling in for absent group members

♦ **Ambassador** ♦

In charge of:

- Making sure that everyone in the group participates and understands the activity
- Checking for understanding
- Facilitating discussions

♠ **Spy** ♠

In charge of:

- Making sure the group finishes the activity on time
- Asking questions to the teacher (The Spy is only allowed to ask a question if no one at the group knows the answer)
- Visiting other groups on the suggestion of the teacher

♥ **Designer** ♥

In charge of:

- Acquiring & returning materials
- Making diagrams and drawings
- Making sure that everyone at the group writes the work in their own notebook

This is a multiple day lesson.

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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: 45 minutes

Description of Engage: Teacher will show students different examples of physical change and chemical change (melting butter, adding food coloring to water, melting an ice cube, tearing a piece of paper, burning a match, burning sugar, ripening bananas, moldy strawberries). Students will observe and discuss among themselves which kind of change each example represents. Students will come up with ideas in their small groups to explain these phenomena and will create a drawing on the molecular level that will attempt to explain it. Model must have: evidence from the examples, drawings on the molecular level of what happens during the change, labels for each component, and a written explanation of the group's ideas for each kind of change.

Teacher's Role	**Teacher Questions**	**Students' Role & Answers to Teacher Questions**
Asking questions Developing a model	I am going to show you some examples of change, either a physical change or a chemical change, and I want you to look at each example and think about it for 1 minute without talking to your group. Take notes and complete the data table for each example. (After 1 minute transpires), now I want you to talk to your group to share your ideas about the example and offer evidence to support your ideas about what kind of change this might be. You are going to create a model to conceptually and visually explain the difference between the two kinds of change based on the evidence from the examples I showed you. Be sure to label the components in your drawing, including the	Students independently look at the examples and take notes on their data table. Students talk in their groups and share their ideas. They get chart paper and markers and draw why they think the two kinds of changes are different, using everyone's ideas.

	components that you think account for the ways the two kinds of changes are different. The teacher will walk around the room and probe for understanding. *"How do you think the two kinds of changes are different?"* *"How are you representing that on your model"?*	Groups put their models aside for later. They will add to these models after the investigation. "*We put adding food coloring to water here because it is still water, just a different color. And we put the ripening bananas here because the bananas are getting mushy, not just changing color. Something else is happening here."*
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: 30 minutes** **Description of Explore: Teacher assembles the materials ahead of time (1 set for each group): empty plastic water bottle (0.5 liter), latex balloon, 1 tbsp baking soda inserted into the balloon before class, and vinegar (enough to fill the bottom of the bottle to a height of one half inch). Teacher creates a post-it for each table group. In the middle of the post-it is a number from 1 to 9 for each table. In the corners of the post-it are the suits of a deck of cards: in each corner the teacher will draw a heart, a diamond, a spade, or a club so that each corner has a different suit. The student sitting closest to a corner will acquire the role related to that suit. For example, if a student is sitting closest to the heart, that student would be the designer (see group roles above). As the students explore in this investigation, they fulfill the roles of their suits in order for the team to be successful.** **Teacher will collect the bottles with the balloons still attached. The teacher will use these later in the lesson to have students identify the gas.**		
Teacher's Role	**Teacher Questions**	**Students' Role & Answers to Teacher Questions**
Asking questions	The teacher will tell the students that they will conduct an investigation to collect evidence to help explain the phenomena. Teacher will show students each of the materials and the students will describe these in their data table.	Designer collects the materials. Students take notes about the baking soda and the vinegar in their data table.

	The teacher may model the procedures for mixing the materials together in the bottle so that the students can see how they will conduct their tests. The teacher will walk around the room and probe for understanding. "*What do you notice?"* "*What might be going on here that we can't see?*" *"Are there any patterns or trends?"* *"Is the material in the balloon the same or different from the materials that you mixed together in the bottle: the baking soda and vinegar? Use evidence from your investigation to support your answer."* *"Did you observe the temperature at the bottom of the bottle?"* 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. Teacher collects the bottles with the balloons still attached to use later in	Students watch the teacher to review the steps of the investigations. *"The balloon gets bigger."* **"***The materials mixed and made a gas."* The Spy may visit other groups to see if they are getting the same results. The Spy reports back to the group. "*The gas in the balloon is different. The baking soda is a solid and the vinegar is a liquid but we made a gas."* *"It is cold."*

	lesson. Students will identify the gas in the balloons later.	

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 phenomenon and their model. Teacher also asks questions related to the central question that arose from the phenomenon.

Teacher's Role	**Teacher Questions**	**Students' Role & Answers to Teacher Questions**
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, choosing groups based on misconceptions, then simple answers then more complex, abstract answers. "*What did you find in your activity?"* "*What patterns did you see in the data?"* *"Do you think this investigation was a physical change or a chemical change. Use your evidence to support your answer."* *"Here are the formulas for baking soda and vinegar:* $NaHCO_3$ and CH_3COOH. *What happens to these*	Students talk in their groups to be sure they all agree on their explanation. "*We found _____*." **"***We started with a solid and a liquid but made a gas."* *"We made something different. So it was a chemical change."* *"They change into something new and different."*

	materials when you mix them in the bottle?"	
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.**		
Teacher's Role	**Teacher Questions**	**Students' Role & 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 they 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 Test Tube Games: Bond Breaker Classroom Edition https://testtubegames.com/bondbreaker3.html Students can work independently or with one partner to play the first 4 levels of the game. These levels will give the students more information about attraction and repulsion of particles. Students could access the game in class or on their own since the game can be accessed by their phones or by their tablets if they are in a one-to-one district. The levels that pertain to this lesson are Level 18 and the quiz that follows it, and Levels 34 and 35. The students should write down important information that they think could help them revise their models.**		
Teacher's Role	**Teacher Questions**	**Students' Role & Answers to Teacher Questions**
Planning an investigation Drawing a conclusion from evidence	When students have completed the levels of the game, both the introductory levels and the later ones,	Students tell each other what they learned in the lesson.

Obtaining information Communicating information	including the quiz, 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 chemical change. "*What did you learn about chemical change that you might use in revising your model?"* *"Why do you think the bottle became colder? What was the direction of the thermal energy? Is that important to notice?"*	*"Sometimes molecules can break apart."* *"Sometimes molecules need heat to break apart."* *"If the bottle was getting colder, then the energy must have been going into the system?"*

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 of other groups, 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 by other students. The students make one last revision to the model.

Teacher's Role	**Teacher Questions**	**Students' Role & 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	Students work productively to make more revisions. Students then walk around and leave productive comments on post its as feedback to classmates.

	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.	
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: 10 minutes** **Description of Extend/Elaborate: Teacher uses the gas in the balloons from the investigation to extinguish a lit candle in a glass jar. Teacher asks students to use this information to identify the gas. Teacher reminds students about the formulas for baking soda and vinegar: $NaHCO_3$ and CH_3COOH to use as hints to the possible identify of the gas.**		
Teacher's Role	**Teacher Questions**	**Students' Role & Answers to Teacher Questions**
Arguing from evidence Communicating information	Teacher lights a tea candle in a glass jar and tells the students to observe what happens when the gas from the balloons in the investigation comes in contact with the lit candle. The teacher may need to repeat this demonstration a few times for the students. Teacher tells students to identify the gas based on this evidence. Teacher gives the students the formulas for baking soda and vinegar, $NaHCO_3$ and CH_3COOH, to give them hints about the possible identity of the gas.	Students observe the demonstration. Students talk in their groups about their ideas. They may use these sentence frames in their discussions: *"The evidence I use to support _____ is _____.* *I believe _____ (statement) because _____ (justification).* *I know that _____ is _____ because _____.* *Based on _____, I think _____.*

	"Was the gas part of the materials that you mixed into the bottle?" Teacher asks students if their models have enough information to explain the phenomenon. What is their evidence? Teacher then asks students to write three sentences about chemical change to answer this question: **How do substances combine or change (react) to make new substances?**	*Based on _____, my hypothesis is _____."* *"The atoms are there but it was not the solid or the liquid."* 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. Students should write about: How chemical change is different from physical change. What happens in a chemical change. Where the atoms come from in a chemical change.

Tools, Materials, & Resources

Equipment needs:	Items: For Engage: butter, hot plate, food coloring, water, an ice cube, a piece of paper, a match, sugar, metal pie pan to contain sugar, ripening bananas, moldy strawberries For Explore: empty plastic water bottle (0.5 liter), latex balloon, 1 tbsp baking soda inserted into the balloon before class, and vinegar (enough to fill the bottom of the bottle to a height of one half inch).
Safety requirements	Waft vinegar when observing. Be sure that the balloon is snug on the top of the bottle to prevent spills.
Visual aids, Powerpoint slides, handouts.	**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**

Breaking Up is Hard to Do
Demonstrations

Complete the data table for each example. Write down your evidence for each change. You will use these ideas in your group's model.

Material	Observation	Evidence for the kind of change
melting butter		
adding food coloring to water		
melting an ice cube		
tearing a piece of paper		
burning a match		
burning sugar		
ripening bananas		
moldy strawberries		

Use these sentence frames in talking to your group members about your ideas.

I think that _____ is a _____ change because _____.

Based on _____, I think that _____ is a _____ change.

Breaking Up is Hard to Do
Investigation

Complete the data table. You are collecting data to use as evidence to make a claim about what kind of change you are observing.

Materials before mixing	Observations (state of matter, color, texture)
Baking soda	
Vinegar	
Materials after mixing	**Observations (state of matter, color, texture)**

What happens when you mix the materials in the bottle?

Do you think that baking soda or vinegar is still present in the bottle? What is your evidence?