LESSON 11: How is it possible that a new substance (the gas) was produced and the total mass of the closed system didn't change?

PREVIOUS LESSON

We gathered and summarized information from a reading on investigations scientists did and molecular models they developed. We will individually use those models to predict and explain what gas is produced in the bath bomb reaction and what is happening to the particles in the system.

THIS LESSON

PUTTING PIECES TOGETHER

4 days

We work with our class and our group to revise our model to reflect what we have learned. We put all of the pieces together to build a revised model and scientific explanation to answer this question: How is it possible that a new substance (the gas) was produced and the total mass of the closed system didn't change? We are given a transfer task that asks us to think about what could be in the leftover liquid after a bath bomb reacts in water. This is our assessment for the unit.

NEXT LESSON

There is no next lesson.

BUILDING TOWARD NGSS

MS-PS1-1, MS-PS1-2, MP-PS1-5

WHAT STUDENTS WILL DO

Revise and use a model and use it to develop a scientific explanation for how the total number of atoms that make up the molecules that react (cause) rearrange to form the products in a chemical reaction when the ath bomb produces gas bubbles (effect). but the number and types of atoms do not change and thus mass is conserved.

Analyze and interpret data to predict the possible products in a chemical reaction, explain how it is possible for other new substances to come from the starting substances in the bathbomb and describe additional plans for investigations that would help identify the substance(s) based on properties (patterns).

WHAT STUDENTS WILL FIGURE OUT

Although no new content is introduced in this lesson, students will use the following scientific principles in their explanations:

- Matter in all states is made of atoms and molecules that take up space and have mass.
- In a chemical reaction, the amount of matter at the beginning (in the reactants) is the same amount of matter at the end of the reaction (in the products). This is because all of the atoms we started with are still there. No new atoms can appear that weren't there to start with.
- Atoms in the molecules of the reactants rearrange to form new molecules in different combinations.
- The properties of a substance determine the number, type, and arrangement of atoms in the molecules of that substance.
- Molecules are made of atoms and all the substances in our world are made of very few types of atoms.
- A substance is made of the same type of molecules (or atoms) throughout. The number, type, and arrangement of atoms in the molecules that make up a substance are unique to that substance.

Lesson 11 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION--SMALL GROUP DISCUSSIONS** Gather in small groups and use a discussion protocol and *Constructing a revised explanation* to learn from classmates and get feedback on the models they created in the previous lesson.		completed copies of *Constructing a revised explanation*,
2	10 min	**REVISITING CONSENSUS MODEL** Move to a Scientists Circle to discuss revisions to the consensus model from lesson 6. Students work as a class to identify places to revise the model and questions that their model should answer.	B	consensus models from Lesson 6 and Lesson 9,
3	23 min	**SMALL GROUP EXPLANATORY MODELS** Working in small groups, students construct their models based on the group's consensus.	C	1 snack sized resealable bag, cut out models from *2D Molecule Cards*, 1 single sided copy of *Template to Organize Final Models*, scissors, clear tape or glue,
4	3 min	**NAVIGATION--QUESTIONS WE HAVE** Record questions for peer feedback on models. Post models and questions for review in the next class.		sticky notes,
				End of day 1
5	20 min	**NAVIGATION--CONSENSUS MODEL GALLERY WALK AND REVISIONS** Review others' models in a gallery walk and provide feedback. Look for answers to questions that are posted on models and record ideas for revisions.	D	sticky notes,
6	10 min	**INTRODUCING SCIENTIFIC EXPLANATION TASK** Review and revise the Anchor chart to include scientific explanations. Work with the class to develop a list of questions to address in their scientific explanations.	E	Anchor chart,
7	15 min	**INDIVIDUAL ASSESSMENT--EXPLAINING A CHEMICAL REACTION** Begin individually writing scientific explanations to answer the question, *How is it possible that a new substance (the gas) was produced and the total mass of the closed system didn't change?*	E	*Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)*, Anchor chart, Scientific Principles poster, group consensus models,
				End of day 2
8	15 min	**CONTINUING SCIENTIFIC EXPLANATIONS OF CHEMICAL REACTIONS** Complete the scientific explanations that students began in the last class.		*Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)* that they started in the last class, Anchor chart, Scientific Principles poster, group consensus models,
9	30 min	**USING DATA TO PREDICT AND EXPLAIN PRODUCTS IN A CHEMICAL REACTION** Use additional data about the reaction of the bath bomb and water to explain and model what substances could be present in the liquid after the gas bubbles come out.		*Lesson 11 Assessment: Explaining new aspects of the anchoring phenomena (part 2)*, Anchor chart, Scientific Principles poster, group consensus models,
				End of day 3
10	3 min	**NAVIGATION** Turn and talk to an elbow partner about the scientific principles used in explanations.	F	Scientific Principles poster, group consensus models,

Part	Duration	Summary	Slide	Materials
11	22 min	**BUILDING CONSENSUS AROUND SCIENTIFIC PRINCIPLES** Working in a Scientists Circle and review each principle that students tried out in their explanations. Add additional principles to the list.		Scientific Principles poster, group consensus models, markers,
12	15 min	**REVISIT THE DRIVING QUESTION BOARD** Gather around the DQB and note which questions can be answered now and which questions still need more information.	G	Driving Question Board, markers,
13	5 min	**UNIT CLOSING** Revisit classroom norms and have students self-assess how well they did on the norms. Then celebrate class accomplishments.		*Science Classroom Norms*,

End of day 4

Lesson 11 • Materials List

	per student	per group	per class
Lesson materials	• science notebooks • completed copies of *Constructing a revised explanation* • science notebook • sticky notes • *Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)* • *Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)* that they started in the last class • *Lesson 11 Assessment: Explaining new aspects of the anchoring phenomena (part 2)* • *Science Classroom Norms*	• 1 snack sized resealable bag • cut out models from *2D Molecule Cards* • 1 single sided copy of *Template to Organize Final Models* • scissors • clear tape or glue • sticky notes	• consensus models from Lesson 6 and Lesson 9 • Anchor chart • Scientific Principles poster • group consensus models • markers • Driving Question Board

Materials preparation (20 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

- Prepare these cards for the Word Wall:
    - **Reactants** - The substances you start with in a chemical reaction.
    - **Products**- The new substances that are produced from a chemical reaction.
- Cut apart models from *2D Molecule Cards*. Groups will need **1** page of models to work with. Place the cards from each copy of the handout into snack-sized resealable bags.

Lesson 11 • Where We Are Going and NOT Going

Where We Are Going

Students will model and explain the chemical reaction of a bath bomb in water. Students will discover know that the reactants in the bath bomb dissolve in water, react to produce products, and that these new products have different properties than the reactants. They will figure out that the atoms and molecules that make up the products are the same atoms that were in the reactants. They will figure out that mass is conserved in this process and generalize that this concept applies to all chemical processes. They will figure out that the molecules that make the reactants and products are made from atoms and that the number, type, and arrangement of these atoms make each substance what it is.

Where We Are NOT Going

While students will be able to explain many parts of the chemical reactions, there will still be parts of the reactions that students cannot explain. The molecular structures of the substances in the reactions are simplified and ionic compounds are represented as individual particles rather than as extended structures. Students will not know that the ionic compounds dissociate in water.

LEARNING PLAN for LESSON 11

1 · NAVIGATION--SMALL GROUP DISCUSSIONS

10 min

MATERIALS: science notebooks, completed copies of *Constructing a revised explanation*

ADDITIONAL GUIDANCE	Use the student ideas, models, and explanations that were demonstrated on the assessment on *Unknown material with identifier: ca.l10.sa1* to determine how to prioritize your interactions with the small groups during the upcoming discussion time. Note which students had incomplete or divergent understandings of concepts and visit their small group discussions early. Listen for responses to any incomplete explanations or misinterpretations from other members of these students' groups. In cases when other group members do not clarify the important ideas, have a few planned questions ready that will help the group explicate the important ideas or concepts.

Small group work discussion protocol. Pass back the completed copies of *Unknown material with identifier: ca.l10.sa1*. Have students meet in groups of 3-4 students. Say, *In our last class, we figured out that we could use different models to represent what was going on in a bath bomb. We could also use those models to explain to others what was going on. Take time now to share any questions that your models or your explanation raised by following this discussion protocol.* Have students refer to their work on *Unknown material with identifier: ca.l10.sa1*.
Display slide A and read through the protocol.
Discussion Protocol

1. Decide who will go first and move clockwise around your group.
2. Share your model with the group as you use it to explain where the new molecules of the new substance comes from. Be sure to explain **how** the new substance was made.
3. Discuss how your model helped you understand and explain what you cannot see because it is too small.
4. Think about the questions you had about your model. Listen to other's ideas and see if you need to use some of their ideas to make your model better.
5. If you still have questions about how to show something in your model after everyone has shared, ask your teammates for help.

2 · REVISITING CONSENSUS MODEL

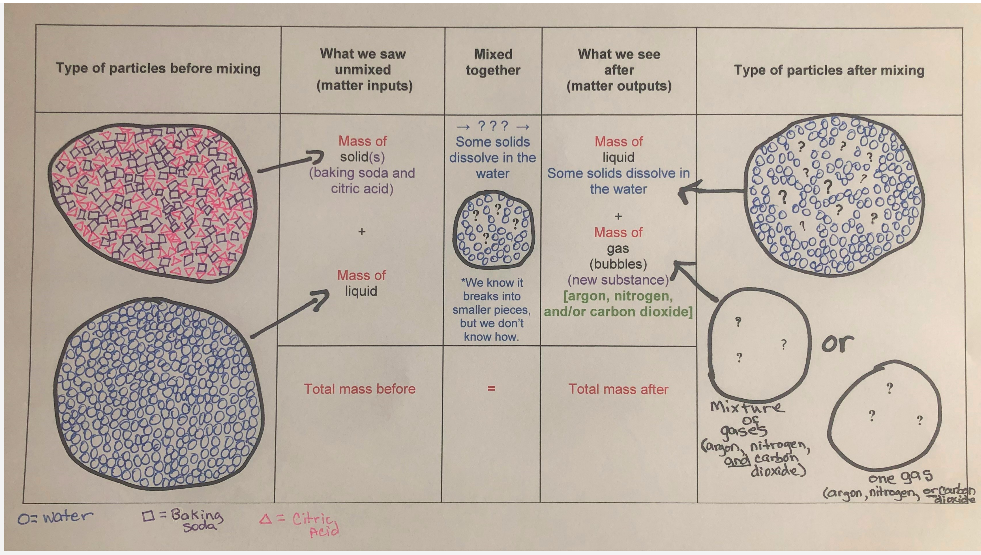
10 min

MATERIALS: science notebooks, consensus models from Lesson 6 and Lesson 9

Gather in a Scientists Circle. Display **slide B.** As students gather in a Scientists Circle, call their attention to their model from lessons 6, shown here:

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY

Over the course of the unit, students will transition from focusing their thinking on the macroscopic scale -- what they can see and measure during this reaction (gas bubbles being produced, the mass not changing, properties of substances) -- to the atomic or invisible scale, as they use models to explain what is happening at the level they can't see. Foreground the idea of scale during this conversation with questions like:

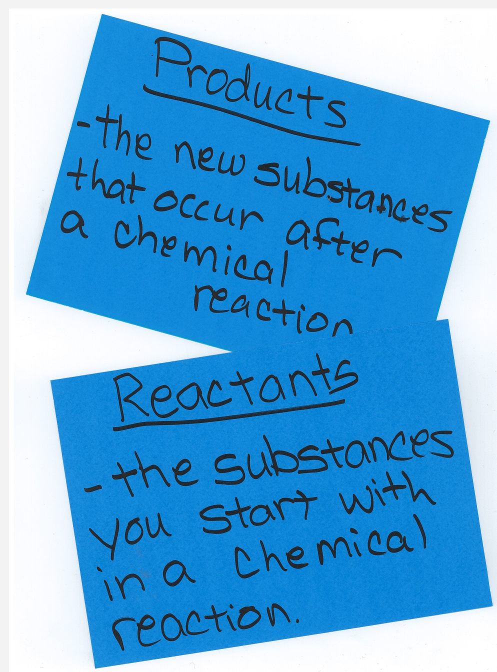


Say, *The last time we updated our consensus model we came up with this representation for the chemical reaction that happens between a bath bomb and water. Take a minute to look over our model and think about more details we can add or things we need to change.*

Give them 2 minutes to think about revisions individually. Then say, *I want to give you some scientific language to practice using when we talk about this model--it will help us in our discussion and this will be a good chance for you to practice using two new words that you already know the meaning of. We have been talking about the substances we start with in this chemical reaction--the baking soda, citric acid, and water. That is all this stuff on the left side of the poster. We call any of the substances that we start with in a chemical reaction* ***reactants.*** *Why would we want to call these "reactants?" We call the substance that we have after the chemical reaction, the* ***products****. Why would we use the word "products" to describe these substances?* Write the words "Reactants" and "Products" above the representations on the model.

Add new vocabulary to the word wall. Add the cards you have prepared for reactants and products to the word wall.

Say, *Let's go through this model and mark the places where we need to change information based on evidence we have from our investigations and readings.* Continue with a dialog similar to that below to identify places for revisions. As you discuss, mark the class consensus model with a star or put a colored dot on places that need revision. Encourage students to take notes of revisions in their science notebooks.



- "What scale should be used to show this part of the model (where the pieces of molecules are getting broken up)?
- Would our model look different or be more or less useful depending on the scale we use to explain it?
- Is it possible to fully explain what's going on at the macroscopic level?
- What can we now explain more fully regarding the idea of conservation of mass?

✱ SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

When they are agreeing on the boundaries for these models, encourage students to evaluate the limitations of some of the representations--some might be easier to do quickly but are too simple and won't show enough detail, while others, which have great detail (i.e. the gum drop model because it is 3 dimensional or ball and stick because it looks three dimensional), are not practical for time constraints. They should weigh the tradeoffs of each kind of model as they make their decision based on the elements required to show the necessary scale and detail.

Suggested prompts	Sample student responses	Follow-up questions
*Let's start with the lower right corner--the gas or gases that were **produced** from the bath bomb. These circles on the right represent the products. It looks like we were uncertain here. Do we need to make changes?*	*Yes! We know it is carbon dioxide now.*	*How do you know--what is your evidence?*
Let's move around clockwise. The bottom of our model says that the total mass before equals the total mass after. How do we know this?	*Because we took mass measurements before and after the reaction.*	*Can you describe the measurements you took and use our new vocabulary--reactants and products?* *Other than this being evidence that the mass didn't change, what else did you learn by doing this?*
How can we be sure that our models show this important feature?	*Since we are representing the matter here with particles, we need to make sure we have the same number of particles before and after.*	*But, wait, I thought you said some particles could break up--wouldn't that give us more particles?*
How can we represent that the mass doesn't change in this chemical reaction?	*The number of compound particles may change--they may break up. But, the number of atoms should not change.*	*So what should we do or show in our model?*
The next circle on the bottom left shows water. This is one of the substances we started with. What do we call those?	*We call them reactants.*	*Are there other reactants?*
Do we need to make changes here?	*Yes! We know that water is made of two gases! So we need to show that in the model.*	*Think back to our models of water when we added energy with electricity. Do we want to use something similar to that? (Show OP.CA.L9.002)*
The next circle on the consensus model shows citric acid and baking soda. Do we need to make any revisions here?	*Yes! These are definitely compound particles. We have those in our molecular model cards.*	*Since these are pretty complicated, it might take forever for us to draw ball and stick models. Do we have other options?*
We had this place on our model in the middle that we used to represent dissolving. Do you have ideas about what is going on with the dissolving particles?	*I think water breaks the particles up.* *I think water gets in between the particles.*	*Do those ideas seem reasonable?* *Can we add those ideas to our model?*

Suggested prompts	Sample student responses	Follow-up questions
The last part we have to think about is this circle in the top right. We know that carbon dioxide gas is produced. Do you think there are substances still in the water?	*Yes, the water looks like there is stuff in there.* *No, I think all the citric acid reacted with the baking soda and it all changed into carbon dioxide.*	*It sounds like you may still have questions about this circle. We may need more evidence so that we know for sure. Maybe developing a particle-based representation of what is happening to the reactants can help us figure this out.*

KEY IDEAS

Purpose of this discussion:

- To clarify the places on the existing consensus model that we need to revise.
- To pool students ideas for what needs to be added and for students use evidence from their investigations to support these ideas.
- To allow students to focus on and ask questions about the places on the model they still need to figure out.

Listen for ideas such as:

- The bubbles contained carbon dioxide.
- We can use molecular models to show what the compounds are made of.
- The molecular models will allow us to show what is happening at the atomic scale that we cannot see, including things like:
    - water molecules are getting between molecules and breaking them into smaller pieces,
    - those smaller pieces can react with each other,
    - we can keep track of the number and type of atoms that we start with to help show **why** mass doesn't change, and
    - we can use our models to show that the atoms in the CO_2 came from the molecules we started with and we can also see what atoms we have left over.
- We still aren't really sure how the reactants break up in the water (do they randomly split in half or doo they split into even smaller pieces?).
- We also aren't sure how molecules, other than CO_2 molecules, come back together.

Make a list of questions that our model should answer. Work with the class to summarize these revisions in a list of questions that their models should answer. You can develop this list of questions as you discuss using the dialog above or you can develop this list after the discussion, as a summary. The list of questions should be similar to these:✱

- What substance is produced in the gas bubbles?
- What process (that we can't see) must have occurred between the molecules of the reactants to make this product?
- What leftover matter could still be dissolved in the water after the reaction?
- How do we represent (in all the circles) that the mass of the reactants is equal to the mass of the products?

Agree on some boundaries for our models. Take time to work with the class to agree on how many of each of the reactants to start with. Since student representations will be more complicated and detailed, it will be too time consuming to use as many particles as we showed on the first models. Agree on about 10-12 molecules of water to start with and about 3-4 molecules of both citric acid and baking soda. ✱

Give students 30 seconds to talk with a partner about which of the molecular models would be best to use and some ideas for how they could use the more complicated models. Find a way to save time. Have them share their ideas and then say, *I was thinking about some of these same things last night because I didn't want you all to spend so much time just copying molecules. I thought it might be a little faster for you if I made some cards that you can cut out and manipulate. You may choose to use these cards or you can stick to your original ideas, as long as you know you can complete that part of the task quickly.*

3 · SMALL GROUP EXPLANATORY MODELS

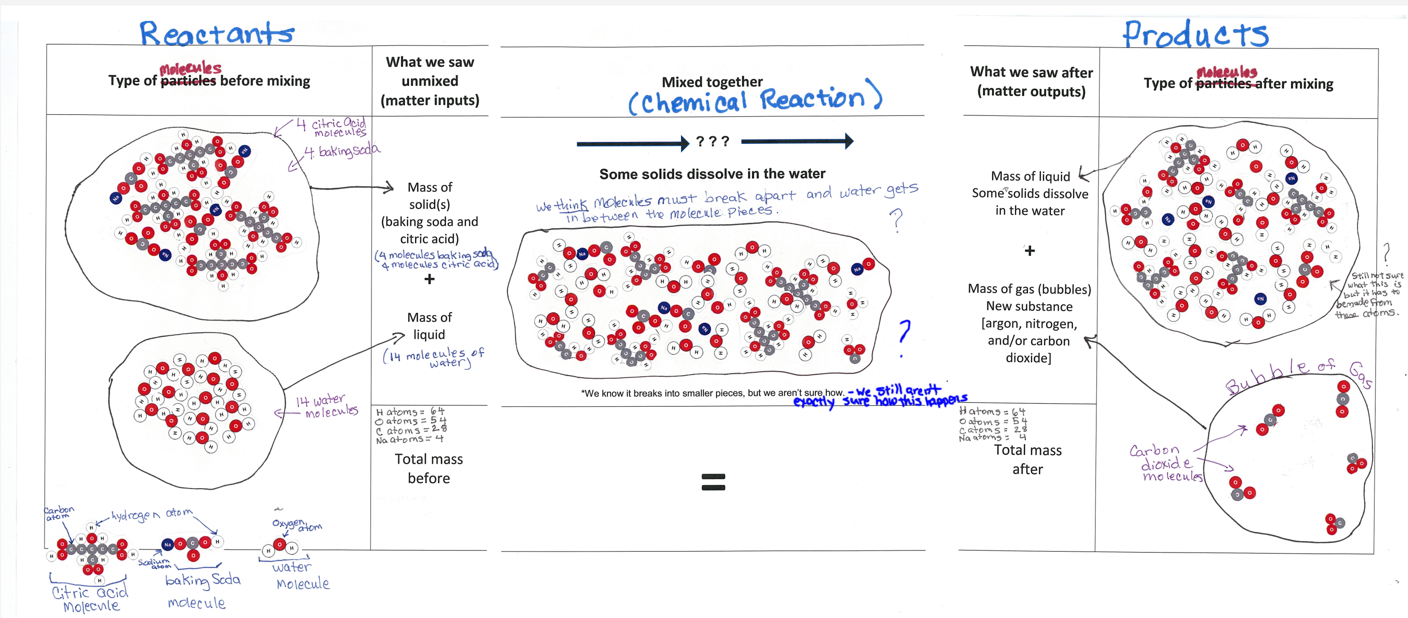
MATERIALS: 1 snack sized resealable bag, cut out models from *2D Molecule Cards*, 1 single sided copy of *Template to Organize Final Models*, scissors, clear tape or glue

Setup for the task. Display **slide C**. Say, *We have all these great ideas for revision of our model. You are going to work in a small group to work on these revisions. Remember the questions your model should answer:*

- What substance is produced in the gas bubbles?
- What process (that we can't see) must have occurred between the molecules of the reactants to make the products?
- What leftover matter could still be dissolved in the water after the reaction?
- How do we represent (in all the circles) that the mass of the reactants is equal to the mass of the products?✱

Build your revised model. Give students until 2-3 minutes before the end of class to work on their models. Even though you have cut the models apart from *2D Molecule Cards*, tell students they may want to trim around the structures so that they have room to put them in the space provided. They do not have to cut out the molecules exactly but rather, trim around them. Encourage them to discuss their model as they are trimming.

They should tape the 3 pages of *Template to Organize Final Models* together and glue or tape their molecular models on it. The table is a duplicate of the earlier consensus model without the circle diagrams. They should complete the model using their molecular structures from *2D Molecule Cards*. They will need to revise some of the printed wording on the table, add details, keys, and make note of other things they have figured out. An example of a completed model is shown below.



✱ SUPPORTING STUDENTS IN DEVELOPING AND USING ENERGY AND MATTER

Reinforce the idea that matter is conserved because atoms are conserved in physical and chemical processes. As students work on their models, have them think about how they can make sure they are not adding or taking away any atoms (circles) from the model. Once they decide how many molecules of citric acid, baking soda, and water to use, they should use these same amounts in the middle circle and in the final circle (the products). If they do this, they won't have to recount the atoms each time. This also reinforces that what is produced in the chemical reaction has to come from what they started with.

ADDITIONAL GUIDANCE

The molecular model on has 12 molecules each of citric acid and baking soda. It also includes 32 molecules of water. Students should decide how many molecules to start with. As long as they don't decide to use more than 4 molecules of citric acid and baking soda or more than 10 molecules of water, then one page of models will be enough for 3 complete sets of their molecules. They will need 3 sets to ensure that they have the same number and kind of molecules at each stage of the chemical reaction that they are representing.

Pause the model revision. Allow groups to work on their revisions until 2-3 minutes before class ends. Reassure students that they will have more time in the next class--you know they are not finished.

4 · NAVIGATION--QUESTIONS WE HAVE

3 min

MATERIALS: science notebook, sticky notes

Record questions for peer review and post models. Have groups decide on and write down any questions they have about how to represent the key parts of the chemical reaction. They should think about what their model does not explain well and ask questions about those parts of their model. They should write their questions on individual sticky notes. Have groups post their models and put the sticky notes with questions on their model. They may also want to put "under construction" on the parts of their model they have not had time to work on.

End of day 1

5 · NAVIGATION--CONSENSUS MODEL GALLERY WALK AND REVISIONS

20 min

MATERIALS: science notebooks, sticky notes

Give feedback and gather ideas from a gallery walk. Display **slide D**. As students arrive in class, have them immediately take out their science notebook, pens, and a pack of sticky notes. Have them move the poster that is directly to the right of their group poster. When all of their team members have arrived, they should begin a gallery walk with their group. They should write down ideas that they see that will help them answer the questions they have posted on their models. They should also record any new ideas they see that will make their models stronger. Encourage students to leave feedback for other groups on sticky notes when they have questions or ideas that could improve their peers' posters.

ADDITIONAL GUIDANCE

As students visit each model and supply feedback, you do the same. Offer ideas to groups for making their models stronger. It would be good to keep the list of revision ideas visible and provide feedback to places the group might have missed.

Allow students to visit each poster. You may want to set a timer based on the number of group posters the students need to see and the 15 min of the time allotted to this activity. This way, students know when to move to the next poster.

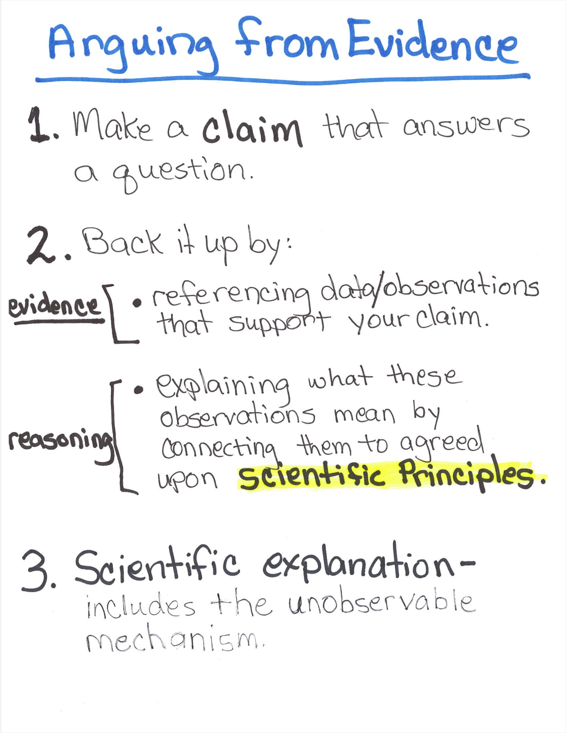
Make note of revisions to group model. Have students meet and talk through what they learned from the rest of the class. Based on how much time you have to spend on this task, either give students the opportunity to make these revisions to their models and finish them or have them make a list of revisions and additions they would make if there was time. They can post this list on their model or make the list directly on their model. The time allotted for this activity (5 minutes) assumes that students only make a list of revisions .

6 · INTRODUCING SCIENTIFIC EXPLANATION TASK

10 min

MATERIALS: science notebooks, Anchor chart

Describe the phenomenon. Display the Anchor chart that you made in lesson 2.



Say, *We have used the important ideas in this Anchor chart to argue from evidence using claims, evidence, and reasoning. Now we can explain how this happens at a particle level to represent and explain what is going on in a chemical reaction that we can't see. When we do this, it moves beyond arguing from evidence to developing a scientific explanation that answers how and/or why all the different aspects of the phenomenon occur.* Write on the bottom of your Anchor chart: 3. **Scientific explanation** includes the unobservable mechanism.

Share the question we are answering. Display **slide E**. Tell students, *You will individually develop a scientific explanation using the process described on the Anchor chart to fully answer this question: **How is it possible that a new substance (the gas) was produced and the total mass of the closed system didn't change?***

Work with the class to make a list of sub-questions. To fully answer the main question, there are sub-questions that are important to answer. Work with your class to come up with a list similar to those listed below. Write these on the board so students can use them in their explanations.

- What substance(s) were produced in the gas bubbles?
  - How did the data and observations that we analyzed help us narrow down which substances were produced?
  - How did the models that we used help us narrow down which substances were produced?
  - How did the data and observations we made, combined with the models that we used help us eliminate all but one substance as the candidate?
- What unobservable process at a particle level must have occurred between the molecules of the substances we started with to form this new substance?
- Why didn't the total mass of the closed system change when the gas was produced?

7 · INDIVIDUAL ASSESSMENT--EXPLAINING A CHEMICAL REACTION

15 min

MATERIALS: *Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)*, science notebook, Anchor chart, Scientific Principles poster, group consensus models

Set up the individual assessment. Tell students that they will start their explanations during this class and finish them in the next class. They will not have time to complete the explanation in this class period. Remind them of the resources that they can use to make their response as complete as possible. These are:

- Anchor chart
- Scientific Principles poster
- group consensus models
- science notebooks
- Word Wall
- Any resource used in the investigations (data tables, notebook sketches, etc.)

Distribute *Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)* to each student. Tell students that they should try to get as much done as possible until class is over. They will continue creating their explanations in the next class. Have students turn in their current explanations to you at the end of class. Tell them they will have 15 more minutes at the beginning of the next class to complete them.

End of day 2

8 · CONTINUING SCIENTIFIC EXPLANATIONS OF CHEMICAL REACTIONS

15 min

MATERIALS: *Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)* that they started in the last class, Anchor chart, Scientific Principles poster, group consensus models

Distribute *Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)*, which students began in the last class. Display **slide E.** Tell them they have 15 minutes to finish their explanations. Have students hand in their explanations before moving on to the next activity.

ASSESSMENT OPPORTUNITY	See *Unknown material with identifier: ca.l11.tref* for assessment guidance on evaluating student responses in terms of all three dimensions of NGSS. This is part one of a summative assessment that targets these NGSS PEs: MS-PS1-1, MS-PS1-2, MP-PS1-5

ADDITIONAL GUIDANCE	If you have time available, allow students more time to complete their assessment, if needed.

9 · USING DATA TO PREDICT AND EXPLAIN PRODUCTS IN A CHEMICAL REACTION

30 min

MATERIALS: *Lesson 11 Assessment: Explaining new aspects of the anchoring phenomena (part 2)*, science notebooks, Anchor chart, Scientific Principles poster, group consensus models

Get a sense of students' confidence. Ask students how well they think the explanations they just turned in explained the substances that were left over in the liquid after all the CO_2 fizzed out. Tell them to give you a show of fingers on a scale of 0 to 5, with 5 being the most confident and 0 being the least confident, how well they think their explanations describe this piece of the phenomenon. Zero would mean that they didn't explain that part very well at all. Allow students to show their confidence levels. It is likely that some, if not all, are not very confident that they can explain this part of the phenomenon very well.

Present the data. Distribute *Lesson 11 Assessment: Explaining new aspects of the anchoring phenomena (part 2)*. Say, *It turns out that others have tested a bath bomb and had some of the same questions as we have had. They did a few more tests than we did--especially on the liquid that remained after the carbon dioxide fizzed out of the system. This handout summarizes what they did and the results they got. Take a few minutes to read the information about their tests. As you read, underline the new data that their investigation provides us.*

Summarize new findings. Lead the class in a short discussion so that everyone recognizes the new information from this investigation. Use a dialog similar to the one below.

Suggested prompts	Sample student responses	Follow-up questions
What did this group do that was similar to what we did?	*They used citric acid and baking soda.* *They took the mass before and after mixing the citric acid, baking soda, and water.* *They took the lid off and made an open system. They measured the mass again.*	*Did they get results similar to ours?*
What did they do that was different from what we did?	*They investigated the liquid that remained after the fizz.*	*What tests did they do and what they find?*

Set up the task. Say, *It looks like there was more water in the products than was present in the reactants. Without explaining your ideas, do you think that is even possible?* You may get a variety of answers but the class should see that some of the students agree that this is possible. You should encourage the students who disagree to think more about how this might be possible; using models might help. Provide the molecular models on a handout for students to use to answer some of the questions.

Review the rest of *Lesson 11 Assessment: Explaining new aspects of the anchoring phenomena (part 2)* with students. Call their attention to the prompts on the page and tell them that they will answer these individually as part of their assessment. Read through the prompts together to ensure that all students understand the questions. Students may want additional cut-out models from *Template to Organize Final Models* to manipulate.

Allow students time to complete the assessment. Students should use the remainder of the class to complete the assessment on *Lesson 11 Assessment: Explaining new aspects of the anchoring phenomena (part 2)*. Use their work on this handout, along with their completed explanations from *Lesson 11 Assessment: Explaining the anchoring phenomena (part 1)*, as a summative assessment.

ASSESSMENT OPPORTUNITY

See *Unknown material with identifier: ca.l11.tref* for assessment guidance on evaluating student responses in terms of all three dimensions of NGSS. This is part two of a summative assessment that targets these NGSS PEs: MS-PS1-1, MS-PS1-2, MP-PS1-5

End of day 3

10 · NAVIGATION

3 min

MATERIALS: science notebooks, Scientific Principles poster, group consensus models

Turn and talk to your elbow partner. Display **slide F**. This slide is animated. Have students turn and talk to their elbow partner about the scientific principles they used to help in the reasoning part of their explanations. Ask them to consider:

- Are there any principles that you did not use?
- Are there some principles that you used but dd not seem to work for the explanation?
- Are there principles that are missing?

11 · BUILDING CONSENSUS AROUND SCIENTIFIC PRINCIPLES

22 min

MATERIALS: science notebooks, Scientific Principles poster, group consensus models, markers

Gather students into a Scientists Circle. Advance **slide F.** Communicate to students that the purpose of this Scientists Circle is to make sure we have important scientific principles on our chart and that everyone agrees, based on their "try out" of these ideas, that the right ideas are on our list. Say, *You have tried out the ideas on this poster in your scientific explanations. We want to make sure that these are useful ideas and see if we need to add to or modify this list.*

Review each principle on the list. Take time to go through each principle on the list. Some of the more recent additions on the list were listed as "temporary" principles until we tried them out in explanations. We did that in the assessment. Now we should review the principles to make sure they worked for us. Use a dialogue similar to the one below to guide the discussion for each principle that students name. As you have discussed a principle and students have agreed that it is valuable, place a star beside the principle.

Suggested prompts	Sample student responses	Follow-up questions
Can someone name a principle that they found particularly valuable in the explanation you wrote?	*I used the principle, ________ ________________________.*	*Why did you find this principle valuable?* *Did anyone else use this principle?* *Do we all agree that this is a valuable principle to keep on our list?*

Continue the dialog. Continue the discussion until students have named all of the principles they used. Use the dialog below as an example of how to elicit principles that no one names.

Suggested prompts	Sample student responses	Follow-up questions
What about the principle, __________? Did anyone use this principle?	*No.*	*Should we keep this on our list or revise it?*
Why did we put the principle on our list in the first place? What did it explain?	*Accept answers that recall the reason the principle was initially used.*	*Do we think that this principle is valuable to keep on the list in case we need it in the future?* *Does anyone disagree or have revisions they want to suggest?*

Adding more principles to the list. Continue the consensus building discussion by asking for additions to the list. Ask students if there are principles that are related to the mass being the same for reactants and products. Also ask if we have a principle that describes what happens to make the products. Use the example dialog below to bring out these ideas.

Suggested prompts	Sample student responses	Follow-up questions
Did some of you try out ideas about the mass of reactants and products? (Note to teacher: This idea may have come up in the earlier discussion.)	*Yes. I said the mass of the products was the same as the mass of the reactants.*	*Do you think that is a principle that is true for all chemical reactions?* *Do others agree? Does anyone disagree?* *Do you think we could add this as a principle that we might use again? Maybe we want to try this out more before we are sure.*
Were there other ideas you tried out in your explanations? Did you use ideas about how we get the molecules that make up the products? (Note to teacher: We represented these ideas in our models but did not add the ideas to our written list. It is likely that students used the ideas but we need to add them to our list.)	*Yes, I said that the atoms that made up the carbon dioxide gas came from the molecules that were in the reactants.*	*Do you think that is a principle that is true for all chemical reactions?* *Do others agree? Does anyone disagree?* *Do you think we could add this as a principle that we might use again?*

Record the ideas. At the end of the discussion, make sure that these ideas are on the list:

- In a chemical reaction, the amount of matter at the beginning (in the reactants) is the same amount of matter at the end of the reaction (in the products). This is because all the atoms we started with are still there. No new atoms can appear that weren't there to start with.
- Atoms in the molecules of the reactants rearrange to form new molecules in different combinations.
- The number, type, and arrangement of atoms in the molecules of a substance determine its properties.
- Molecules are made of atoms and all the substances in our world are made of very few types of atoms.
- A substance is made of the same type of molecules (or atoms) throughout. The number, type, and arrangement of atoms in the molecules that make up a substance are unique to that substance.

Summarize what we know in a chemical reaction. Ask students to consider the bath bomb reaction. Say, *Let's consider all that we have learned and represent it as a chemical reaction.*

Discuss with students what they have learned as you put together a chemical reaction on the board or on chart paper.

Reactants			**atoms rearrange to form**			**Products**		
$3NaHCO_3$	+	$C_6H_8O_7$	→	$Na_3C_6H_5O_7$	+	$3H_2O$	+	$3CO_2$
baking soda		citric acid		sodium citrate		water		carbon dioxide

Check for understanding. Ask students if they all agree that this is a way to represent what they have learned. Ask students if they understand what the numbers in the molecules and the numbers written before the molecules mean. Use a dialog similar to the one below to bring out these ideas.

Suggested prompts	Sample student responses	Follow-up questions
Look at the formula for baking soda-- $NaHCO_3$.What does the small 3 at the end of the formula mean ?	*It means that there are three oxygen atoms.*	*What does it mean when there is no number? Like after the Na and the H?*
Looking at the same formula, there is a big 3 in front of the formula. What does that 3 mean?	*It means there are 3 of the baking soda molecules.*	*What does it mean when there is no number in front, like for citric acid?*
How would you represent $3H_2O$ in a model?	*I would show three separate water molecules.*	*And can you explain how you used the small number 2 to make your water molecules?*
Why do you think it is important to show 3 molecules of baking soda?	*Well maybe it takes more baking soda.*	*Can you think about what is produced and your scientific principles to say why it takes more baking soda?*
What does the molecule of sodium citrate tell you about the number of Na atoms? Na is the symbol for sodium.	*Well, it looks like the molecule has 3 atoms of sodium (Na)--that is the little number.* *So we need to have 3 atoms from the reactants.*	*Which of our scientific principles are you using to reason about those ideas?*

12 · REVISIT THE DRIVING QUESTION BOARD

15 min

MATERIALS: Driving Question Board, markers

Revisit the DQB and check off the questions that students can now answer. Display **slide G.** As a whole class, evaluate what questions the class has answered from the DQB. Have students work in pairs to mark questions they think the class has answered according to the symbology listed below:

- We did not answer this question or any parts of it, yet: **?✱**
- Our class answered some parts of this question or the ideas we developed helped me see how I could now answer some parts of this question: ✓
- Our class answered this question or the ideas we developed helped me see how I could now answer this question: ✓✓

Talk through the unanswered questions and ask students where they would go next if they could. Are there resources they could consult to satisfy their curiosity if any questions went unanswered?

✱ SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS

Revisiting the DQB at the end of the unit helps students see the progress they made toward answering questions that are important to them at the outset of the unit. Students were tasked with asking questions "that require sufficient and appropriate evidence to answer." Through the investigations in the unit and individual and whole group sense-making, they can now answer many of the questions. This final visit to the DQB also allows students to see how their hard work toward a shared learning goal helped them figure out the phenomenon but can also explain lots of the other phenomena in the world.

13 · UNIT CLOSING

5 min

MATERIALS: *Science Classroom Norms*

Take a moment to revisit the Science Classroom Norms. Ask students to look back at *Science Classroom Norms*. Give them a moment to read through the norms. Ask students to privately note which norms they feel they did well with and which norms should be personal goals moving forward. If time allows, ask students to share their thinking with a partner.

At the very end of the unit, celebrate the class accomplishments. Have students reflect on their experiences with the unit. Have them record their ideas on an exit ticket.

- What was most rewarding in this unit? What experiences would they want to have again?
- What was most challenging?
- What might they want to do differently the next time they have a challenging unit?