(Optional) Lesson 3: Investigating and Explaining Soda Water Fizzing

Overview

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Students investigate changes in mass and CO_2 concentration for soda water fizzing. Then they explain results using molecular models and chemical equations to answer the Movement Question and the Matter Change Question.

Guiding Question

What happens when soda water loses its fizz?

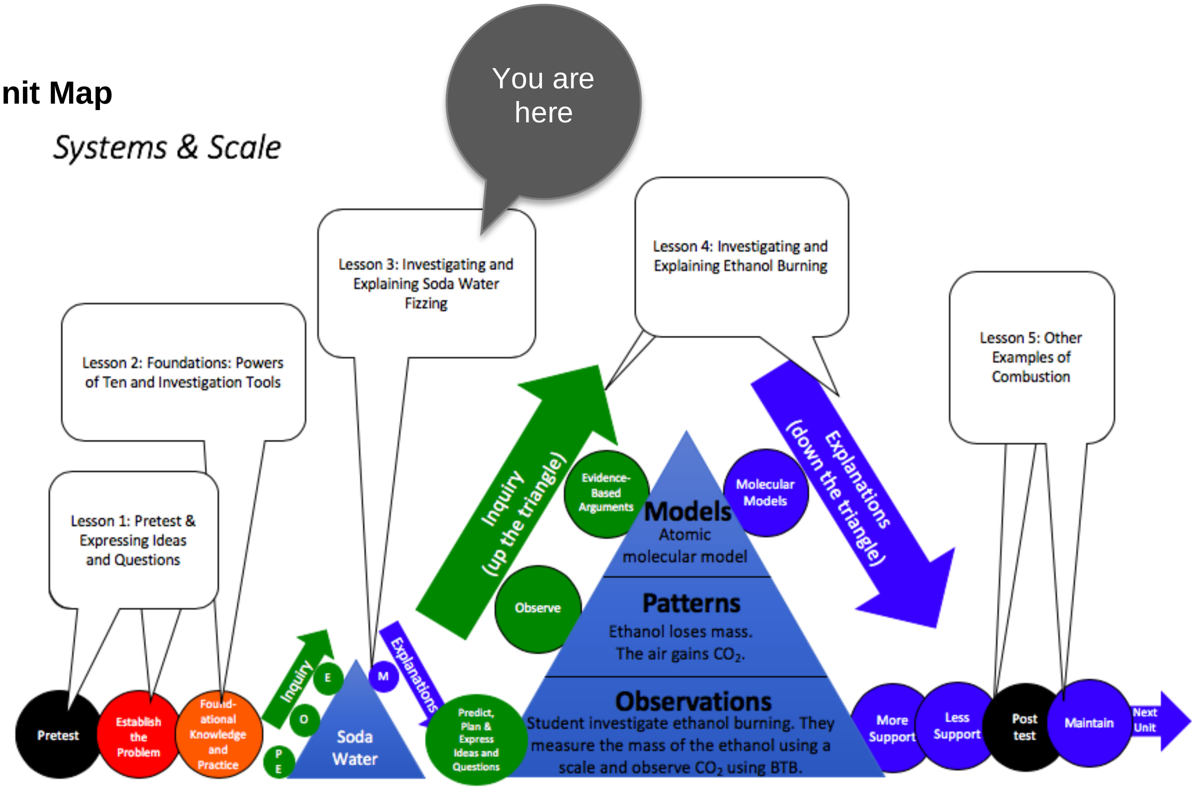
Activities in this Lesson

Note: Lesson 3 is optional depending on your knowledge of your students and learning goals. This lesson is recommended for middle schoolers to introduce them to using investigations, molecular models, and chemical equations to describe a simple chemical change. See the Systems and Scale Unit Read Me file for more information to consider when making this choice.

- Activity 3.1: Predictions about Soda Water Fizzing (20 min)
- Activity 3.2: Observing Soda Water Fizzing (30 min)
- Activity 3.3: Evidence-Based Arguments about Soda Water Fizzing (45 min)
- Activity 3.4: Molecular Models for Soda Water Fizzing (45 min)
- Activity 3.5: Explaining Soda Water Fizzing (40 min)

Unit Map

Systems & Scale



Learning Goals

Target Performances

Activity	***Target Performance***
(Optional) Lesson 3 – Investigating and Explaining Soda Water Fizzing (students as investigators and explainers)	
Activity 3.1: Predictions and Planning for Soda Water Fizzing (20 min)	Students develop hypotheses about how matter moves and changes when soda water loses its fizz and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter.
Activity 3.2: Observing Soda Water Fizzing (30 min)	Students record data about changes in mass and BTB when soda water fizzes and reach consensus about patterns in their data.
Activity 3.3: Evidence-Based Arguments about Soda Water Fizzing (45 min)	Students (a) use data from their investigations to develop evidence-based arguments about matter movements and matter changes when soda water fizzes, and (b) identify unanswered questions about matter movement and matter change that the data are insufficient to address.
Activity 3.4: Molecular Models for Soda Water Fizzing (45 min)	Students use molecular models to explain how carbon, oxygen, and hydrogen atoms are rearranged into new molecules during the

	decomposition of carbonic acid (the chemical change that happens when soda water fizzes).
Activity 3.5: Explaining Soda Water Fizzing (40 min)	Students explain how matter moves and changes when soda water loses its fizz (connecting macroscopic observations with atomic-molecular models and using the principle of conservation of matter).

NGSS Performance Expectations

Middle School

- . Structures and Properties of Matter. MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
- Chemical Reactions. 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.
- Chemical Reactions. MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

High School

- Chemical Reactions. HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Background Information

Three-dimensional Learning Progression

This lesson (which is optional for high school students) uses a simple chemical change, the decomposition of carbonic acid, to introduce students to using investigations, molecular models, and chemical equations to describe chemical changes.

Carbonic acid is a weak acid, meaning that it always exists in equilibrium with dissolved CO_2 in water, which in turn is in equilibrium with gaseous CO_2 in the air. Increasing temperature and decreasing pressure drive the equilibrium in the direction of gaseous CO_2, so when the soda water "loses its fizz," carbonic acid is dissociating, and dissolved CO_2 is escaping into the air.

In this lesson students are introduced to *two* of the Three Questions. All *Carbon TIME* Units share a focus on understanding the chemical changes involved in complex processes, such as combustion and growth of plants and animals. We will consistently focus on the idea that understanding these processes involves answering Three Questions:

- **The Matter Movement Question: Where are molecules moving?** (How do molecules move to the location of the chemical change? How do molecules move away from the location of the chemical change?)
- **The Matter Change Question: How are atoms in molecules being rearranged into different molecules?** (What molecules are carbon atoms in before and after the chemical change? What other molecules are involved?)

Matter (the Matter Movement and Matter Change Questions). We find that even students who have learned how to balance chemical equations do not appreciate the meaning of the procedure:

- Conservation of atoms (the Matter Change Question): The numbers of atoms on the left and right side of a chemical equation have to be the same because they are THE SAME

ATOMS! A chemical equation just shows how they are being rearranged into new molecules.

- Conservation of mass (the Matter Movement Question): ALL the mass of any material is in its atoms (and none of the mass is in the bonds, which are just attractive forces between atoms). So the mass of the products is always the same as the mass of the reactants.

In this lesson, students will focus only on *two*: The Matter Movement Question and the Matter Change Question. They turn to the Energy Change Question in the following lesson when they investigate burning ethanol.

The investigations in all units will make use of two essential tools:

- Digital balances. Students can detect movement of atoms (the Matter Movement Question) by measuring differences in mass. In this activity students will be able to observe changes in the system of the soda water.
- Bromothymol blue (BTB) is an indicator that changes from blue to yellow in response to high levels of CO_2. Thus, changes in BTB can partially answer the Matter Change Question by detecting whether there is a chemical change that has CO_2 as a reactant or product.

Key Ideas and Practices for Each Activity

Activity 3.1 is the **Predictions and Planning Phase** of the instructional model (beginning the climb up the triangle). During this phase, students record their predictions and express ideas about what happens to matter when soda water fizzes. They use the **Predictions and Planning Tool** to do this.

Activity 3.2 is the **Observations Phase** of the instructional model (going up the triangle). During this phase, the students conduct the investigation for soda water fizzing, record data, and try to identify patterns in their data and observations. The important practices students focus on in this activity are 1) making measurements and observations, 2) recording their data and evidence, and 3) reaching consensus about patterns in results. They use the **Observations Worksheet** and **Class Results Poster** to do this.

Activity 3.3 the **Evidence-Based Arguments Phase** of the instructional model (going up the triangle). During this phase, the students review the data and observations from their investigation of soda water fizzing and develop arguments for what happened during the investigation. In this phase, they also identify unanswered questions: at this point they have collected data and observations about macroscopic scale changes (BTB color change and mass change), but they do not have an argument for what is happening at the atomic-molecular scale. They use the **Evidence-Based Arguments Tool** to record their arguments at this phase.

Activity 3.4 is the first part of the **Explanations Phase** of the instructional model (going down the triangle). Students construct molecular models of the chemical change they observed in the investigation to help them develop an atomic-molecular explanation for what happened.

Activity 3.5 the second part of the **Explanations Phase** of the instructional model (going down the triangle). Students use the **Explanations Tool** to construct final explanations of what happens when soda water fizzes. Ideally, at this phase their explanations will combine evidence from macroscopic-scale observations during the investigation with their new knowledge of chemical change at the atomic-molecular scale.

Key carbon-transforming processes: Decomposition of carbonic acid

Content Boundaries and Extensions

Talk and Writing

At this stage in the unit, students will complete the inquiry and application sequences for soda water fizzing—they go both up and down the triangle. This means that they will go through the **Predictions Phase,** the **Observations Phase,** the **Evidence-Based Arguments Phase,** and the **Explanations Phase** in one lesson. The tables below shows specific talk and writing goals for these phases of the unit.

Talk and Writing Goals for the Predictions Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Treat this as elicitation and brainstorming (like the Expressing Ideas and Questions Phase), but with more directed questioning.	*Now that we have set up the investigation, we want to predict what we think will happen to matter and energy.*	**Predictions and Planning Tool**
Elicit a range of student ideas. Press for details. Encourage students to examine, compare, and contrast their ideas with the ideas of other students.	*Who can add to that?* *What do you mean by _____? Say more.* *So I think you said _____. Is that right?* *Who has a different idea?* *How are those ideas similar/different?* *Who can rephrase ________'s idea?*	Investigation Video (first half)
Encourage students to provide evidence that supports their predictions. .	*How do you know that?* *What have you seen in the world that makes you think that?*	
Have students document their ideas to revisit later.	*Let's record our ideas so we can come back to them and see how our ideas change.*	**Predictions and Planning Tool**

Talk and Writing Goals for the Observations Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Help students discuss data and identify patterns.	*What patterns do we see in our data?* *How do you know that is a pattern?* *What about ______ data. What does this mean?*	Class Results Poster Class Results Spreadsheet
Encourage students to compare their own conclusions about the data and evidence with other groups and other classes.	*What about this number? What does this tell us?* *How is group A's evidence different from Group B's data?* *How do our class's data differ from another classes' data?*	Class Results Spreadsheet Class Results Poster Investigation Video (second half).
Make connections between the observations and the data/evidence.	*It says here that our BTB turned colors. What does that mean?* *You recorded that your ethanol lost weight. What does that mean?*	
Have students consider how their predictions and results compare.	*Let's revisit our predictions. Who can explain the difference between our class predictions and our results?* *Who had predictions that were similar to our results? Has your explanation changed? How?*	

Talk and Writing Goals for the Evidence-Based Arguments Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal

Press for details. Encourage students to examine, compare, and contrast their ideas with the ideas of other students.	*Who can add to that argument?* *What do you mean by _____? Say more.* *So I think you said _____. Is that right?* *Who has a different argument?* *How are those arguments similar/different?* *Who can rephrase ________'s argument?*	Investigation Video (second half)
Students provide evidence from the investigation (not just experiences in the world) to develop arguments.	*Does your argument include evidence from the investigation?* *What evidence is most important here?* *What does this evidence tell us about what happened?* *What evidence do we still need for a complete picture of what happened?* *How do you know that?*	**Evidence-Based Arguments Tool** Class Results Poster Class Results Spreadsheets Investigation Video (second half) Data from other classes
Focus on how matter and energy were transformed at different scales.	*What does this evidence tell us about how matter is changing?* *What does this evidence tell us about how energy is changing?*	**Evidence-Based Arguments Tool**
Revisit predictions and examine change in thinking.	*Let's revisit our Predictions and see how our thinking changed now that we know what happened.*	**Evidence-Based Arguments Tool** **Predictions and Planning Tool**
Encourage students to consider the questions they don't have answers to.	*This investigation told us many things about what happen to matter and energy during ____. But what questions do we still have?*	

Talk and Writing Goals for the Explanations Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Examine student ideas and correct them when there are problems. It's ok to give the answers away during this phase! Help students practice using **precise language** to describe **matter and energy**.	*Let's think about what you just said: air molecules. What are air molecules?* *Are you talking about matter or energy?* *Remember: atoms can't be created. So that matter must have come from somewhere. Where did it come from?* *Let's look at the molecule poster again… is carbon an atom or a molecule?*	Molecule Poster
Focus on making sure that explanations include multiple **scales**.	*The investigation gave us evidence for what was happening to matter and energy at a macroscopic sale. But what is happening at an atomic-molecular scale?* *What is happening to molecules and atoms?* *How does energy interact with atoms and molecules during chemical change?* *Why doesn't the macroscopic investigation tell us the whole story?* *Let's revisit our scale poster… what is happening to matter at the molecular scale?*	Molecular Models Molecular Modeling Worksheets **Explanations Tool** PPT Animation of chemical change Powers of Ten Poster
Encourage students to recall the investigation.	*When did this chemical change happen during our investigation?* *How do we know that? What is our evidence?* *What were the macroscopic indicators that this chemical change took place?*	**Evidence-Based Arguments Tool** Investigation Video

Elicit a range of student explanations. Press for details. Encourage students to examine, compare, and contrast their explanations.	*Who can add to that explanation?* *What do you mean by _____? Say more.* *So I think you said _____. Is that right?* *How are those explanations similar/different?* *Who can rephrase ________'s explanation?*	**Explanations Tool**

Activity 3.1: Predictions about Soda Water Fizzing (20 min)

Overview and Preparation

Target Student Performance

Students develop hypotheses about how matter moves and changes when soda water loses its fizz and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter.

Resources You Provide

- Petri dish, plastic (1 per class)
- soda water (1 cup per class)

Resources Provided

- 3.1 Predictions and Planning for Soda Water Fizzing PPT
- 3.1 Predictions and Planning Tool for Soda Water Fizzing (1 per student)
- 3.1 Assessing the Predictions and Planning Tool for Soda Water Fizzing

Setup

Print one copy of 3.1 Predictions and Planning Tool for Soda Water Fizzing for each student. Prepare a computer and projector to display the PPT.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.1 Predictions and Planning for Soda Water Fizzing PPT.

2. Introduce Lesson 3.

Tell students that in this lesson, they will be investigating what happens when soda water fizzes to learn more about how what happens to matter during chemical changes.

- Tell students that during the investigation, one of the goals is to learn about the chemical change that is happening. Display slide 3 on the 3.1 Predictions and Planning for Soda Water Fizzing PPT. Use this slide to overview what we mean when we say “chemical change.”
- Pour soda water into a Petri dish in the front of the classroom. Encourage them to take a closer look at the soda water if they are interested.
- With slide still open, draw the students’ attention to the **Matter Movement Question** and the **Matter Change Question**. Tell them that in this lesson they will be trying to answer these two questions about chemical change.

3. Review the Matter Movement Question.

Display slide 4 of the PPT.

- Draw students’ attention to the slide and point out that the question is accompanied with “rules to follow” as well as ways to “connect atoms to evidence.”
- Emphasize the following rule about matter: Atoms are bonded together in molecules.

4. Review the Matter Change Question.

Display slide 5 of the PPT.

- Emphasize the following rule about matter: Atoms last forever.

5. **Have students complete Part A of the Predictions and Planning Tool for Soda Water Fizzing.**

Show slide 6 of the PPT. Pass out one copy of 3.1 Predictions and Planning Tool for Soda Water Fizzing to each student. Ask them to record their ideas as individuals for part A for the Matter Movement and Matter Change Questions for soda water fizzing.

- Remind students that these are just *predictions*, and that there are no wrong answers at this point. Encourage them to write down all their ideas on the tool.

6. **Discuss Matter Movement Question as it relates to a digital balance**

Show slides 7 and 8 of the 3.1 Predictions and Planning for Soda Water Fizzing PPT. Discuss with students how a digital balance can be used to measure matter moving into or out of a system. Highlight that the mass of the system can be measured before and after a change happens in a system. Discuss the two possible conclusions students can draw from their observations:

- If the mass of the system increases, then matter *must* have moved into the system (remember the facts about atoms)
- If the mass of the system decreases, then matter *must* have moved out of the system.

7. **Discuss Matter Change Question as it relates to BTB**

Show slide 9 of the 3.1 Predictions and Planning for Soda Water Fizzing PPT. Discuss with students how BTB can be used to measure matter change in a system. Highlight that the BTB in a closed container can be observed before and after a change happens in the system. Discuss the two possible conclusions students can draw from their observations:

- If the BTB changes from blue to yellow, then a chemical change may be producing CO_2
- If the BTB changes from yellow to blue, then a chemical change may be using CO_2 as a reactant.

8. **Have students make predictions about using investigation tools to detect matter movement and matter change.**

Show slide 10 of the PPT. Have students have complete Part B of their Prediction Tool. Have them focus on the matter movement and matter change as they make their predictions about what happens in soda water loses its fizz.

Divide students into pairs and tell them to compare and contrast their predictions with each other and to look for differences and similarities.

Give students 2-3 minutes to compare their predictions**.**

9. **Save the Predictions and Planning Tool for later.**

Display slide 11.

- Tell students that tomorrow they will discuss their predictions together as a class.
- Also, they will revisit their ideas after the investigation to see how their ideas changed over time.

10. **Have students share plans for the investigation**

Show slide 12 of the PPT and describe the instruments and materials necessary for carrying out the investigation. Have students begin planning their investigation. There are two main variations in how much control students can have over this planning process:

- Minimal student control: Discuss student ideas for how an investigation could be set up. Then have students follow the lab instructions for lesson 3.2
- Maximal student control: Students in the class develop their own consensus plans that will replace the lab instructions in lesson 3.2. Note the importance of having different student groups following the same plan so that they can come to a consensus about patterns in data in lesson 3.2 Some possible ideas of using lab materials are below.
    - Students might choose to add controls to the experiment, for example including both a Petri dish of yellow bromothymol blue (BTB) (made from blowing into the blue BTB with a straw) and a Petri dish of blue BTB to the chamber.
    - Students might also choose to set up a chamber with a Petri dish of blue BTB alone without the soda water fizzing.

Assessment

The Matter **Movement Question** and **Matter Change Question** will be new to students, and Level 2 students will find the questions themselves hard to understand. Note whether students use the "Facts about atoms and molecules" that they studied in Lesson 2 as they try to answer the Matter Movement and Matter Change questions.

- Rules to follow: The most important rule (and the first Fact about Atoms) is: Atoms last forever. Do they follow that rule when they try to answer the questions?
- Evidence to look for: Students will address this column in more depth when they do the investigation. One thing to note for now: When students see gas bubbles leaving the soda water, do they cite that as evidence that atoms are leaving the soda water? Do they suggest ideas about what gas might be in the bubbles? Note whether students connect bubbles leaving soda water with atoms leaving soda water.

Differentiation & Extending the Learning

Differentiation

Modifications

Tips

- Have a designated place in the classroom where students store their **Predictions and Planning Tool** so they can easily refer back to their ideas at the end of the lesson.

Expect many students to make the right predictions for the wrong reasons. Note in particular whether they say that changes in the mass of the soda water indicate that atoms are moving.

Extending the Learning

Students can discuss other situations where bubbles form and leave liquids, such as the bubbles that form when water is boiled, when baking powder or Alka-Seltzer are dissolved in water, or when vinegar and baking soda are mixed. How do they see these phenomena as similar to or different from soda water fizzing? What do they see as happening to mass?

Activity 3.2: Observing Soda Water Fizzing (30 min)

Overview and Preparation

Target Student Performance

Students record data about changes in mass and BTB when soda water fizzes and reach consensus about patterns in their data.

Resources You Provide

- BTB, blue (less than 1 cup per group of four students)
- digital balance (1 per group of four students)
- Petri dish, plastic (2 per group of four students)
- sealable, 9.5-Cup container (1 per group of four students)
- soda water (less than 1 cup per group of four students)
- (From previous activity) 3.1 Predictions and Planning Tool for Soda Water Fizzing

Resources Provided

- 3.2 Soda Water Fizzing Class Results 11 x 17 Poster (or spreadsheet) (1 per class)
- 3.2 Observing Soda Water Fizzing Worksheet (1 per student)
- 3.2 Assessing the Observing Soda Water Fizzing Worksheet
- 3.2 Observing Soda Water PPT

Recurring Resources

- BTB Information and Instructions Handout
- (Optional) BTB Color Handout (1 per group)

Setup

Prepare the BTB (see instructions in the BTB Information and Instructions Handout), Petri dishes, soda water, digital balances, plastic containers, and safety glasses for students to retrieve for their groups. If you plan to use the poster to record student data, print one copy of the poster before class and post it on the wall. Print one copy of 3.2 Observing Soda Water Fizzing Worksheet for each student. Prepare a computer with an overhead projector to display the PPT. Optionally, print one copy of the BTB Color Handout for each group.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.2 Observing Soda Water PPT.

2. Have students set up the investigation.

Display slide 3 of the PPT. Divide students into groups of four.

- Pass out one copy of 3.2 Observing Soda Water Fizzing Worksheet to each student.
- Walk through the steps in Part A of the worksheet that goes over how to set up and conduct the investigation.

3. Have students conduct the investigation.

Display slide 4 while students are conducting the investigation.

- Students will need to wait 20 minutes to see color change in the BTB.

4. Have students discuss their predictions about the Matter Movement Question as a class.

While waiting for the soda water to lose some fizz, display slide 5 of the PPT. Ask students to retrieve their completed tools from the previous activity: 3.1 Predictions and Planning Tool for Soda Water Fizzing.

- Ask pairs of students to share their ideas for the Matter Movement Question. Ask students what they expect to see in the investigation and what that might mean.
- Record students' ideas on the slide.
- Help the students look for similarities and differences in the predictions in the class. Try to get a range of ideas on the slide.

5. Have students discuss their predictions about the Matter Change Question as a class.

While continuing to wait for the soda water to lose more fizz, display slide 6 of the PPT and ask pairs of students to share their ideas for the Matter Change Question.

- Lead a discussion by asking students what they expect to see in the investigation and what that might mean.
- Record students' ideas on the slide.
- Help the students look for similarities and differences in the predictions in the class. Try to get a range of ideas on the slide.

6. Have students record data and observations.

Display slide 7 of the PPT. Have students record their group's data and observations about the mass change and BTB color on their worksheet.

- Next, have students select a recorder to input their group's results on the 3.2 Soda Water Fizzing Class Results 11 x 17 Poster, or in the 3.2 Soda Water Fizzing Class Results Spreadsheet.

7. Have students' groups compare and identify patterns in BTB Color.

Display slide 8 of the PPT.

- Lead a discussion to help students compare results across groups and identify patterns in the data. Have students discuss how BTB has a gradient of colors depending on how much CO_2 is absorbed.
- Optionally, have them use the BTB Color Handout to interpret the color of the BTB.

8. Have students' groups discuss patterns in class results.

Show students slide 9 to discuss patterns that students see in the class results.

- Ask students to identify patterns in the data for both the mass change and also the BTB color change and discuss any outliers or unexplained data points.
- If you input data into the spreadsheet, the software will construct a graph of the students' data. Use the graph to elicit more interpretation of their observations.

9. Have students compare their class's data with data from another class.

Show slide 10 of the PPT to view data from Ms. Hach's class.

- Ask students to compare the patterns they observed with the patterns from Ms. Hach's class. What similarities or differences do they notice?

The remainder of the unit is based on the assumption that your class results are similar to those of Ms. Hach's class and the Soda Water Fizzing demonstration. If your class results are significantly different for any reason, after a conversation about why that may have happened, decide whether to have students conduct the investigation again or to refer to Ms. Hach's data as they work through the remainder of the unit.

10. Have students compare their class's BTB color with data from another class.

Show slide 11 of the PPT to view BTB from Ms. Hach's class.

- Ask students to compare the colors they observed with the colors from Ms. Hach's class. What similarities or differences do they notice?

11. Revisit predictions from the previous activity.

Use slide 12 to revisit students' predictions from Activity 3.1.

- Have them compare the predictions they made with the results of the investigation.
- Which predictions were correct? Which predictions were incorrect? What questions do they still need to answer?

12. Have students complete an exit ticket.

Show slide 13 of the 3.2 Observing Soda Water PPT.

- Conclusions: What did you observe during the investigation?
- Predictions: What do you think is one conclusion you can make from investigation?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead in to the next activity.

Assessment

Use the class discussion to interpret how successful your students are at identifying patterns in the class data. Use the 3.2 Assessing the Observing Soda Water Fizzing Worksheet to determine if your students had any trouble with data collection.

Differentiation & Extending the Learning

Differentiation

Modifications

Have students develop the experimental design on their own using the tools provided. For example, students may choose to set up a control treatment as a chamber with BTB and no soda water.

Tips

Addressing problems at this point as students try to find patterns in data will support their learning in future investigations. This is the first investigation, so it is likely to expose challenges that may come up again.

Extending the Learning

Students may want to compare what happens with soda water fizzing with other conditions, such as seeing what happens to mass and BTB with plain water in the Petri dish, or how their observations are affected by the amount or temperature of the soda water.

Activity 3.3: Evidence-Based Arguments for Soda Water Fizzing (45 min)

Overview and Preparation

Target Student Performance

Students (a) use data from their investigations to develop evidence-based arguments about matter movements and matter changes when soda water fizzes, and (b) identify unanswered questions about matter movement and matter change that the data are insufficient to address.

Resources You Provide

- (From Previous Activity) 3.2 Observing Soda Water Fizzing Worksheet
- (From Previous Activity) 3.2 Soda Water Fizzing Class Results 11 x 17 Poster (or spreadsheet)

Resources Provided

- 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing (1 per student)
- 3.3 Assessing the Evidence-Based Arguments Tool for Soda Water Fizzing
- 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT

Recurring Resources

- Learning Tracking Tool for Systems & Scale (1 per student)
- Assessing the Learning Tracking Tool for Systems and Scale

Setup

Print one copy of 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing for each student. Make sure that the 3.2 Soda Water Fizzing Class Results 11 x 17 Poster (or spreadsheet) from the previous activity is available.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT.

2. Have students review their results from the investigation.

Display slide 3 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT. Draw students' attention to the 3.2 Soda Water Fizzing Class Results 11 x 17 Poster (or spreadsheet) from the soda water investigation and students' own 3.2 Observing Soda Water Fizzing Worksheet, section D, "Results for the whole class." Ask the students to find a partner, and in their own words, review what happened during the investigation. Tell them to discuss:

- What patterns they observed in the mass change
- What patterns they observed in the BTB color change

Tell students that when scientists construct arguments for what happened, using evidence from observations is important, so today's activity is designed to help them use the evidence from the investigation to construct an argument for "What happens when soda water fizzes" and come to class consensus.

3. Have students develop arguments for what happened as individuals.

Display slide 4 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT.

- Pass out one copy of 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing to each student. Review Tool directions.
- Instruct students to complete their evidence, conclusions, and unanswered questions as individuals for the **Matter Movement Question** and the **Matter Change Question** in Part A of the worksheet
- Give students about 5-10 minutes to complete part A of the process tool. Remind students that these are just *predictions*, and that there are no wrong answers at this point. Encourage them to write down all their ideas on the tool.

4. Continue developing arguments for what happens when soda water loses its fizz using the EBA tool.

Display slide 5 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT. Have students find part B on the worksheet and fill out the class evidence, conclusions and unanswered questions sections for both the matter movement and matter change sections.

5. Have students compare and revise arguments in pairs.

Display slide 6 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT. Divide students into pairs.

- Have each pair compare their **evidence, conclusions** and **unanswered questions** for both the Matter Movement Question
- Have partners discuss how are their ideas alike and different. Have students change or add to their responses, based on partner input.
- Have students repeat this step for the Matter Change Question.
- You will want to begin moving towards class consensus in this activity.
- Partner work should take about 10 minutes.

As students are sharing, circulate through the groups. Consider asking questions such as, *How does this (refer to students' evidence and/or conclusions) help us better understand the Matter Movement Question or Matter Change Question? What questions do you still have at the atomic-molecular level to better understand this phenomenon?*

Pay attention to patterns in students' ideas. You will want to begin moving towards class consensus in this activity.

Partner work should take about 10 minutes.

6. Have a class discussion of the Matter Movement Question; move toward class consensus.

Display slide 7 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT.

- Have students/pairs share their evidence and conclusions for the Matter Movement Question. Keep a class record, using the PPT slides or board. Ask students to update their answers by using a different colored writing utensil. Discussions should move toward class consensus. Use class conversation to correct student ideas.
- Have students share unanswered questions. Discussions should move toward class consensus. Use the 3.3 Assessing the Evidence-Based Arguments Tool for Soda Water Fizzing to guide your goals for consensus. Note that students may contribute unanswered questions that may not closely align with those on the Assessing worksheet. You may still choose to record those unanswered questions. These may be answered in other parts of this unit or even in other units during the school year. However, at this point in this unit,

though there may be several viable paths of inquiry moving forward, you will begin to more closely guide the path of inquiry in one direction – in this case towards molecular modeling of soda water fizzing.

- Class discussion should take about 10 minutes.

7. Repeat step 5 with the Matter Change Question; move toward class consensus.

Display slide 8 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT.

- Class discussion should take another 10 minutes.

8. Discuss how the Unanswered Questions shape our next steps, and the transition from inquiry to application.

Display slide 9 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT.

- Use the Unanswered Questions to set the stage for students' next steps, specifically the need to know what's happening at the atomic-molecular scale.

Take a moment to show students that you have arrived at the "top of the triangle" on the instructional model. This means they will be making a transition. When they went "up the triangle," they conducted an investigation and collected evidence based on what they could observe using their own eyes and also tools (e.g., macroscopic observations). Now they are preparing to go "down the triangle," when they will figure out how to explain what happened in the investigations at an atomic-molecular scale by being provided and practicing with a model for scientifically-accurate thinking.

9. Save the Evidence-Based Arguments Tools for later.

Display slide 10. Tell students that they will revisit their unanswered questions later in the unit to see which questions they can now answer.

10. Have a discussion to complete the Learning Tracking Tool for this activity.

Show slide 11 of the 3.3 Soda Water Fizzing PPT.

- Have students take out their Learning Tracking Tool for Systems & Scale.
- Have students write the activity name, "Investigating Soda Water" and their role "investigator" in the first column.
- Have a class discussion about what students did during the activity. When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students figured out during the activity that will help them in answering the unit driving question. When you come to consensus as a class, have students record the answer in the third column of the tool.
- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the fourth column of the tool.
- Have students keep their Learning Tracking Tool for Systems & Scale for future activities.
- Example Learning Tracking Tool

Activity Chunk	What Did We Do?	What Did We Figure Out?	What Are We Asking Now?
Investigating Soda Water	Conduct an investigation to explore what happens when soda	Soda water fizzing lost mass and made	What happens to the molecules in soda water as it fizzes?

Investigator	water fizzes and use the Predictions and Planning Tool and the Evidence-Based Arguments Tool	the BTB change from blue to yellow.	

11. Have students complete an exit ticket.

Show slide 12 of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing PPT.

- Conclusions: What is our conclusion for the matter movement question from the investigation?
- Predictions: Where do you think the carbon atoms in the CO_2 that turned the BTB yellow came from?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead in to the next activity.

Assessment

During the class discussion, listen for students making connections to the investigation and their arguments. Are they drawing on observations from the investigation, or from other sources of knowledge and experience? Use the 3.3 Assessing the Evidence-Based Arguments Tool for Soda Water Fizzing to compare your students' answers with patterns in student thinking from other classrooms.

Differentiation & Extending the Learning

Differentiation

Modifications

Tips

- Have the students store their 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing in the same place as their Expressing Ideas and Questions and Predictions and Planning tools so they can be easily revisited.
- Because this is the first time that students will use the Evidence-Based Arguments Process Tool, review the questions ahead of time so they understand the purpose and structure of the tool.

Extending the Learning

- Students can return to a discussion of other situations where bubbles form and leave liquids, such as the bubbles that form when water is boiled, when baking powder or Alka-Seltzer are dissolved in water, or when vinegar and baking soda are mixed. How does what they have learned about soda water affect their ideas and questions about those situations?

- Use cobalt chloride indicator paper to test for the presence of water after soda water fizzing activity.

Activity 3.4: Molecular Models for Soda Water Fizzing (45 min)

Overview and Preparation

Target Student Performance

Students use molecular models to explain how carbon, oxygen, and hydrogen atoms are rearranged into new molecules during the decomposition of carbonic acid (the chemical change that happens when soda water fizzes).

Resources You Provide

- Molecular model kit (1 per pair of students)

Resources Provided

- 3.4 Molecular Models for Soda Water Fizzing Worksheet (1 per student)
- 3.4 Grading the Molecular Models for Soda Water Fizzing Worksheet
- 3.4 Molecular Models for Soda Water Fizzing PPT

Recurring Resources

- Molecular Models 11 x 17 Placemat (1 per pair of students)
- Learning Tracking Tool for Systems & Scale (1 per student)
- Assessing the Learning Tracking Tool for Systems and Scale

Setup

Prepare one model kit for each pair of students. Print one copy of the Molecular Models 11 x 17 Placemat and one copy of the 3.4 Molecular Models for Soda Water Fizzing Worksheet for each student. Prepare a computer and a projector to display the PPT.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.4 Molecular Models for Soda Water Fizzing PPT.

2. Show to students the chemical formula for carbonic acid.

Tell students that atoms are too small to see, so scientists keep track of them in other ways. Write on the board "carbonic acid molecule" and the formula "H_2CO_3" and explain that this is the molecule that is responsible for the fizz in soda water. Tell students that the formula means that there are two hydrogen, one carbon and three oxygen atoms in the molecule.

Explain to students that they will use the molecular models to figure out how carbonic acid can break up into molecules of water and carbon dioxide when soda water loses its fizz.

3. Have students use the molecular model kits to make carbonic acid molecules.

Divide the class into pairs and give each pair a molecular model kit and Molecular Models 11 x 17 Placemat. Pass out one copy of 3.4 Molecular Models for Soda Water Fizzing Worksheet to each student.

- Use slide 3 of the 3.4 Molecular Models for Soda Water Fizzing PPT to explain the bonding of atoms in molecules. Tell students that the rules on this slide are important because they apply to all molecules that they will make in all *Carbon TIME* units.

- Use Slide 4 to show instructions to construct a molecule of carbonic acid. Students can also follow instructions in Part A of their worksheet.
- Use Slide 5 to instruct students to compare their own molecule with the picture on the slide.
- Slide 6 shows an **important message**: after students create their reactant molecules, make sure they put away all unused pieces of their molecule kits. This helps reinforce that the matter and energy in the reactants are conserved through the chemical change, and that only the materials from the reactants are used to build the products.

4. Have students construct a model of the chemical change.

Tell students to follow the instructions the worksheet to construct their Products.

- When soda water sits in the open, a chemical process occurs. Releasing the pressure on the soda water and allowing it to warm up allows the carbonic acid to decompose into carbon dioxide (CO_2) and water (H_2O).
- Show slide 7 of the PPT and have students re-arrange the atoms to make molecules of CO_2 and H_2O. To do this, they will need to move their molecules from the Reactants side to the Products side of the 11 x 17 Placemat. Explain to students that atoms last forever, so they should not add or subtract atoms when they change the reactant molecule into product molecules.
- Show students Slide 8 to compare the products they made to the products on the slide.
- Show students Slide 9 to make a comparison between the reactants and products.

5. Have students watch an animation of the chemical change.

Show slides 10-14 in the PPT to encourage students to make connections between what is happening in the animation and the molecular models they made.

- For each slide, focus on different atoms in the molecule. The animation draws attention to where they atoms begin and end in the reaction.

6. Have students complete Part C of their worksheets.

Show slide 15. Tell students to complete Part C of their worksheet to trace the atoms during the chemical change.

Have students verify that the number of atoms before and after remained constant: Atoms last forever! Tell students that this means that the number of atoms before and after the reaction does not change.

7. Help students write a balanced chemical equation.

Tell students that now that they have represented a chemical change using molecular models and in animations, they will represent chemical change by writing the chemical equation.

- Show Slide 16 of the presentation to guide students through the process of writing a balanced chemical equation for the decomposition of carbonic acid. Indicate that the decomposition of carbonic acid is a chemical reaction and that the chemical equation is a representation of this reaction. Tell students that these rules apply to all chemical reactions.
- Tell students to write their equations in Part D of their worksheet.
- Have students write their own chemical equations before comparing them with the one on Slide 17.

Assessment

Listen for the students' sense of necessity to make sure that atoms last forever during chemical changes. Asking them about the "atoms are forever" rule during the molecular modeling and animation may give you a sense of how committed they are to conserving matter.

Differentiation & Extending the Learning

Differentiation

Modifications

Tips

- Laminate the Molecular Models 11 x 17 Placemats. These will be used multiple times in each unit.
- During the molecular modeling activity and animation, focus on how matter and energy are conserved through the chemical change. This is the main goal of the activity!

Activity 3.5: Explaining Soda Water Fizzing (40 min)

Overview and Preparation

Target Student Performance

Students explain how matter moves and changes when soda water loses its fizz (connecting macroscopic observations with atomic-molecular models and using the principle of conservation of matter).

Resources You Provide

- (from previous activity) 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing

Resources Provided

- 3.5 Explanations Tool for Soda Water Fizzing (1 per student)
- 3.5 Explaining Soda Water Fizzing PPT
- 3.5 Grading the Explanations Tool for Soda Water Fizzing

Setup

Print one copy of the 3.5 Explanations Tool for Soda Water Fizzing for each student. Return students' completed versions of the 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing for review.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.5 Explaining Soda Water Fizzing PPT.

2. Revisit students' arguments about soda water.

Show slide 3 of the 3.5 Explaining Soda Water Fizzing PPT.

- Tell students that this activity's purpose is to develop explanations for what happens when soda water fizzes.
- Return each student's copy of 3.3 Evidence-Based Arguments Tool for Soda Water Fizzing and have them review their arguments before they completed the molecular modeling activity.
- Ask them to think about what they know now that they didn't know then.

3. Have students complete the front of the Explanations process tool.

Show slide 4 of the 3.5 Explaining Soda Water Fizzing PPT. Give each student one copy of 3.5 Explanations Tool for Soda Water Fizzing.

Make sure students understand that they will use the information from the front of the explanations tool help them construct their explanations paragraphs on the back.

Give students about 10 minutes to complete the front of the Explanations Process Tool.

Display slide 5. Then, have students compare their responses with a partner, with the goal of confirming that their responses are the same.

4. Have students check the front of the explanations tool using the PPT.

Display slides 6-8 of the PPT. Have students compare their answers to the Matter Movement Question with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.

- Display slide 9-10 of the PPT for the Matter Change Question and repeat the process above.

5. Have students write paragraph explanations of the process of soda water fizzing.

Display slide 11. Ask students to write paragraphs explaining the process of soda water fizzing on the second page of the 3.5 Explanations Tool for Soda Water Fizzing.

- Remind students that they have the information they need in their responses to the questions on the front of the Explanations Tool.
- Remind students that the graphic organizer on the front has the information they need to write their explanations paragraphs.

6. Have students share explanations with each other.

- Show slide 12 of the 3.5 Explaining Soda Water Fizzing PPT. Divide students into pairs and have them compare explanations.

7. Have students critique and improve their full explanations.

Display slide 13 of the PPT for the full explanation. Have students check that their story includes each of the parts (matter movement, matter change and matter movement) and answers the prompt in a cohesive way.

- If students don't have all three parts in their explanation, instruct them to add to their explanation using a different colored writing utensil.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

8. Discuss how ideas have changed

Show slide 14. Have students Gather together their process tools for the unit (Predictions and Planning Tool, Evidence-Based Argument Tool). Have a discussion about how their ideas have changed related to:

- Scale?
- Movement?
- Carbon?

Ask students what do they know about soda water now that they didn't know before the investigation? Record responses.

9. Use Three Questions to look ahead.

Show slide 15 of the 3.5 Explaining Soda Water Fizzing PPT. Tell students that in this lesson they focused on two of the Three Questions: The Matter Movement Question and the Matter Change Question. For the rest of the Carbon TIME lessons, we will also be discussing the third question: The Energy Change Question.

8. Have a discussion to complete the Learning Tracking Tool for this activity.

Show slide 16 of the 3.5 Explaining Soda Water Fizzing PPT.

- Have students take out their Learning Tracking Tool for Systems and Scale.
- Have students write the activity name "Explaining Soda Water Fizzing" and their role "Explainer" in the first column,

- Have a class discussion about what students did during the activity. When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students figured out during the activity that will help them in answering the unit driving question. When you come to consensus as a class, have students record the answer in the third column of the tool.
- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the fourth column of the tool.
- Have students keep their Learning Tracking Tool for Systems & Scale for future activities.
- Example Learning Tracking Tool

Activity Chunk	What Did We Do?	What Did We Figure Out?	What Are We Asking Now?
Explaining Soda Water Fizzing Explainer	Model the chemical change that occurs as soda water fizzes using molecular model kits and use the Explanations Tool to explain what happens when soda water fizzes.	The carbonic acid in soda water decomposes into carbon dioxide and water as it fizzes. No atoms are created or destroyed during the chemical change.	What happens to ethanol when it burns?

10.

11. Have students complete an exit ticket.

Show slide 17 of the 3.5 Explaining Soda Water Fizzing PPT.

- Conclusions: What should be included in a good explanation?
- Predictions: How do you think what you learned about soda water fizzing will apply to ethanol?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

During the class, circulate while students are comparing their explanations. Listen to see if they are able to explain soda water fizzing at both the macroscopic and atomic-molecular scales. After class, use the 3.5 Grading the Explanations Tool for Soda Water Fizzing Worksheet to grade their explanations. At this point in the lesson, students should be held accountable for correct answers.

Differentiation & Extending the Learning

Differentiation

Modifications

- If time allows, have students revisit their initial predictions and planning tools from Activity 3.1. Comparing their early predictions to their final explanations may show a greater change in their thinking over time.
- Because this is the first time that students will use the Explanations Tool, review the questions ahead of time so they understand the purpose and structure of the tool.

Extending the Learning

Students can explore other phenomena where carbon dioxide dissolves in water and forms carbonic acid:

- Carbonic acid in rain water dissolves limestone. This is how most caves are formed. https://www.bgs.ac.uk/mendips/caveskarst/caveform.htm
- Carbon dioxide dissolves in ocean water, and the resulting carbonic acid makes the oceans more acidic, damaging coral reefs and populations of shellfish. https://www.nationalgeographic.com/environment/oceans/critical-issues-ocean-acidification/
- Bread dough and cake batter have bubbles of carbon dioxide like soda water, but the “stickiness” of the dough prevents the bubbles from escaping. This is how bread dough rises. https://www.compoundchem.com/wp-content/uploads/2016/01/The-Chemistry-of-Bread-Making.pdf