This 5E model for instruction will be useful to help students gain an understanding of the conservation of mass in a system. Students will investigate various reactions to prove that mass is not lost after the reaction. Students will understand how to balance and classify a chemical reaction.

Student Science Performance

Grade level: 9-12 Physical Science	**Title:** Where Oh Where Did My Candle Go?
Topic: Properties of Elements and Compounds	

Performance Expectations for GSE:
SPS3 Obtain, evaluate, and communicate information to support the Law of Conservation of Matter.

a. Plan and carry out investigations to generate evidence supporting the claim that mass is conserved during a chemical reaction.
b. Develop and use a model of a chemical equation to illustrate how the total number of atoms is conserved during a chemical reaction.

Performance Expectations for Instruction:

- Plan and carry out investigations of various chemical reactions to determine if mass is conserved in the reaction.
- Analyze and interpret data from the investigations to determine the mass before and after the reactions.
- Balance and classify chemical equations demonstrated in the activity.

Additional notes on students supports

Materials:

- Access to internet resources
- Candles (1-2 per group)
- Matches (1 book per group)
- Balance (1 per class, min.; 1 per group, max.)
- Vinegar (100mL per group)
- Baking soda (20g per group)
- Steel wool (small piece for each group)
- Plastic bags (1-2 per group)
- Balloons (1 per group)
- Erlenmeyer flasks (1 per group)
- Cups (2-3 per group)

Engaging Learners	***Phenomenon:*** A burning candle will lose mass as it burns. Place a candle on an electronic balance. Light the candle and as the candle burns, the mass reading on the scale will decrease. Have students ask questions about what is happening. Remind the students of the Law of Conservation of Mass. Many will remember that mass cannot be created or destroyed. Given this understanding, engage the students in a discussion using the question: "Where does the mass go as the candle burns"? (It is likely a student will have posed this question.) Many students will say that the mass is converted to heat energy or that wax dripping off causes the candle to lose mass. Some will say the wax is burning away or the wax is evaporating.

	Optional videos that help to explain the Law of Conservation of Mass: video 1, video 2. ***Communicating:*** Have the students write their thoughts on the following question, "Does the burning candle disprove the law of conservation of mass?" They must organize their thoughts in a CER (claim, evidence, reasoning) format. They must make a claim about the candle and how the loss of mass either proves or disproves the Law of Conservation of Mass. Next, they discuss the evidence they used to make that claim. Additional teacher notes on topic, focus, and phenomena
Exploring	***Obtaining*:** After students have made their claims about the burning candle and the conservation of mass, tell them we are going to investigate a number of other situations and determine if mass is conserved. An investigation to illustrate Conservation of Mass is the reaction between vinegar and baking soda. 1. Have students place vinegar in an open cup or beaker on a balance. Then 2. Then they add the baking soda and record the mass immediately after they add baking soda 3. Have them observe the mass over time. Like the candle, the mass will decrease. Have students ask questions about why this happens. 4. Have students design an investigation that will allow students to demonstrate the conservation of mass. *Teacher Notes: The following demonstration will allow students to observe Conservation of Mass. Place a small cup of 20g of baking soda and a small cup of 40 ml of vinegar in a sandwich size zip top bag. Place the bag on a scale and place the two cups inside the bag. Seal the bag while squeezing out as much air as possible. Then pour the vinegar into the baking soda. Students can then observe the reaction and see if the reading on the scale changes.* Another investigation involves steel wool and vinegar. 1. The mass of small piece of steel wool is measured. 2. Then the steel wool is soaked in vinegar. The steel wool is removed from the vinegar after 5-7 minutes. 3. The steel wool is then allowed to sit in a flask with a balloon over the opening of the flask. After about 30 to 40 minutes the mass of the steel wool is measured. 4. The steel wool will oxidize(rust) and the balloon will be sucked into the flask. Various steel wool and vinegar activities can be found online. *Teacher Note: During these investigations the students should not be given too much instruction or a detailed procedure. Allow them to think about the procedure before they start the activity. Simply tell them the amounts of each material they will use and how they will be mixed together. The vinegar/baking soda reaction can be mixed in zip*

	top bags and observed on the lab table. The key concept is for the students to determine the system that is being observed in this activity. This leads to the observation that if the system is not closed within the bag there will be a change in mass. ***Remember the students need to follow all safety procedures when doing these investigations. Safety glasses should be worn at all times. Even the simple and easy activities can be dangerous if not done safely.* Student Data Sheet for conservation of mass activities
	Evaluating: After completing the investigations above, have the students research and find the chemical reactions that are taking place. These can be found easily by searching the internet. The unbalanced reactions for each are listed below: 1. Vinegar and baking soda $NaHCO_3 + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + H_2O + CO_2$ 2. Steel wool and vinegar $Fe + O_2 \rightarrow Fe_2O_3$ These equations can now be used to explore the reactions that took place in the investigations. The discussion does not need to center on a detailed description of the reactions. Instead the discussion needs to focus on why the vinegar and baking soda reaction lost mass when the plastic bag or container was left open. The students could not see the mass leaving but the scale showed that mass was indeed being lost. The students need to come the understanding that mass was being lost because one of the products of the reaction is carbon dioxide which is a colorless gas. This gas can easily escape into the air unnoticed. This reaction does not violate the conservation of mass law as long as the system is closed, and we can account for the escaping carbon dioxide. The steel wool and vinegar reaction that creates rust is interesting because this reaction does not create a gas but uses gas from the closed system. The total mass stays constant even though the balloon is sucked into the flask. The observation implies that something is used up as the balloon sucks into the flask. After looking at the reaction, students can see that the oxygen is not being "used up" but being combined with the iron to make iron oxide or rust.
	Communicating: Students should at this point have an understanding that in a chemical reaction the elements that make up the reaction are the same elements that are present at the end of the reaction. These elements will be rearranged to form different compounds, but all the elements are still present. The chemical reactions did not create or destroy any of the elements. The students will now write a few short sentences to explain what is meant by the Law of Conservation of Mass. They must use the words *element* and *compound* in their answer and they must cite one of the investigations in their explanation.
Explaining	***Obtaining:*** Now that the students have explored a few reactions, they have seen that mass can leave the system without being easily observed. Give them a candle and matches and tell them to light their candle and take a second look at the burning candle. They are aware that it is losing mass, so they must discuss in their group and

	determine where the mass is lost. Many groups may determine that the mass is lost because something is burned. If they try to light just the candle wax, they will see that the wax does not burn. Ask them now to blow out the candle and see if it can be relit without touching the match to the wick. They should be able to relight the candle by holding the match just above the wick. This will show them that the solid wax is being melted and then turned into a gas by the flame. The gas is burning which is why the candle can be relit above the wick. An interesting extension of this activity is to purchase the magic candles that will relight themselves as soon as they are extinguished. Have the students try to blow out these candles and when they are not successful, tell them to try and figure out why the candles keep relighting without a match. Student should not look up the answer on the internet. Let them try and come up with theories of the method that is used to make these candles relight continuously. Let these discussions go on until all ideas have been presented. Then have the groups go online and find the answer.
Elaborating-	***Obtaining*** The chemical equation is a model of a chemical reaction. The elements that start the reaction are the same and only elements that finish the reaction. The elements are rearranged into different compounds after the reaction. However, the total number of each element must be the same before and after the reaction. Based on the investigations, students should now have seen some of these patterns in chemical reactions. Give the students the formula for the burning of a candle: $C_{31}H_{64} + O_2 \rightarrow CO_2 + H_2O$ Continue the discussion about the loss of mass in the burning candle, and from the equation the students can see that the mass is leaving as a gas CO_2 and some water H_2O. Closing the system so the gas and water cannot escape means that mass is conserved. The students should see that the carbon, hydrogen and oxygen start this reaction in the form of wax and oxygen. These same elements are rearranged after the reaction to form carbon dioxide and water. They should also observe that 31 carbon atoms and 64 hydrogen started this reaction but only one carbon and two hydrogen is listed after the reaction is complete. Where did the carbon and hydrogen go? Tell the students the reactions are incomplete. They must finish the model of the reaction by "balancing" the equation. The balanced version of this equation is difficult to solve and could be given as a challenge. The answer is $C_{31}H_{64} + 47\ O_2 \rightarrow 31CO_2 + 32H_2O$ Tell the students to look at the steel wool rusting reaction for a start to balancing equations. The balanced version of the equation is $4\ Fe + 3\ O_2 \rightarrow 2Fe_2O_3$. Balancing chemical equations is taught in several ways. This is a good video series that explains the basics of balancing chemical equations. Once students are introduced to the basics, there are numerous sources of equations to balance. The following computer simulation allows students to practice this skill (others can be found online): PhET Balancing Chemical Equations (Attribution: PhET Interactive Simulations, University of Colorado Boulder; https://phet.colorado.edu)

	As students are mastering the task of balancing equations, make sure to introduce them to the different types of chemical equations. There are a number of types listed but in the context of physical science we are only concerned with synthesis, decomposition, single replacement and double replacement reactions. Students will balance and classify simple chemical reactions by the end of this activity. ***Communicating:*** As students master the skills of balancing and classifying reactions, have them write the answers to this question: Why does a chemical reaction have to be balanced? The answer should include a short discussion on the conservation of mass and should reference some of the reactions demonstrated in this activity.
Evaluation	***Assessment of Student Learning*** Based on all the investigations, discussions and information students will have the following understandings: 1. The Law of Conservation of Matter can be observed in a chemical reaction by the presence of the same elements as products and reactants. 2. The total number of atoms in a reaction do not change. 3. A chemical equation is a model of a chemical reaction that is classified as one of the following types: synthesis, decomposition, single displacement or double displacement. 4. A chemical equation must be balanced. In order to determine if students are mastering these understandings, have the students take small formative assessments as they build their skill at balancing and classifying equations. Students can take a small formative assessment and based on their performance find out if they need to work more to master that level of balancing equations or move to the next level. The learning and assessment should move from simple equations to more complex. By allowing the students to take small formative assessment as they progress in their learning, students that need help are identified and targeted early. The students that master the skill can move on to the next level. There are a number of online platforms that are available for this assessment or a grading method, and they give students quick feedback of their progression in learning the skill. Immediate feedback and help to correct student misunderstandings are key to moving all students towards a full understanding of the Conservation of Mass and the balancing and classification of chemical reactions.
SEP, CCC, DCI	**Science Essentials**
Science and Engineering Practices	● Asking questions and defining problems ● Developing and using patterns ● Planning and carrying out investigations ● Analyzing and interpreting data ● Constructing explanations ● Engaging in argument from evidence ● Obtaining, evaluating and communicating information
Crosscutting Concepts	● Patterns ● Cause and Effect ● Systems and System Models ● Energy and Matter
Disciplinary Core Ideas	From A Framework for K-12 Science Education: PS1.B: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and

	these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. Provide calculators as needed. 2. Provide graph paper as needed.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. Before lighting the candle have a student record the mass of the candle on the board. Then light the candle and let the student record the mass on the board every 2 minutes as the candle burns.
2. Have the class discuss what is occurring as the candle burns and focus on the mass. Have the students make observations as the candle burns.
3. The teacher should present this phenomenon in another way. The videos that are provided can be used to reinforce that this happens in different settings and every time that a candle burns.
4. The teacher should provide a format for the students to do their CER. It may be beneficial for some

students to have sentence starters to not be staring at a blank page.
5. The teacher should have well established guidelines for discussions that are enforced and provide a safety net for the students.

Exploring:

1. The teacher should provide a data sheet for the students to record observations, questions and thoughts on.
2. The teacher should provide a template for planning an investigation.
3. The teacher should do a demo on how to write a scientific procedure. The teacher can do a demo on how to make a sandwich (PB&J if no one in the class is allergic to peanuts). Do not do anything that the students do not instruct the teacher to do. The teacher should be prepared to try and get materials out without opening packages, ect.
4. The teacher may need to provide resources for the students to use while doing research.
5. As the students are doing research it may be beneficial to walk around and ask how mass could be lost and other questions to guide students in their research.
6. The teacher should provide multiple formats for the students to express their knowledge. These formats could include writing, drawing or designing a play.
7. The teacher should provide the CER format to students that are struggling and provide sentence starters to students that are struggling.

Explaining:

1. The teacher should provide an organizer for the students to record their observations of the candle.
2. The teacher should have discussion guidelines for students when they work in groups. This will make students feel safe and more likely to contribute to the discussion.
3. The teacher should use this discussion and explanation from the groups as a formative assessment. Then the teacher can review, re-teach or extend the activity as needed.
4. The magic candles can be used as an extension activity for students that understand where the mass is going.

Elaborating:

1. Balancing equations can be very difficult for students. Some ways that the teacher could make this more palatable for students is to give them objects to balance. Have objects represent the different elements in the equation. Students can then work until the number match on each side and then count the elements.
2. Another idea for balancing equations is to give the basic equation with blanks on a piece of chart paper. Provide sticky notes with numbers and have students move the sticky notes to the appropriate places within the equation. Have students justify their placement.
3. The teacher can find an online interactive activity that has students balance equations.
4. Providing students multiple ways to interact with balancing equations increases the chance that students will gain an understanding of the material. Other ways that the teacher can expose the students are videos, demos and practice problems.
5. The teacher should continually formatively assess students in this lesson and provide re-teaching as needed.
6. The teacher should provide multiple formats for students to express their knowledge. These formats could include writing, drawing or designing a play.
7. Have the students answer the question as an individual, share their answers with a neighbor and then

revise their answers.
Evaluating: 1. The teacher should be sure to check for understanding throughout the lesson and build in re-teaching, review and enrichment as needed by each student. 2. The teacher should provide tangible and constructive feedback for students throughout the lesson. 3. The teacher should provide multiple formats for students to express their knowledge. These formats could include writing, drawing or designing a play.

Return to Instructional Segment

C-E-R Template

Does the burning candle disprove the Law of Conservation of Mass?	
Initial Claim:	The burning candle_____ _____ _____
Supporting Evidence	1._____ 2._____ 3._____
Reasoning	

Return to Instructional Segment

Conservation of Matter Data Sheet

Reactants	Total Mass Before Chemical Reaction (grams)	Total Mass After Chemical Reaction (grams)	Change in Mass (grams) (Final Mass – Initial Mass)	Notes

Return to Instructional Segment

Stability and Change in Reactions

GSE: **SPS3a,b; SPS7a**

Anchoring Phenomenon:

Cars and rockets are powered by chemical reactions.

Topic	Focus	Lesson Phenomenon	GSE/Notes/Language
Conservation of Matter	• Students must understand that matter is conserved in chemical reactions. • Students will relate observations to written chemical reactions. • Making models of atoms involved in simple chemical reactions help students understand need to "balance" reactions. • The focus is on conceptual understanding of conservation of mass, not on mathematical balancing of equations. • Students can use many simple examples such as lead nitrate and potassium iodide (produces clear chemical reaction with color changes) to demonstrate conservation of mass. • Students can use reactions that produce gas to challenge students to explain observed "loss" of mass (vinegar and baking soda, etc.). • Students will	*If you place a candle on a balance and light it, the balance will show a decreasing mass over time.* This is due to the vaporization of the wax, however, close observation of a candle burning makes it appear as if only the wick is burning and the wax is melting. It is through the wax being drawn up the wick by capillary action that this occurs.	SPS3a. Plan and carry out investigations to generate evidence supporting the claim that mass is conserved during a chemical reaction. (Clarification statement: Limited to synthesis, decomposition, single replacement, and double replacement reactions.) SPS3b. Develop and use a model of a chemical equation to illustrate how the total number of atoms is conserved during a chemical reaction. (Clarification statement: Limited to chemical equations that include binary ionic and covalent compounds and will not include equations containing polyatomic ions.)

	recognize and describe synthesis, decomposition, single replacement and double replacement reactions. ● Students will relate the charge of an ion to the formula of a binary ionic compound between metals and nonmetals.		

Return to Instructional Segment