Lab: Mass & Change

FOR THE TEACHER

Summary
In this lab, students will use unified particle pictures of solid, liquid, and gas to explain the law of conservation of mass after carrying out various experiments.

Grade Level
Middle School, High School

NGSS Alignment
This activity will help prepare your students to meet the performance expectations in the following standards:

- **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.
- **Scientific and Engineering Practices**:
  - Developing and Using Models
  - Analyzing and Interpreting Data

Objectives
By the end of this lab, students should be able to:

- Explain the concept of the law of conservation of mass.
- Distinguish between physical and chemical changes.
- Draw particle diagrams differentiating between solids, liquids, and gases.

Chemistry Topics
This lesson supports students’ understanding of:

- Conservation of mass
- Physical change
- Chemical change
- States of matter

Time
**Teacher Preparation**: 30 minutes
**Lesson**: 2 x 45 minute periods

Materials
For each group:

- Balance
- Steel wool
- **Vial with cap** (5)
- Piece of ice
- Ca(NO$_3$)$_2$ solution (concentration not important)
- Na$_2$CO$_3$ solution (concentration not important)
- Crucible tongs
- Bunsen burner
- Evaporating dish
- Sugar
- Water
- Alka-Seltzer tablet

Safety
- Always wear safety goggles when working in a lab setting.
- Dispose of all chemicals in the appropriate disposal container.
Teacher Notes

- Prior to this activity, students should have some familiarity with the differences between solids, liquids, and gases on a particulate level and with the concepts of physical and chemical changes.
- Generic questions you can ask students during the investigation:
  - How did you know that?
  - What evidence did you have for _____?
  - How would your results change if you had ....?
  - How do your results compare with Table ___?
  - Can you explain how that happened in terms of our model?
- The questions below could be asked in a class discussion setting as the groups do each part of the lab, but this does require that all students do the same parts at the same time, which requires each group to have a set up for each part of the lab and could be challenging in terms of pacing. You could make this a station-based lab so students rotate around the room and do each activity at a different station. You might place the questions at each station, adapting them so they are less leading/more open-ended. This would allow for some variations in pacing between groups and much less set-up, as you would only need the materials for each part of the lab to be set up once – you could reuse glassware, balance, etc. and just provide enough of the consumables for each group.
- Students will be expected to make a histogram of the class data for one of the six parts of the lab. See this Khan Academy tutorial on histograms if students need guidance: https://www.khanacademy.org/math/ap-statistics/quantitative-data-ap/histograms-stem-leaf/v/histograms-intro
- Making a histogram requires that students have access to all the class data for their section of the lab. You could create a google doc for all students to access or have students enter data on a class computer or data sheet before they leave lab. If data will not be available electronically, be sure students have time to copy class data for their section.

Questions to discuss with students as they’re thinking about the results of each part of this lab:
Part 1:
- How are you representing a solid?
  - Dot spacing?
- Was your mass the same?
  - How would you represent the mass being the same?
  - If nothing flew away, what would your mass be?
  - Where could you have lost/gained mass?
- What happens to the particles when you have a very condensed piece of steel wool and pull it apart?

Part 2:
- Did you change the particles?
  - What did you begin with and what did you end with?
  - What kind of change does this signify?
- How are you representing the difference between the two states of matter, solid and liquid?
  - Expansion of water particles as a solid
- Do you remember the difference between the volume of solid and liquid?
  - What happens when you put a water bottle into the freezer?

Part 3:
- What was different about this experiment in comparison to the previous two?
- What state of matter was produced?
  - How would you represent the change in the state of matter?
- How do you know that this wasn’t a physical change like before?
  - How would you characterize a chemical change?
Part 4:
- How do you know this was a chemical change?
- Does a color change always mean that a chemical change has taken place?
  o Physical and chemical changes are not always easy to distinguish
- Did you witness a change in the state of matter?
- If mass was lost, where did it go?
- What could have caused an increase in the mass?
  o We have had every experiment so far have the mass remain the same.
  o What are the possible particles that could have mixed with the steel wool to gain more mass?
    ▪ From the list, decide on what sound like a reasonable idea that the class thinks is correct

Part 5:
- What does the word “dissolve” mean?
- Did the sugar “react” with the water?
  o How might you test this?

Part 6:
- What states of matter are present in this experiment?
- Where did the loss of mass come from?
  o Did you spill some of the liquid or lose some of the solid?
  o What happened when you mixed the water and Alka-Seltzer?
    ▪ What was produced in this reaction?
    ▪ Where did it go in the midst of the experiment?
- Now you have a solid, liquid, and gas. How would you represent the differences in a particle picture?
  o Can you determine a unified drawing for the particle pictures of a solid, liquid, and gas?

FOR THE STUDENT
Lesson
Mass & Change

Background
Scientists (and you!) need tools to describe matter in a quantitative way. Mass is one useful property of matter that you can measure to determine how much “stuff” you have. The balance is the tool to measure the mass of an object. This is a six-part lab that gives you the opportunity to examine a number of instances where the appearance of a system changes and you will see if the mass changes as well.

Prelab Questions
Answer the following questions on a separate sheet of paper and submit before lab.
1. Predict whether the mass will change if the wad of steel wool is pulled apart.
2. What happens when you leave a soft drink in the freezer? Predict: does its mass change?
3. When some solutions are combined, a solid forms. Predict: will the mass change when the solid forms?
4. What happens when something burns? Predict: will the mass of an object change after it is burned?
5. What happens when something dissolves? Predict: will the mass of a sugar water solution be the same or different as the initial samples of water and sugar?
Safety
- Always wear safety goggles when working in a lab setting.
- Dispose of all chemicals in appropriate disposal containers.

Materials
- Balance
- Steel wool
- Vial with cap (5)
- Piece of ice
- Ca(NO₃)₂ solution
- Na₂CO₃ solution
- Crucible tongs
- Bunsen burner
- Evaporating dish
- Sugar
- Water
- Alka-Seltzer tablet

Procedure
Record data and observations for each part of this lab in the results table below.

PART 1 – MASS OF STEEL WOOL
1. Determine the mass of a wad of steel wool.
2. Carefully pull the steel wool apart so that it appears roughly twice as “big” as before.
3. Determine the mass of the expanded sample of steel wool.

PART 2 – MASS OF ICE AND WATER
1. Place a piece of ice in a vial.
2. Find the mass of the vial and ice.
3. Set the vial aside and go on to part 3. You can return periodically to warm the vial in your hands to speed up the melting process.
4. Once the ice is melted, find the mass of the vial and its contents.

PART 3 – MASS OF A PRECIPITATE
1. Fill a vial no more than 1/3 full with Ca(NO₃)₂ solution.
2. Fill a second vial no more than 1/3 full with Na₂CO₃ solution.
3. Cap the vials and find the mass of both vials with the contents and caps (you’re only finding one mass in this step).
4. Carefully pour the contents of one vial into the other vial. Be careful to not spill any of the contents.
5. Find the mass of both vials (including the empty one), contents, and caps.

PART 4 – MASS OF BURNING STEEL WOOL
1. Find the mass of steel wool and an evaporating dish.
2. Light the burner.
3. Holding the steel wool with tongs near the evaporating dish, heat the steel wool until it glows. Turn the steel wool around in the flame so that all sides are exposed. Any pieces of the steel wool that break free during heating should fall onto the dish.
4. Record your observations when the appearance of the steel wool changes. Let it cool for about 1 minute.
5. Find the mass of the heated steel wool (including any parts that may have fallen during heating) and the evaporating dish.
6. Place the “used” steel wool in the trash can.
PART 5 – MASS OF DISSOLVED SUGAR
1. Fill a vial about 1/2 full with water.
2. Put about a small scoop of sugar in the cap of the vial.
3. Find the mass of the vial, water, cap, and sugar (you are finding one mass in this step).
4. Carefully pour the sugar into the vial (do not spill any). Gently swirl the vial to help the sugar to dissolve. Do not shake the vial vigorously, you don’t want solution to leak out of the vial.
5. When the sugar has completely dissolved, find the mass of the vial, cap, and contents.

PART 6 – MASS OF DISSOLVED ALKA-SELTZER
1. Fill a vial about 1/2 full with water.
2. Find the mass of the vial, water, cap, and an Alka-Seltzer tablet (you are finding one mass in this step).
3. Carefully drop the tablet into the vial (do not spill any).
4. When the tablet has finished reacting, find the mass of the vial, cap, and contents.

Results

<table>
<thead>
<tr>
<th>Part #</th>
<th>Starting Mass</th>
<th>Final Mass</th>
<th>Change in Mass</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analysis
For each part of the lab:
1. Calculate any change in mass. Record in the table above.
2. Report your group’s results on the board/computer so that the class data can be collected. Change should be recorded as + (for a gain) or – (for a loss).
3. Draw “before” and “after” particle picture explanations in the space below.

Particle Pictures

Part 1

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Wool, pulled apart</td>
<td></td>
</tr>
</tbody>
</table>

Part 2

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice and Water</td>
<td></td>
</tr>
</tbody>
</table>

Part 3

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitate</td>
<td></td>
</tr>
</tbody>
</table>

Part 4

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel wool, heated</td>
<td></td>
</tr>
</tbody>
</table>

Part 5

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar dissolved in water</td>
<td></td>
</tr>
</tbody>
</table>

Part 6

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alka-Seltzer dissolved in water</td>
<td></td>
</tr>
</tbody>
</table>
1. Did the mass change or stay mostly the same when you pulled the steel wool apart? What about when you heated it? Explain the difference. Classify each of these experiments as either a physical or chemical change and justify your classification with evidence from your data and observations.

2. When ice melts, the volume of water is smaller than that of the ice. How does the mass of the water compare to the mass of the ice? What does this mean for the density of ice compared to that of water? Does that make sense based on your experience with ice and water?

3. When the precipitate formed from two solutions mixed together, did the total mass change? Would you classify this as a physical or chemical change? Justify your classification with evidence from your data and observations.

4. Did the mass change or stay mostly the same when you dissolved sugar in water? What about when the Alka-Seltzer “dissolved” in the water? Explain the difference. Classify each of these experiments as either a physical or chemical change and justify your classification with evidence from your data and observations.


6. In some of the experiments you did in this lab, you may have seen the mass change by a small amount. Assume that these minor differences are due to small errors introduced during the experiment. For each of the experiments where the mass only changed by a small amount, suggest possible sources of error that could have contributed to the difference.

**Conclusion**

1. You will be assigned one part of this lab to report on to the class, taking into account the data from everyone in class. For your assigned experiment your group should:
   a. sketch a histogram based on class results.
   b. produce a particle representation of the system before and after the change.

2. Your group will present your work to the class.