Designing a Device Utilizing a Balloon Filled with Carbon Dioxide

SLED
Science Learning through Engineering Design

Grade Level:	**Total Time Required:**
5	4 periods (60 minute each), approximate

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Lesson Objectives:

In this lesson, students will design and build a device which utilizes the carbon dioxide gas that is a result of mixing baking soda and vinegar in a bottle. A balloon captures the carbon dioxide gas and can be used for many engineering devices that range from inflating objects, using the balloon as a sensor or warning device, or utilizing the gas itself (e.g., fire extinguisher). The project is an open-ended design that can result in many different innovative designs.

Students will be able to:

1. Learn that a gas has mass.
2. Learn about the conservation of mass through an experiment with vinegar and baking soda.
3. Use the carbon dioxide from a chemical reaction between vinegar and baking soda to develop an engineered device. The student will have a number of materials available for them to develop their concepts and examples are provided in the lesson plan.
4. (Optional): Additional learning activities are provided to support the understanding of conservation of mass principles including a demonstration process to recycle the carbon dioxide.

Indiana Standards:

5.PS.1 Describe and measure the volume and mass of a sample of a given material

5.PS.2 Demonstrate that regardless of how parts of an object are assembled the mass of the whole object is identical to the sum of the mass of the parts; however, the volume can differ from the sum of the volumes. (Law of Conservation of Mass).

5.PS.3 Determine if matter has been added or lost by comparing mass when melting, freezing, or dissolving a sample of a substance. (Law of Conservation of Mass).

3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Next Generation Science Standards:

Discipline Core Ideas

3-5.ETS1-1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Science/Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

Crosscutting Concepts

2. Cause and effect: Mechanism and explanation.

Mathematics Connections:

In this design task, students will gain firsthand experience utilizing mathematical ideas in other content areas and finding a solution to a real-world problem presented to them. This activity allows students the opportunity to measure and record the weight of various objects and to substitute actual measurements for simple variable representations of those weights.

In addition, the design activity requires the students to perform the following mathematical procedures:

- Adding and subtracting whole numbers and decimal numbers;
- Weighing an item to a specified decimal place;
- Comparing decimal numbers.

Indiana Academic Standards for Mathematics:

- CCSS Mathematical Practice:
  Use information taken from a graph or equation to answer questions about a problem situation.

Concepts and Vocabulary

Term	***Defined by a scientist or engineer***	***Defined by a student***
Mass	A property of matter equal to the measure of an object's resistance to changes in either the speed or direction of its motion. The mass of an object is not dependent on gravity and therefore is different from but proportional to its weight.	Amount of matter in an object
Weight	The weight of an object is the force on the object due to gravity	How many pounds I am
Density	Density of a material is defined as its mass per unit volume. For the purpose of this lesson, students are asked about the properties relative to the density of gas inside of a balloon	How thick something is
Conservation	The maintenance of a physical quantity, such as energy or mass, during a physical or chemical change.	To conserve or save something
Prototype	(Engineering / General Engineering) one of the first units manufactured of a product, which is tested so that the design can be changed if necessary before the product is manufactured commercially.	First creation of a design
Recycle	To use again, especially to reprocess.	Reusing something
Volume	The amount of space occupied by a three-dimensional object or region of space. Volumes are expressed in cubic units.	Space matter takes up
Chemical Reaction	A process that involves changes in the structure and energy content of atoms, molecules, or ions but not their nuclei.	Two chemicals go together and you get a change
Carbon Dioxide	A colorless, odorless, incombustible gas, CO_2, formed during respiration, combustion, and organic decomposition and used in food refrigeration, carbonated beverages, inert atmospheres, fire extinguishers, and aerosols. Also called *carbonic acid gas.*	An example of a gas
Combustion	A chemical change, especially oxidation, accompanied by the production of heat and light.	Fire

Source: http://thefreedicitonary.com

Equipment, Materials, and Tools

Materials for a class of 20 students with 4 in each team (They will not use all materials).

Materials		
Balloons – Helium quality (50)	Rubber bands (1 pkg)	Brass paper brads (100)
Clips (20)	Marbles (50)	Foam Board (16)
Vinyl corner bead pieces (50)	Plastic cups (5)	Baking Soda (2 boxes)
Flexible straws (4)	Glue (1 bottle)	Vinegar (1 gallon)
Duct tape (2 rolls)	String (100 ft)	Paper Cupcake container (50)
Hose - 5/8 in diameter (25 ft)	Springs (10)	Round plastic plates (5)
16 or 24 oz. soda bottles (50)	Clay (1 pkg)	Slinkys (2)

Tools		
Scissors	Rulers	Triple beam balance or digital scale
Safety goggles		

Safety Guidelines:
Although this lesson does not involve the use of hazardous materials, students are encouraged to wear safety goggles as a means of protecting their eyes.

Science Content

Science Content:

- The lesson requires students to measure the mass of each component demonstrating that mass is the amount of matter in an object.
- Mixing vinegar and baking soda produces carbon dioxide and water. The mixture of the liquid (i.e., vinegar) and solid (i.e., baking soda) produces a liquid solution and gas mixture. The lesson plan is designed so that the students will visualize the reaction (see the balloon filling with a gas). The students will be able to determine there was no change in the mass of the mixture based on measurements before and after the reaction. This example demonstrates conservation of mass principles.
- The mass of the carbon dioxide in the balloon is determined in order to show that a gas has mass.
- The process of measuring multiple components of the materials used before and after the reaction demonstrate how the mass stays the same, but the volumes can be different (i.e., volume is the amount of space that materials occupy). The students can visually see the difference in volume of the materials prior to the experiment and after the reaction (i.e., the balloon filled with carbon dioxide).

Lesson Plan #1
Guiding Question – How can Carbon Dioxide Gas be generated?

Time: one 60 minute class session

An Exercise to Create Carbon Dioxide Gas and Learn About Conservation of Mass

Materials: (per group)
- One 16 - 24oz empty plastic drink bottle (avoid wide-necks)
- 12” helium quality balloon
- Graduated cylinder and measuring spoons (teaspoon, table spoon)
- Powder funnel and Cupcake container (paper, approx. 2 ½” size)
- 200mL distilled white vinegar
- 3 level teaspoons (or 1 level tablespoon) Baking Soda (15 – 20g)
- Balance (0-500g measuring to 0.1g)
- Bag clip
- Sharpie marker

Note: Use the worksheet or template entitled, “Data Table (Measuring Carbon Dioxide)” when instructing the first part of this lesson.

Procedure:

1. Carbon Dioxide Formation.
   a. Introduce mass, weight, gases liquids and solids by writing these terms on the marker or Smart board.

      Ask: Can you give me an example of a gas?
      Can you give me an example of a liquid?
      Can you give me an example of solid?
      What does “mass” mean to you? What does “weight” mean to you?
      What is the difference between mass and weight?
      Does a solid, like this box (or other object), have mass?
      Does this liquid, say in this bottle, have mass?
      Does a gas have mass?

      Inform students that they are going to determine the mass of gas. Prepare students for the investigation by reviewing the Data Table (Measuring Carbon Dioxide), showing them the materials and tools they will be using, and instructing them to put on their safety goggles. Review all safety guidelines regarding conducting an investigation using chemicals.

   b. Instruct students to weigh the bag clip, balloon **(A, B) –** Worksheet.

c. Instruct students to weigh out approximately 20g of baking soda into the cupcake container (1 tablespoon).

d. Instruct students to transfer baking soda to the balloon using the funnel. (balloon should be approximately ¼ full)

e. Instruct students to weigh the balloon containing the baking soda **(C)** - Worksheet. Instruct students to determine the mass of the baking soda. **(Difference = C - B)** –at least 15g, add more if needed and re-weigh.

f. Instruct students to measure out about 200mL of vinegar with the graduated cylinder and record the volume **(I)** – Worksheet.

g. Instruct students to add 200mL of vinegar to the bottle and weigh the combination **(D)** – Worksheet.

h. Encourage students to carefully mark the level of the liquid in the bottle.

i. Instruct students to attach the balloon to the vinegar bottle being careful *not* to transfer the baking soda. This is best done with one person holding the vinegar bottle and the other stretching the balloon over the bottle.

j. Instruct students to weigh the combination **(E)** – Worksheet.

k. This step can be done on the balance to provide a check for leaks around the balloon (rare). Slowly raise the balloon and add **small** portions of the baking soda into the vinegar. Do this at such a rate that the foaming does not rise into the neck of the bottle. You may have to hold the balloon down as it is inflating to prevent large amounts of baking soda transferring at once. Swirl the bottle if needed until all the baking soda has dissolved – complete reaction. At the end, tap the neck of the balloon to make sure all the contents have been transferred. The balloon should have blown up firmly following the addition.

l. Instruct students to re-weigh the combination and check whether mass has been conserved **(F)** – Worksheet.

Ask: *What did you observe happen?*
Did it change? Why or why not?

m. Instruct students to observe and record the level of the liquid.

Ask: *Did it change? Why or why not?*
What do you think happened?
What exactly is in the bottle?
What exactly is in the balloon?
How do you know? Based on what evidence? (Encourage students to use data or evidence from their data tables to explain or justify their explanation)

2. Mass Balance.
   a. Instruct students to twist the balloon *several turns* to seal it off and clamp with the bag clip. Remove the balloon + clip combination from the reaction bottle.

   b. Instruct students to weigh the inflated balloon + clip **(G)** – Worksheet and compare with their original mass.

      Ask: *What can you conclude?*
      Using evidence from your data tables, please write your conclusion in two or three sentences.

   c. Tie off one balloon to show that a balloon filled with carbon dioxide sinks to the floor. Compare its buoyancy with a balloon filled with air.

      Ask: *How does the density of carbon dioxide compare with the density of air?*
      Do you think it is more or less than the density of air? How do you know? Based on what evidence?

   d. Instruct students to remove the clip.

      Ask: *What happens when you release the balloon?*

   e. Instruct students to weigh the vinegar bottle with its contents **(H)** – Worksheet. Compare the mass of the balloon + clip + vinegar bottle and their contents with the total mass of the components originally.

      Ask: *What can you conclude?*
      What do think is happening?

   f. Instruct students to pour the liquid in the bottle into the measuring cylinder and record the volume **(J)** – Worksheet.

      Ask: *What did you observe?*
      What do think happened? Why?

   g. *Optional*: Add one tablespoon of sand (15mL) to the vinegar mix, and measure the new volume **(K)** – Worksheet.

      Ask: *How does this volume compare with the previous volumes of vinegar?*

Optional Shortened Version to Calculate Carbon Dioxide Gas

1. Weigh Balloon + Bag Clip.
2. Fill Balloon.
3. Put on bottle and weigh Balloon, Bottle, Vinegar and Baking Soda.
4. Do the experiment on the scale. They can see that there is no change in mass.
5. Weigh the Balloon, Bag Clip to determine the mass of gas.

Data Table (Generating Carbon Dioxide)

Complete steps in order and fill out each column that is not shaded including units.

Steps	Item	Measured Mass	Mass Difference	Identity
A	Bag Clip			
B	Balloon			
C	Balloon containing Baking Soda		**C-B =**	Mass of baking soda (Check to make sure 15 to 20 grams of baking soda)
D	Bottle + Vinegar			
E	Bottle + Vinegar + Balloon + Baking Soda (before addition)		**C+D=**	
F	Bottle + Vinegar + Balloon + Baking Soda (after addition)		Is there a difference between E and F?	Note: Buoyancy may lead to apparent loss of approximately 4 grams
G	Balloon + Gas + Clip		**G-B-A =**	Mass of gas!
H	Bottle + Vinegar + Baking Soda		**D+(C-B)=**	Mass conserved?
	Optional Activity			
	VOLUMES	**Measured Volume (mL)**		
I	Vinegar used			
J	Vinegar + baking soda		**J-I =**	
K	Vinegar + baking soda + sand		**K-J =**	

Lesson Plan #2
Guiding Question – How can Carbon Dioxide Gas be generated?

Time: one 60 minute class session

Note: In this lesson, students will design and build a device which utilizes the carbon dioxide gas that is a result of mixing baking soda and vinegar in a bottle. This is a very open-ended project and there are many ways to fabricate a working model using multiple materials.

Procedure:

1. Distribute a copy of the design challenge to the students.

2. Ask: *What is the problem?*
   Who is the client?
   Who is the end user?
   What are examples of constraints?

3. Ask: *Now that you have captured this gas, how can you use this gas?*
   How could you use this gas to power a device or to develop a device that can sense a change in a particular space?

4. Record students' ideas on the marker or Smart board.

5. Introduce the materials and items that students can use to build a device (see examples from the list of Inflatable Devices and Sensors below).

6. Instruct students to brainstorm some ideas as an entire class. You may use some of the ideas provided in this section to assist in getting the students thinking about possible design concepts. In order to start the process, provide them with an example of a design that inflates an item and one that is used as a sensor.

7. The students can independently sketch possible designs for a device in their design books.

   Ask: *What are the important features?*
   What are some other features you must consider?

8. Instruct students to decide on one plan after they share their designs. The design could be a specific design of one student or a combination of designs.

9. Students will then construct and test one prototype per team.

   Ask: *What is your team's plan?*

What is the purpose of your device? How does it work?
Did you meet the client's needs?
What is one weakness of your design?
How could you improve on your design?

10. If time permits, encourage students to re-design. If time does not permit, encourage students to share ideas with the class on how they can improve on their designs.

Possible options:

Examples of Inflatable Devices:	**Examples of Sensors:**
Inflate a toy	Room Entry Detector (When bottle tips over balloon inflates signaling someone has been in the room)
Airbag for a toy car	Wind speed warning device (When the wind speed gets too high a device lifts the empty balloon and start the reaction)
Life Preserver	
Life Raft	

Assessment

The following are possible sources of formative and summative assessment:

- Design notebooks (individual) – Note how students identify and clearly label their drawings; Identify the types of science vocabulary students use in their notebooks (tally the number of times each concept is used); Note how students record data from testing their prototypes and how well they explain their results (patterns in the data)

- Presentation of design to class by the team. Provide positive design attributes, how design criteria where met, and possible redesigns.

- Participation (group) – Note level of engagement; questions students asked; how well they worked in a group; how well each team met the goals of the task.

- Other (individual and/or group) – Create a short pre and posttest that highlights key science vocabulary terms; Present a new situation or new problem on the same theme.

Lesson Extensions and Resources

Activity Extensions:

Possible additions are

1. Estimate volume of the filled balloon from its circumference. (Can also measure by displacement)

2. Determine the density of carbon dioxide.

3. Estimate the volume and mass of carbon dioxide that was lost when balloon was transferred between the bottles.

4. Determine the density of the solutions.

Design Activity

Student Resource

An employee of the Indiana Sand Dunes Chemical Company noticed that a byproduct (a substance made during a reaction, but not used) of the chemical process he was developing was a gas. In fact, the employee noted that a lot of this gas was formed after combining two reactants, vinegar and baking soda. The gas, carbon dioxide, was enough to inflate a balloon The Indiana Sand Dunes Chemical Company is convinced that the production of the gas can be used to make a useful product and they are asking you to help them design a product that people would want to buy and use. Your team is limited to one balloon filled with gas.

You may use the following materials to generate the amount of gas necessary for your device:

- One 16 - 24oz empty plastic drink bottle (avoid wide-necks)
- 12” helium quality balloon
- 200mL distilled white vinegar
- 3 level teaspoons (or 1 level tablespoon) Baking Soda (15 – 20g)
- Bag clip

Carbon Dioxide Capture

(Demonstration by Teacher Only)

This is a teacher only demonstration!
Lime is caustic and can causes severe irritation when inhaled or placed in contact with moist skin or eyes.

Materials:

- Balloon filled with carbon dioxide sealed with clip
- Three tablespoons Hydrated Lime (40 – 50g)
- Empty Bottle (16 to 24 oz)

Procedure:

1. Take the bottle containing the lime and sprinkle a tablespoon of water throughout the bottle wetting as much surface as possible. (This speeds up the absorption of carbon dioxide) Weigh the bottle and its contents **(J)**.

2. Attach the balloon to the lime bottle. This may take two pairs of hands.

3. Weigh the combination **(K).**

4. Release the bag clip and allow the contents of the balloon to flow into the lime bottle. Shake occasionally and monitor the mass. If equipment permits carry out this process on the balance and follow the mass change – ideally none if the balloon is well sealed to the bottle. The balloon should deflate. This step may take 5 - 15 minutes to observe noticeable deflation. Feel the temperature of the bottle. **Warning:** if the surface wetting was done effectively, the bottle may become hot enough to make it difficult to hold. After checking that the bottle is not dangerously hot, allow the students to feel the heat. Occasional shaking may be needed to make deflation visible and generate more heat. Ask them to explain why the balloon deflated and the bottle became hot.

5. Measure the mass after the balloon has deflated **(L) –** don't forget the clip. What conclusions can you draw?

6. Remove the balloon and weigh both the lime bottle **(M)**

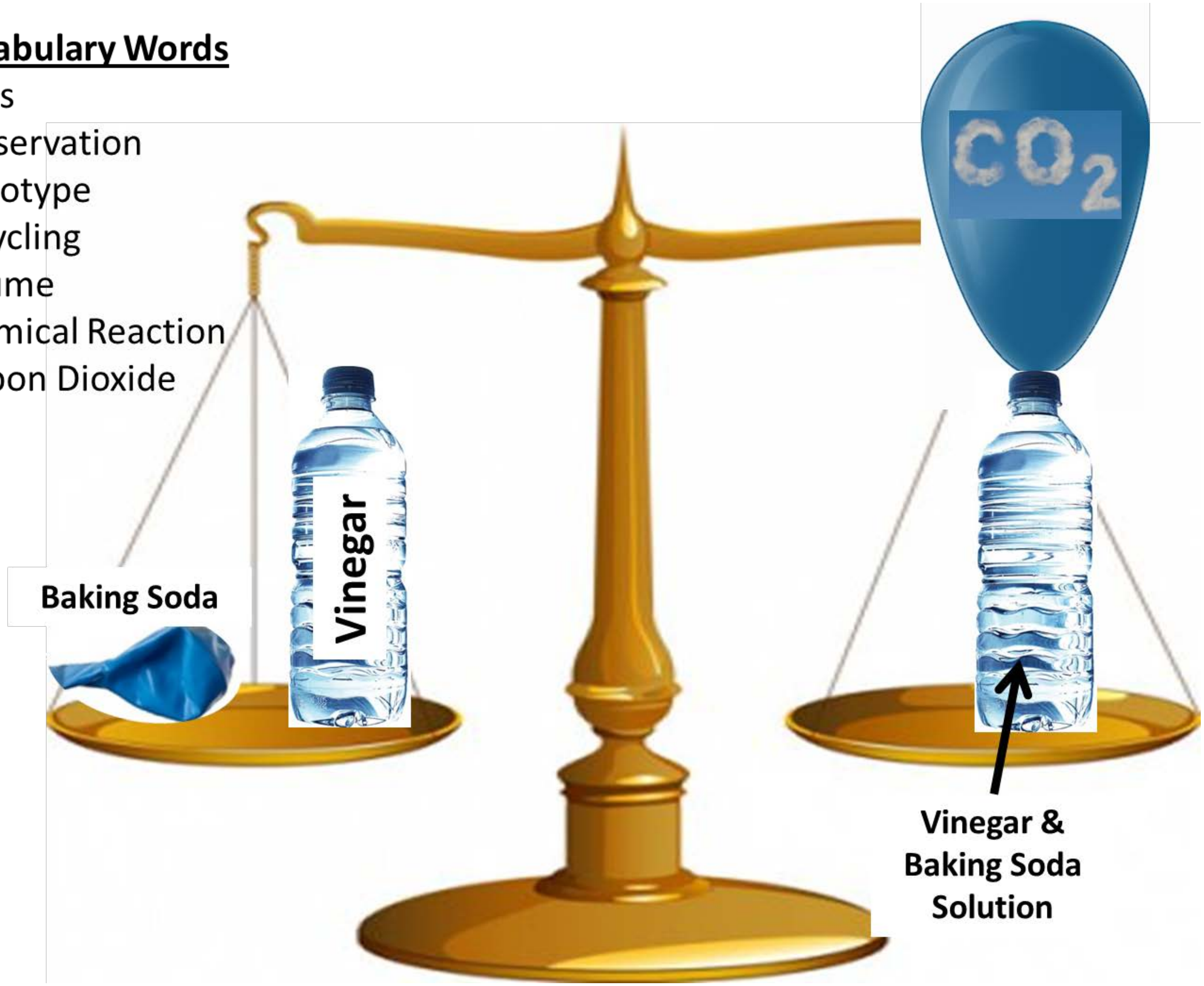
7. Account for the observed mass changes. What conclusions can be drawn?

Data Table (Carbon Dioxide Capture)

Step	Item	Measured Mass	Mass Difference	Identity
J	Bottle + Lime + water			
K	Balloon + Bottle + Lime + clip (before addition)		**= G+J??**	
L	Balloon + Bottle + Lime + clip (after reaction)		**= G+J??**	Was mass conserved??
M	Bottle + Lime (after addition)		**M-J =**	mass of gas absorbed
	VOLUMES	**Measured Volume(mL)**	**Volume Difference**	**Identity**
N	Vinegar used			
O	Vinegar + baking soda		**O-N =**	Was volume conserved??
P	Vinegar + baking soda + sand		**P-O =**	Was volume conserved??

Vocabulary Words

Mass
Conservation
Prototype
Recycling
Volume
Chemical Reaction
Carbon Dioxide



Answers to Questions Posed in Procedures

Procedure:

1. Carbon Dioxide Formation.
   a. Introduce mass, weight, gases liquids and solids by writing these terms on the marker or Smart board. *# 1 (DOK Level1, Bloom's Taxonomy- Remembering) #2 (DOK Level 2 & Bloom's Taxonomy – Analysis)*

   b. Instruct students to weigh the bag clip, balloon **(A, B) –** Worksheet.

   c. Instruct students to weigh out approximately 20g of baking soda into the cupcake container (1 tablespoon).

   d. Instruct students to transfer baking soda to the balloon using the funnel. (balloon should be approximately ¼ full)

   e. Instruct students to weigh the balloon containing the baking soda **(C) -** Worksheet. Instruct students to determine the mass of the baking soda. **(Difference = C - B)** –at least 15g, add more if needed and re-weigh.

   f. Instruct students to measure out about 200mL of vinegar with the graduated cylinder and record the volume **(I)** – Worksheet.

   g. Instruct students to add 200mL of vinegar to the bottle and weigh the combination **(D) –** Worksheet.

   h. Encourage students to carefully mark the level of the liquid in the bottle.

   i. Instruct students to attach the balloon to the vinegar bottle being careful *not* to transfer the baking soda. This is best done with one person holding the vinegar bottle and the other stretching the balloon over the bottle.

   j. Instruct students to weigh the combination **(E)** – Worksheet.

   k. This step can be done on the balance to provide a check for leaks around the balloon (rare). Slowly raise the balloon and add small portions of the baking soda into the vinegar. Do this at such a rate that the foaming does not rise into the neck of the bottle. You may have to hold the balloon down as it is inflating to prevent large amounts of baking soda transferring at once. Swirl the bottle if needed until all the baking soda has dissolved – complete reaction. At the end, tap the neck of the balloon to make sure all the contents have been transferred. The balloon should have blown up firmly following the addition.

l. Instruct students to re-weigh the combination and check whether mass has been conserved **(F)** – Worksheet .

Ask: *What did you observe happen?*
Did it change? Why or why not?
(DOK Level 2 & Bloom's Taxonomy – Application)

Answer: The mass is unchanged in principle; there will be the loss of about 4 grams due to buoyancy of the balloon when the balloon is blown up.

m. Instruct students to observe and record the level of the liquid.

Ask: *Did it change? Why or why not?*
(DOK Level 2 & Bloom's Taxonomy – Application)

Answer: The level should remain the same. When the baking soda dissolves in the vinegar, the volume of the solution is equal to the volume of the original liquid, just like dissolving salt or sugar in water. Droplets on the bottle walls could lead to an apparent lower level, but tapping the sides will fix that.

What do you think happened?
What exactly is in the bottle?
What exactly is in the balloon?
How do you know? Based on what evidence? (Encourage students to use data or evidence from their data tables to explain or justify their explanation)
(DOK Level 2 & Bloom's Taxonomy – Application)

Answer: The baking soda (sodium bicarbonate $NaHCO_3$) reacted with the vinegar (5% acetic acid, 95% water) to form carbon dioxide gas, water and sodium acetate.

$$NaHCO_3 + HOAc \rightarrow NaOAc + H_2O + CO_2$$

The liquid in the bottle is the unreacted vinegar containing sodium acetate.
The balloon and the bottle are filled with carbon dioxide gas.

3. Mass Balance.
   a. Instruct students to twist the balloon *several turns* to seal it off and clamp with the bag clip. Remove the balloon + clip combination from the reaction bottle.

   b. Instruct students to weigh the inflated balloon + clip **(G) –** Worksheet and compare with their original mass.

Ask: *What can you conclude?*
Using evidence from your data tables, please write your conclusion in two or three sentences.
(DOK Level 3 & Bloom's Taxonomy – Application)

Answer: The mass is greater (by approx. 2 g.) than the original mass of balloon and clip. The difference is the mass of carbon dioxide. A gas – like all matter – has mass!

c. Tie off one balloon to show that a balloon filled with carbon dioxide sinks to the floor. Compare its buoyancy with a balloon filled with air.

Ask: *How does the density of carbon dioxide compare with the density of air?*
Do you think it is more or less than the density of air? How do you know? Based on what evidence?
(DOK Level 3 & Bloom's Taxonomy – Analysis)

Answer: Carbon dioxide is denser than air, so the balloon filed with carbon dioxide sinks in air. You may wish to contrast with helium balloons.

d. Instruct students to remove the clip.

Ask: *What happens when you release the balloon?*
(DOK Level 3 & Bloom's Taxonomy – Analysis)

Answer: The balloon is propelled by the release of the fast moving carbon dioxide molecules. Note: It is not the escaping molecules that do the pushing, but the ones left in the balloon. Since the mouth of the balloon is open, there are no collisions with that side of the balloon while the top of the balloon is still experiencing the force of the collisions.

e. Instruct students to weigh the vinegar bottle with its contents **(H)** – Worksheet. Compare the mass of the balloon + clip + vinegar bottle and their contents with the total mass of the components originally.

Ask: *What can you conclude?*
What do think is happening?
(DOK Level 3 & Bloom's Taxonomy – Analysis)

Answer: In principle the total mass should be unchanged. Mass is conserved in a chemical reaction because the number of atoms is unchanged. The atoms have found different partners. In practice, there will be a small loss of mass as the carbon dioxide that was in the bottle when pressurized with the balloon will have been lost.

f. Instruct students to pour the liquid in the bottle into the measuring cylinder and record the volume **(J)** – Worksheet.

Ask: *What did you observe?*
What do think happened? Why?
(DOK Level 1 & Bloom's Taxonomy - Comprehension)

Answer: The volume is unchanged – apart from incomplete transfer.

g. *Optional*: Add one tablespoon of sand (15mL) to the vinegar mix, and measure the new volume **(K)** – Worksheet.

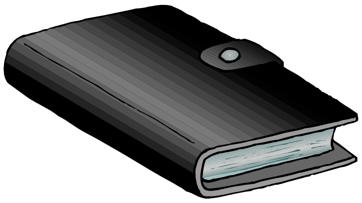
Ask: *How does this volume compare with the previous volumes of vinegar?*
(DOK Level 2 & Bloom's Taxonomy – Analysis)

Answer: The volume will be larger by 15mL – the volume of added sand. The insoluble solid sand still occupies the same space. Contrast this with a soluble salt where the ions in solution are between able to fit water molecules.

Data Tables

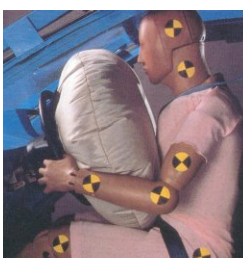
	Item	Measured Mass	Mass Difference	Identity
A	Bag Clip			
B	Balloon			
C	Baking Soda + container			
D	Balloon containing Baking Soda		**D-B =**	Mass of baking soda
E	Bottle + Vinegar			
F	Bottle + Vinegar + Balloon + Baking Soda (before addition)		**= D+E??**	
G	Bottle + Vinegar + Balloon + Baking Soda (after addition)		**Any change??**	
H	Balloon + Clip			Mass of gas! = H-B-A
I	Bottle + Vinegar + Baking Soda		**= E+(D-B)???**	Mass conserved??
J	Bottle + Lime + water			
K	Balloon + Bottle + Lime + clip (before addition)		**= H+J??**	
L	Balloon + Bottle + Lime + clip (after reaction)		**= H+J??**	Was mass conserved??
	VOLUMES	**Measured Volume(mL)**		
M	Vinegar used			
N	Vinegar + baking soda		**N-M =**	
O	Vinegar + baking soda + sand		**O-N =**	

Client Cards



Paige's older brother keeps getting in her desk drawer and reading her diary. He tells his friends what she has written in her diary. It is very upsetting to Paige. Is there a way you could design and build a detector that would alert her when someone has read the diary?

The local fire department is designing a new fire extinguisher. They're asking for the community's help in designing a fire extinguisher. The prototype of the winning fire extinguisher will be put on display with a picture of the designers. Also, the winning team's name will be placed on each manufactured fire extinguisher.



The Pas toy car company wants to make a car that is very realistic. It has decided that it would like to have an air bag inflate when a car hits something. Would you be able to help the company design a system that inflates an air bag?

Abbey has decided that her pool company would be able to sell more pools if they had some unique inflatable toys to display in their pools. She feels the new toys would catch the customers' attention, and they would spend more time looking at the pools, thus maybe deciding to buy one. Please help the Abbey Pool Company sell more pools by designing some new toys that inflate automatically.