SciTREK

How Science Works

Grade 7

Class Question:

How and why is mass lost, gained, or conserved in a chemical reaction?

Module 2: Conservation of Mass

Answers
Teacher/Lead Info
Student Packet

Student: ______________________________

UCSB Team Leader: ______________________________

Teacher: ____________________ **Period:** __________

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NGSS Standards Covered:

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [*Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.*]

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.** [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [*Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.*]

MS-PS1-6. **Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*** [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [*Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.*]

Science and Engineering Practices

Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4)
- Develop a model to describe unobservable mechanisms. (MS-PS1-5)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (MS-PS1-6)

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Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2)

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*

PS1.B: Chemical Reactions

- 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. (MS-PS1-2),(MS-PS1-5) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*
- The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)
- Some chemical reactions release energy, others store energy. (MS-PS1-6)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. *(secondary to MS-PS1-6)*

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. *(secondary to MS-PS1-6)*
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. *(secondary to MS-PS1-6)*

Crosscutting Concepts

Patterns

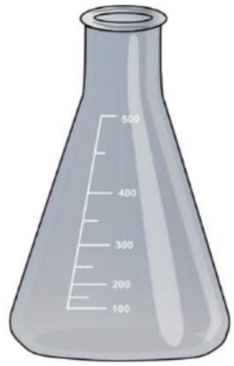
- Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)

LAB TOOLS

Weighing Balance



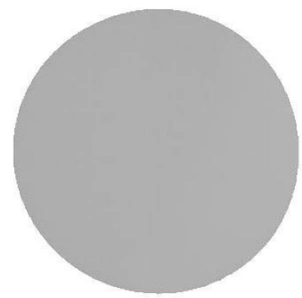
Erlenmeyer Flask

Beaker

Graduated

Plastic Funnel

Weighing Boat



Filter Paper

Petri Dish

Tongs

OVERVIEW & BACKGROUND INFORMATION

Descriptions detailing the experiments for each day, and certain goals we want to attain for students, etc.

Day 1:

- *Introduce the students to the second law of thermodynamics.*
- *Introduce the students to chemical vs physical changes.*
- *Students need to have a good grasp on what an* ***open system*** *does in a chemical reaction.*

Day 2:

- *Remind the students of what an* ***open system*** *does.*
- *Introduce the students to what a* ***closed system*** *does in a chemical reaction.*
- *Students should be able to use the scale and lab equipment efficiently.*

Day 3:

- *Remind the students the differences between an* ***open*** *vs* ***closed*** *system.*
- *The students should be able to master the mathematics of the module by this point.*
- *Have the students start brainstorming how to turn an* ***open system*** *reaction to a* ***closed system*** *reaction.*

Day 4/ Day 5:

- *Students should be able to write down the purpose of the experiment as well as how they are going to accomplish their goals.*
- *This should illustrate their mastery of proper technique when using materials.*
- *The students should be able to find some errors in their design and use the three-four trials to improve upon the previous experiment.*

Day 6:

- *The students should be able to examine their data and come to the conclusion if their experiment was successful or not.*
- *Students should be able to illustrate their findings and be able to discuss how they could improve upon their experiment.*

DAY 1 Marshmallow Madness & Steel Wool

Introduction of Sci-Trek

Before the students go into their small groups, there will be a short introduction into what you will be doing that day. It will first start with introductions. Say a few words about yourself. Name, what year you are in school, why you are interested in science. Keep in mind that some students come from underprivileged backgrounds and don't have doctors for parents.

The lead volunteer should introduce the topic for this week's experiment. Tell the class that we are interested in mass. How do chemical reactions affect mass? We will be studying mass by carefully weighing reactants, performing reactions, then weighing the products. Give the students some perspective of what they will be doing this week. The lead will go through the idea of mass. Do I have mass? How do you think I can change my mass? Do if I start working out a lot, and I lose some of my mass, where does that go? Then go through the signs of a chemical reaction. Some of the different signs are change of state, color change, release of a gas, and many more. Tell the students to keep these in mind as they go through the experiments today. Then tell them the two experiments they will be doing: burning a marshmallow and burning steel wool. The students can then split into their small groups.

Key Concepts:

A chemical reaction is a rearrangement of the atoms in an initial compound or compounds (the reactants) to form a new substance or substances (the products). Some examples are:

i) synthesis: $A + B \rightarrow AB$

ii) decomposition: $AB \rightarrow A + B$

iii) single-replacement: $AB + C \rightarrow AC + B$

iv) double-replacement: $AB + CD \rightarrow AC + BD$

v) carbohydrate combustion: $CH2O + O2 \rightarrow CO2 + H2O$

A chemical reaction is usually accompanied by an observable physical change, such as a change in color and/or temperature, the emission of light, the evolution of a gas, or the formation of a precipitate. Reinforce this understanding by teaching the students to make ***observations*** *of these perceivable changes.*

DEMO 1: MARSHMALLOW MADNESS

Overview:

This demo is the first of two that will be conducted to demonstrate chemical reactions and spark students' intellectual curiosity by further enhancing their knowledge on the ***complete system*** *for these reactions beyond what is immediately obvious.*

Marshmallows are made of fructose ($C6H12O6$), sucrose ($C12H22O11$), water ($H2O$), and gelatin (a mixture of proteins). For our purposes, we will simplify the chemical reaction that occurs when burning marshmallows to the combustion of glucose:

$$C6H12O6 + 3\ O2 \rightarrow 6\ CO2 + 6\ H2O$$

For this reaction to occur, the marshmallow alone is not enough – you must also consider the oxygen in the room as a reactant. This will not be immediately clear to the students from the chemical formula alone. The end result of this demo is an apparent loss in mass.

Objective:

The main goal is to have the students realize that gases, either as reactants or products, should be considered when they are evaluating whether the total mass is conserved.
Students will make predictions about what will occur when the marshmallow is burned, using the idea of conservation of mass. They will observe what happens as the marshmallow is changed from one state to another.

Safety Precautions:

Make sure they are using a candle to light the marshmallow, NOT the lighter or matches, and making sure that it stays in the Petri dish. After the flame has gone out, make sure that the students do not touch the Petri dish for at least two minutes.

Marshmallow Madness Procedure

1. Write down your hypothesis and your justification. What will happen to the mass of the marshmallow after burning and why?
2. Record the mass of the glass Petri dish.
3. Record the mass of the Petri dish + a marshmallow (before burning).
4. Subtract the mass of the Petri dish from the mass of the Petri dish + the marshmallow to obtain the initial mass of the marshmallow.
5. Set the Petri dish with the marshmallow on the desk away from any pieces of paper.
6. Using the metal tongs, hold the marshmallow over a lit candle to ignite it.
7. Quickly put the marshmallow back in the Petri dish. Record your observations.
8. After the marshmallow is finished burning, allow the Petri dish to cool for two minutes.
9. Record the mass of the Petri dish + the burned marshmallow.
10. Subtract the mass of the Petri dish to obtain the final mass of the marshmallow.

Prediction

The marshmallow will lose mass when burned.

Justification

The marshmallow will shrivel and turn black. This will cause some things to be burned off the marshmallow.

Data Table

Mass of glass Petri dish	
Mass of Petri dish + marshmallow (**before burning**)	
Initial mass of marshmallow	
Mass of Petri dish + marshmallow (**after burning**)	
Final mass of marshmallow	
Change in mass of marshmallow	

Observations ***(Using your five senses to get info)***

1. *The marshmallow gave off a lovely smell (gas molecule formation).*
2. *There was a change in the color of the marshmallow.*
3. *There was emission of light/heat.*

1 Did a chemical reaction take place? What is your evidence?

The students should use inductive reasoning from their observations to come to the conclusion that a chemical reaction has occurred.

2 Was your prediction correct? Explain using evidence from the data collected.

Explanations will vary. Students can talk with their group to interpret and justify why their prediction is correct.

3 Draw a model (visual representation) of the burning marshmallow to explain what happens to the molecules inside the marshmallow. Label all relevant parts visible and not visible.

The students should have a good conceptual understanding of the chemical reaction observed. This can serve as an opportunity for the students to recognize the different components that make up the system, as they go on with the labs. The students should be able to draw the marshmallow molecules being burned off and converted to gas molecules.

DEMO 2: COMBUSTION OF STEEL WOOL

Overview:

The chemical reaction under investigation here is the oxidation of iron:

$$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$$

This second demo is a juxtaposition of the first experiment and will further challenge the students' knowledge by stretching the limits of their understanding a step further – the students will observe an INCREASE in mass. Unlike demo one where the mass loss can be clearly explained with the formation of a gas product, for this demo they will have to consider that a gas is participating as a reactant.

Objective:

The students should try to formulate an idea as to how the two demos are related. Basically, the conclusion should be that the entire system needs to be accounted for, both on the reactant and on the product side of the equation. Sometimes a gas is formed during the reaction, sometimes a gas is used as a reactant. The total mass of the system should remain unchanged. At the end of the day, the students should start to form ideas of how they could design experiments to make sure that they account for all of the components of a chemical reaction, including gasses.

Materials:

- *Petri Dish*
- *Steel Wool*
- *Candle*

Note: *Sometimes, this demo does not work perfectly. Sometimes the steel wool loses weight, due to small errors in weighing. In this case, tell the students that the steel wool was actually supposed to gain mass, and ask them why they think that may have happened.*

Combustion of Steel Wool Procedure

1	Write down your hypothesis and your justification. What will happen to the mass of the steel wool after burning and why?
2	Record the mass of the glass Petri dish
3	Fluff the piece of steel wool so that it just fits in the Petri dish
4	Add the steel wool to the Petri dish and record the mass of the Petri dish + the steel wool
5	Subtract the mass of the Petri dish from the mass of the Petri dish + the steel wool to obtain the initial mass of the steel wool
6	Set the Petri dish with the steel wool on the desk away from any pieces of paper
7	Light the steel wool on fire
8	Record your observations
9	After the steel wool has been extinguished, allow the Petri dish to cool for two minutes
10	Record the mass of the Petri dish + the burned steel wool, then subtract the mass of the Petri dish to obtain the final mass of the steel wool

Prediction→

*The steel wool will gain mass. (**It is okay if their prediction is incorrect. Science is about failure and discovery).***

Justification

By burning the steel wool, we are speeding up the natural rusting process most metals experience.

Data Table

Mass of glass Petri dish	
Mass of Petri dish + steel wool (before burning)	
Initial mass of steel wool	
Mass of Petri dish + steel wool (after burning)	
Final mass of steel wool	

Observations *(Using your five senses to get info)*

1. *The steel wool was ignited as sparks were given off.*
2. *The steel wool changed in color.*

1 Did a chemical reaction take place? What is your evidence?

Yes, a chemical reaction occurred. Sparks were ignited. The smell of the steel wool is not pleasant and there is a change in color. It goes from gray/silver to silver with a blue hue.

2 Was your prediction correct? Explain using evidence from the data collected.

No, my prediction was incorrect. We measured an increase in mass when the wool was weighed after burning.

3 Draw a model (visual representation) of the burning steel wool to explain what is happening to the atoms during the reaction. Label all relevant parts visible and not visible.

The students should come up with something that burning the steel wool causes the oxygen to bind with the iron found in the wool.

Cleaning Duties

1. *Clean Petri dishes for next period*
2. *Ensure all Demo kits are complete (restock marshmallows, steel wool, matches)*
3. *Clean tongs (remove marshmallow residue where necessary)*

Kahoot:

Have the kids pull out their cell phones after they have completed the demonstrations and have returned to their seats. The lead will guide the students through this activity. Help clean up anything that the kids missed.

DAY 2 Mixing Copper Sulfate and Sodium Bicarbonate

Overview:
This experiment is a simple precipitation reaction designed to teach the students to work carefully with basic laboratory equipment and to think about which masses are important to measure. The chemical reaction is as follows:

Cu(SO4) (aq) + Na2CO3 (aq) CuCO3 (s) + Na2SO4 (aq)

Procedure:

1. Place a clean, dry 50 mL graduated cylinder on the balance and press “zero.” This cancels out the mass of the graduated cylinder so that we can measure only the liquid that we put into it.

2. Carefully add about 20 mL of the copper sulfate (CuSO4) solution to the graduated cylinder and record the mass in your data table.

3. Pour the copper sulfate solution into a 125 mL Erlenmeyer flask. Get as much of the solution out of the graduated cylinder as you can

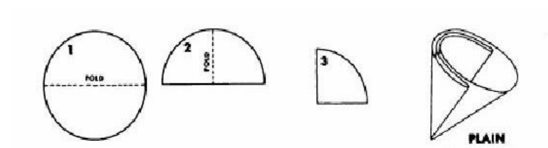
Materials:
1 laboratory balance
1 50 mL graduated cylinder
2 125 mL Erlenmeyer flasks
1 piece of filter paper
1 plastic funnel
1 plastic weighing tray
copper sulfate solution
sodium carbonate solution

4. Clean out the graduated cylinder in the sink and dry it using a paper towel. Make sure there is no water left inside.

5. Put the graduated cylinder back on the balance and zero it again. Then add about 20 mL of the sodium carbonate (Na2CO3) solution to the cylinder and record its mass.

6. Add the sodium carbonate solution to the same Erlenmeyer flask. Record your observations in the space provided.

7. Swirl the contents of the flask to ensure that they are thoroughly mixed together.



8. Record the mass of the other 125 mL Erlenmeyer flask.

9. Record the mass of a piece of filter paper.

10. Fold the filter paper as shown in the diagram above (ask a SciTrek volunteer for help!) and place it into the plastic funnel. Place the plastic funnel and filter paper in the second Erlenmeyer flask.

11. Carefully pour the contents of the first Erlenmeyer flask through the filter paper. Make sure that all of the solid ends up in the funnel.

12. While the solution is draining, place the plastic weighing tray on the scale and press “zero.”

13. Allow the solids to drain until there is no more liquid in the funnel, then remove the filter paper and place it in the plastic weighing boat. Record the mass of the filter paper + solids in the data table.

14. Record the mass of the Erlenmeyer flask + the drained liquid.

Objective:
The focus of today’s lab is for the students to gain competence with their lab techniques and develop respect for precision, since these will directly affect their ability to obtain useful data. Discussions about sources of error will help the students think about whether or not their initial and final masses are statistically the same, or if mass was actually lost/created in the reaction.

Note: *Keep in mind that although we are encouraging strict following of the procedure, we really want to nourish the students’ critical thinking. Frequently ask students why they are performing a particular step in the procedure. Help them put it into the context of the overall experiment.*

Table 1. Data Table for recorded masses.

Observations

Item to be measured	Mass in grams (g)
(A) Mass of 20 mL $CuSO_4$ +solution	
(B) Mass of 20 mL Na_2CO_3 solution	
(C) Mass of empty 125 mL Erlenmeyer flask	
(D) Mass of dry filter paper	
(E) Mass of Erlenmeyer flask + liquids	
(F) Mass of filter paper + solids	

Mass of $CuSO_4$ Solution **(A)**		Mass of Na_2CO_3 Solution **(B)**		Total Initial Mass
	+		=	
Mass of Erlenmeyer flask + liquids **(E)**		Mass of empty Erlenmeyer flask **(C)**		Mass of Liquids Collected
	-		=	
Mass of filter paper + solids **(F)**		Mass of filter paper **(D)**		Mass of Solids Collected
	-		=	
Mass of Liquids Collected		Mass of Solids Collected		Total Final Mass
	+		=	
TOTAL FINAL MASS		TOTAL INITIAL MASS		CHANGE IN MASS
	-		=	

1	Why was it important to get all of the liquid out of the graduated cylinder in Step 3? *It is important to get all the liquid out because this is a potential source for loss of mass and source of error.*
2	Is the **filter paper** part of the reaction? Why do we need to know its mass? *The filter paper is not part of the reaction, however, the purpose of this experiment is to compare the differences in mass between the final product and initial reactant. Not incorporating the mass of the filter paper will provide significant sources of error in the final calculation.*
3	Did a chemical reaction occur? What is your evidence? *Yes, a chemical reaction has occurred. Precipitate was formed when the two solutions were mixed.*
4	Draw a model (visual representation) of this chemical reaction to explain what is happening to the atoms during the reaction. Label all relevant parts visible and not visible. *The student should be drawing a picture of the two chemicals in liquid form slowly combining to form a solid while leaving some parts of each molecule in the liquid phase. It is important that the students don't use anything outside of the two liquids to force a reaction.*

Cleaning Duties

1. *Clean E. flasks for next period (hazardous waste containers will be in the classroom)*
2. *Clean workstations and organize lab materials*
3. *Replenish solutions and filter paper*

Kahoot:

Have the kids pull out their cell phones after they have completed the demonstrations and have returned to their seats. The lead will guide the students through this activity. Help clean up anything that the kids missed.

DAY 3 Baking Soda & Vinegar

Overview:
This reaction generates a gas. If nothing is done to contain the gas, it will leave the system and the apparent mass will decrease.

$$NaHCO_3 (s) + CH_3COOH (aq) \; CO_2 (g) + H_2O (l) + NaCH_3COO (aq)$$

The first step of the reaction produces carbonic acid (H_2CO_3) and sodium acetate. The carbonic acid spontaneously decomposes into water and carbon dioxide. The students are not expected to understand this full reaction, only that a gas is formed when the two reactants are mixed together.

Objective:
The students will increase their level of independent thinking to explore the "conservation of mass law" by measuring the total mass change in a new reaction. The students will be given a procedure for the experiment and then asked to improve their system based on their findings.

An important test of any theory is its applicability to a range of problems. Today, you will attempt to gather evidence to support your theory by using a different chemical reaction, but by keeping the general procedure the same. If you get stuck, refer to Mixing Vinegar and Baking Soda from yesterday for help.

Procedure:
1. Use the graduated cylinder, the balance, and the "tare/zero" button to carefully measure the mass of 20 mL of vinegar.
2. Record the mass of the 100 mL beaker.
3. Add about 2 grams of baking soda to the beaker, then record the mass of the beaker + the baking soda.
4. Place the beaker with the baking soda on the table and slowly add the vinegar. Record your observations. If the solution bubbles over, you will need to start again from step one.
5. While the reaction is finishing, write down your hypothesis in your handbook. Will the mass decrease, stay the same, or increase? Provide a brief explanation.
6. When the reaction is done, weigh the beaker and products.

Materials:
1 Laboratory Balance
1 50 mL graduated cylinder
1 125 mL Erlenmeyer Flask
1 100 mL Beaker
1 Plastic Funnel
1 Plastic Weigh Boat

Vinegar
Baking Soda

Note: *This procedure will NOT work to prove the conservation of mass in this system – a net loss will be observed due to the formation of a gas. After they discover a net loss in mass, the students will begin to consider their accounting and develop a closed system to test their theory about mass conservation.*

Prediction **Justification**

Table 1. Data Table for recorded masses.

Item to be measured	Mass in grams (g)	Observations
Mass of 20 mL vinegar		
Mass of the beaker		
Mass of beaker + baking soda		
Mass of beaker + products		

Cleaning Duties

1. *Clean E. flasks for next period (the contents can be disposed of in the sink)*
2. *Clean workstations and organize lab materials*
3. *Replenish solutions and filter paper*

Days 4 & 5 Final Experiment

Objective:

The goal of today is to allow the students to turn the open system reaction into a closed system reaction. In the box, the students will have the same materials as yesterday and will undergo a similar procedure; however, there will be additional items in the box that the students can use to close the system.

Introduction *Write a brief statement describing the purpose of this experiment.*

The goal of today's experiment is to turn an open system into a closed system! We will perform the same reaction as yesterday, but our overall goal is to not lose any mass to the surroundings.

Design Sketch *Draw how you will build your design. Label all materials. Your experiment may change as you go through each trial. Make sure to redraw every change that you make as you progress through each attempt.*

Trial #1 *Sketches will vary*
Trail #2 *Sketches will vary*
Trail #3 *Sketches will vary*

Data Table for recorded masses.

Item to be measured	Mass in grams (g)		
Any item you use needs to be measured!	Trial 1	Trial 2	Trial 3
All items in this chart will vary between groups!!!			

Calculations

Use the space below to do your calculations

Trial 1	Trial 2	Trial 3

Results of each Trial

	1	2	3
Total Initial Mass (g)			
Total Final Mass (g)			
CHANGE IN MASS (g)			

Write down what you think contributes to the variability in your data (that is, why your results aren't all identical)

Glossary:

- **Observation:** Any information that can be obtained by using your five senses(For these experiments we will only be using smell, sight, and hearing to gather information).
- **Prediction:** Using background knowledge of previous experiences to state what might occur in the future.
- **Justification:** Explaining the prediction by using background information to provide the logic to your prediction.
- **Chemical Reaction:** A reaction that takes place in which the starting substance are changed into a different substance by the end of the reaction. Some examples are combustion, mixing acids and water, rusting.
- **Physical Reaction:** A reaction that takes place in which the starting substances remain the same once the reaction is over. Some examples are melting, freezing, evaporating.
- **Data Table:** A place to record measurements to be used for further discovery and analysis.
- **Error Source:** An educated guess as to why something wrong occurred before, during, or after the experiment.
- **Closed System Reaction:** A reaction that takes place in an environment that does not lose any of the reaction's matter to the surroundings.
- **Open System Reaction:** A reaction that takes place in an environment that loses some of the reaction's matter to the surroundings.
- **System:** The environment where the reaction takes place.
- **Surroundings:** The environment that exists outside the reaction.
- **Universe:** The environment that is made up of both the system and the surroundings.