Junk Food Chemistry

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Chemistry - Take home laboratory #1
A Tasty Saturated Solution Made by Boiling Point Elevation

The following is a take home lab activity. You are required to do one of the 3 options. Bring a sample of your product for a quality control check by _______________. This activity is worth a 10 point lab grade. This sheet must be signed by your parent with their comments as to how the product turned out to verify you completed the task.

Purpose: To make a great tasting saturated solution that uses boiling point elevation to react.

Procedure: Have your parent supervise and sign below.

Ingredients: 3 cups sugar, ¾ cup margarine, 2/3 cup evaporated milk, 12 oz chocolate chips (semi-sweet or your choice of flavors…stick to chocolate of some type), 7 oz jar marshmallow crème, 1 tsp. vanilla, 1 cup nuts (optional)

1. Combine sugar, margarine and milk in 3 qt saucepan; bring to a full rolling boil, stirring constantly. Continue boiling for 5 minutes, stirring constantly, over medium heat. (This step is to boil off the water, which will increase the boiling point, since the molality of the solution will increase when the water is boiled away.) Stirring vigorously also breaks up any crystals that form. The smaller the crystals the better the product will be. Grainy fudge is bad!

2. Remove from heat. Stir in chocolate chips until melted.

3. Add remaining ingredients; beat until well blended. Pour into a greased or foil lined 13x9 pan. Cool at room temp. Fudge can be stored in the refrigerator for several weeks.

4. Clean lab (kitchen) so it's spotless.

5. Remember to get full credit: you need to bring this sheet back with a parent signature and small sample of the product for quality control check.

6. Good luck and happy chemistry.

Parent Verification: My child, ______________________________, completed this take home lab on __________(date). I supervised his/her work and verify that they followed safety rules, left the lab(kitchen) clean and neat, and completed the activity without assistance. Please add a few words about how the product turned out.

____
parent/guardian

Chemistry - Take home lab #2
Solidification of a Supersaturated Aqueous Solution of a Mono- and Disaccharide

Purpose: To solidify a supersaturated aqueous solution to form hard candy.

Procedure: Have your parent supervise this and sign below.

Ingredients: sugar, water, light corn syrup, salt, flavoring oil*, powdered sugar
*you can buy a pre-measured vial of flavoring at Joanne's or other craft stores w/ candy making supplies – try Lorann Gourmet 0.125 oz bottle

1. In a saucepan combine: 1 ¾ cup of sugar, ½ cup of water, ½ cup light corn syrup, and a dash of salt. This mixture will be heated on the stove and allowed to boil. While it boils, the water is leaving as vapor and the solution becomes increasingly more concentrated in sugar. As a solution becomes more concentrated, its boiling point rises. The proper concentration of sugar is needed for the final product to solidify.
2. Cover and bring to a rolling boil. Remove lid and place a candy thermometer in the pot and cook to 250^0F. Add food coloring if desired and continued cooking to 300^0F. (Remove from heat at 285^0F as temperature will continue to rise). Let cool a few minutes. Add flavoring oil (use 1-2 tsp if using an extract and depending on how strong you want the candy) and cover for 5 more minutes. Pour onto sheet of aluminum foil that has been dusted with powdered sugar.

3. Let the mixture cool until hard. While the mixture is cooling, use hot water and soap to clean the equipment. Good chemists keep their labs clean and organized, just like good cooks.

4. When the mixture has hardened, break it into mouth sized pieces. Bring a few pieces in a plastic bag with this sheet for quality control check. Flavoring used _____________

Parent Verification: My child, _____________________, completed this take home lab on _____________(date). I supervised his/her work and verify that they followed safety rules, left the lab (kitchen) clean and neat, and completed this activity without assistance.
Please add a few words about how the product turned out.

____
parent/guardian

Chemistry - Take home lab #3
Making Ice Cream through Freezing-Point Depression

Purpose: To make a great tasting ice cream using the concept of freezing point depression.

Procedure: Have your parent supervise and sign below.

Ingredients: 1 quart milk, 1 quart whipping cream or non-dairy creamer, 1 ½ - 2 cups sugar, 2 tsp vanilla, flavoring of your choice, crushed ice, salt, zip-loc bags
You may cut this recipe in half, or double it, depending on how much ice cream you choose to make. This procedure calls for zip-loc bags, but if you have an ice cream maker you could use that.
1. Mix the milk, cream, sugar, and vanilla in a bowl and stir until the sugar has dissolved.
Pour the ½ of the mixture into a half gallon sized zip-loc, seal tightly and try to get all of the air out.

2. Place the bag into a gallon sized zip-loc. Add several cups of crushed ice to the gallon bag. Pour about ½ cup salt over the ice and seal the large bag. Knead the small bag inside the large bag to expose it to the cold temperature of the ice-salt mixture. Add desired flavoring at this point, such as strawberries or chocolate syrup.

3. Continue kneading for at least 15 minutes. Add more ice/salt if needed.
When the mixture has frozen, remove it from the larger bag. You can now eat your ice cream or put it in the freezer. Repeat with other ½ of mixture.

4. Clean up the lab (kitchen).

Have your family try the ice cream and critique it. Bring in a small container with your name on it – I have a freezer – for the quality control check.

Parent Verification: My child, ___________________________, completed this take home lab on _______(date). I supervised his/her work and verify that they followed safety rules, left the lab (kitchen) clean and neat, and completed the activity without assistance. Please add a few words about how the product turned out.

____
parent/guardian

Name -________________________________ Period ______ Date _______

Lab 5-5 Thermal Energy From Foods

Background Information

All things need energy to function. Our car gets the energy it needs by burning gasoline and releasing the chemical energy contained in the gas. As humans we get all of our energy from the foods that we eat. We digest the food, and slowly convert the chemical energy contained in the food, to energy that we can use. We use this energy to carry out our daily activities such as thinking, running, or reading.

The amount of thermal energy that is contained in food cannot be determined directly. We can however determine the amount of thermal energy that is in food. The food can be burned, the thermal energy changed to heat, and the heat used to raise the temperature of a known quantity of water, and the amount of heat released can be calculated.

To do this, we will make the assumption that the heat released by the food is equal to the heat absorbed by the water.

$$\textit{Energy released}_{(food)} = \textit{Energy absorbed}_{(water)}$$

Energy (heat) released can be calculated if the quantity of water is known, the starting and ending temperatures of the water are known, and we use the heat capacity of water of
1 cal / g · °C. The following formula is used to make this calculation.

$$\text{Heat} = \text{mass}_{(water)} \times \text{temperature change}_{(water)} \times 1\ \text{cal / g} \cdot {}^{o}\text{C}$$

Objectives:

- calculate the amount of energy contained in a food
- calculate the number of calories per gram of the food

Problem

Materials *(per group)*

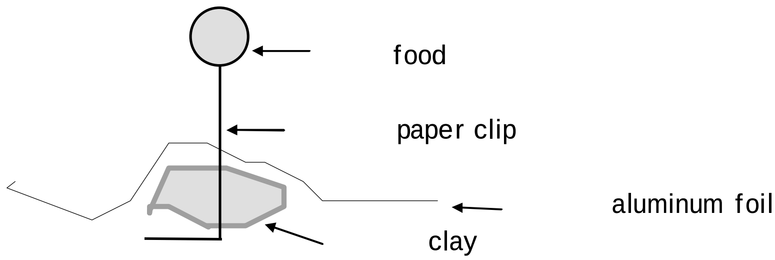
goggles, wooden splints, matches, pop can calorimeter, 3 paper clips, ring stand, ring, thermometer, graduated cylinder, metric balance, small ball of clay, aluminum foil, food sample, and a rubber band.

Procedure

1. Measure the mass of your food sample and record it in the data table.
2. Obtain the small ball of clay, cover it with the aluminum foil to make a blanket of protection over the top of the clay. This blanket will catch any fire which may fall off later on. See Figure 1.

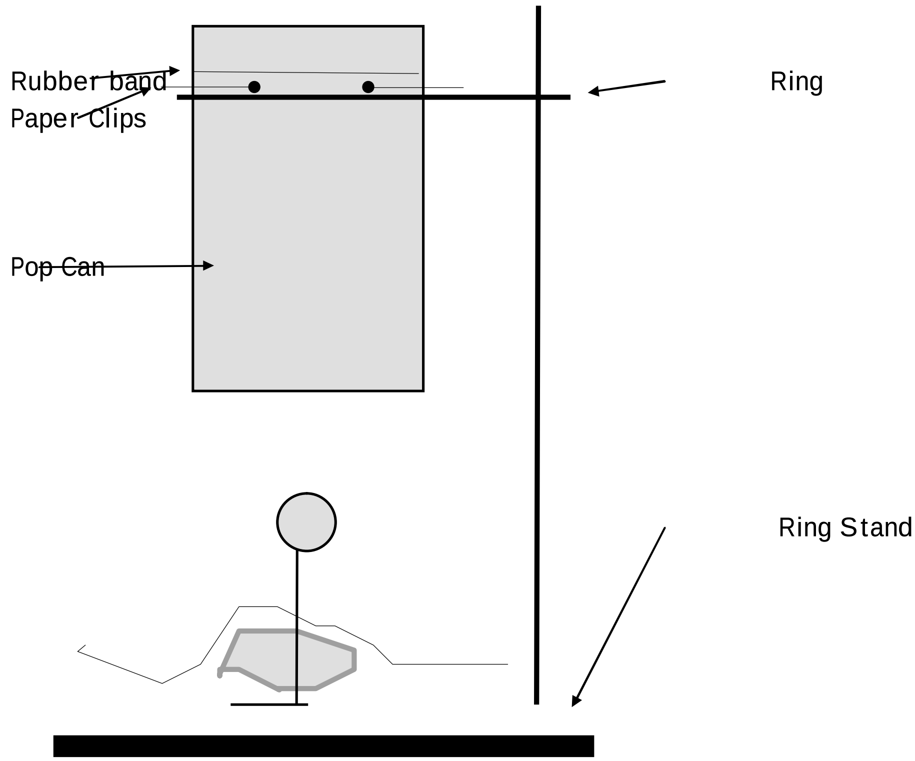
3. Straighten one end of one of the paper clips and push it up through the bottom of the clay and through the aluminum foil. This will make a post that you can stick your food on to burn. Stick your food sample on top of this post.

Figure 1



4. Suspend the pop can from the ring by the 2 paper clips.
5. Measure 50 ml of water and carefully pour it into the pop can. Remember, 1ml of water has a mass of 1 gram. Record the temperature of the water in the data table.
6. Place your food sample underneath the pop can set up. Adjust the pop can and ring so that the bottom of the pop can is about one inch above your food sample. See Figure 2. Remove the food sample away the pop can.
7. Using the matches, light the wooden splint. Use the splint to ignite the food on fire. When the food is burning immediately place it under the pop can.
8. While the food is burning, slip the thermometer into the pop can to record the temperature of the water. Be careful not to let the thermometer bulb touch the pop can.
9. Allow the food to burn out completely.
10. Continue to monitor the temperature of the water in the can until it no longer rises. Record this temperature in the data table for final temperature of water.
11. Mass the leftover food which did not burn.
12. Clean up your lab area and return to your seat to answer the questions.

Figure 2



Lab #20 Thermal Energy From Foods

Data Table

Mass of food sample	
Temperature of water in pop can before heating	
Temperature of water in pop can after heating	
Mass of water in pop can	
Mass of unburned food (the ashes left over)	

Conclusions

1. In order to calculate the amount of energy released or absorbed by a substance, what information do you need?

____

____

2. How do you know that energy is being transferred in this experiment?

____

3. Did you measure the energy released by the food sample or the energy gained by the water?

____

4. Most of the energy released by the food was absorbed by the water. What do you think happened to the small amount of energy that was not absorbed by the water?

____

SHOW WORK !!!

5. How many calories of heat were gained by the water?

6. How many calories of heat were released by the food?

7. How many calories are contained in each gram of the food sample?

8. How much heat would be released if you were to burn 100 grams of your food sample?

Name________________________________
Hour___________ Date________________

What is a limiting reactant?

A delicious treat known as a **S'more** is constructed from the following ingredients:

2 graham crackers squares
1 chocolate bar
1 marshmallow

Suppose we find that these ingredients are available only in full packages, each of which contains <u>one dozen</u> of the item. The packages of ingredients have the following weights:

graham crackers squares	200.0 g
chocolate bars	145.0 g
marshmallows	75.0 g

Each group will build S'mores out of the package of ingredients that you receive. Build as many S'mores as you can, but don't eat the S'mores yet.

<u>**Questions:**</u> **(You may use your S'mores to help you visualize these problems)**

1. Using G for the graham crackers, C for the chocolate bars, and M for the marshmallows, write a balanced equation that would represent the production of S'mores from the starting materials.

2. Based on the information given about the three ingredients, which weighs the most? Which weighs the least?

3. If we have 12 graham crackers (one package), how many chocolate bars and how many marshmallows do we need to make S'mores with all the graham crackers?

4. How many S'mores would we be able to make?

5. Suppose we have one package of each of the ingredients. (Show work)
How many S'mores can we make?

Will any of the ingredients be left over?

How much?

6. Based on what is in <u>**your bag**</u> of ingredients....
A) How many s'mores can you make?
B) What is (are) the limiting substance(s)?
C) What is (are) the excess substance

7. Is it correct to say that if we start with 4 lb each of G, C, and M, we should end up with 3 x 4 = 12 lb of S'mores? Explain

Now let's apply the same concepts to a chemical situation: SHOW WORK!!!

Ammonia (NH_3) can be formed from the elements N_2 and H_2 , as shown below.

N_2 + 3 H_2 -------------- > 2 NH_3

1. How many moles of ammonia can be made from 1.0 mole of N_2 and 3.0 moles of H_2?

2. Suppose we had 3.0 moles **each** of the N_2 and H_2 available to react. Which of the reactants would be the limiting reactant? Hint: calculate moles of NH_3 produced by each and see which makes less.

3. A) How many moles of ammonia could we make?

B) Would any of the reactants be left over?

C) How many moles would be left?

4. Using the same equation above…

A) What mass of ammonia could we make from 100.0 grams each of N_2 and H_2?

B) What is the limiting reactant?

Now that you have finished….bring your paper to get checked and toast your marshmallow to make your s'more J

Bean City Lab

Name______________
Date _________ **Hr**___

You and your partners will examine the element beanium. Beanium has 3 isotopes. You will choose a baggie filled with beanium atoms.

Procedure:
Get a bag with beanium atoms. Divide them into 3 piles.

Draw a picture of each type here:

Type 1 Type 2 Type 3

Count the number of beans in each pile…record

Type 1 _________ Type 2 _________ Type 3________

Add the 3 types together…total number of beanium atoms in your sample = ____

Now mass each pile…put a square of paper on the balance…tare…add the beans…record the mass, repeat for the other 2 types.

Type 1 _________g Type 2 ________g Type 3 _________g

Determine the percent abundance for each type: show work in margin

$$\% \text{ abundance} = \frac{\text{\# of beans of one type}}{\text{Total \# of beans}} \times 100$$

Type 1 % =______ Type 2 % = ______ Type 3 % = _______

Determine the average mass of one atom of each type…show work in margin

$$\text{Average} = \frac{\text{mass of sample of type 1}}{\text{\# of beans of type 1}}$$

Type 1 avg. = ______g Type 2 avg. = ______g Type 3 avg. = _______

Now calculate the average mass of the element beanium: show work below
Average mass = (% type 1)(type 1 avg.) + (%type 2)(type 2 avg.) + (%type3)(type 3avg.)

Average mass = _________________g

Isotope Activity

Name____________________
Date__________ Hr____

Objective: To investigate what makes atoms of the same element isotopes.

Materials: balance, starburst fruit chews

Procedure:
1. Obtain 2 sets of "atoms."
2. Record the name (flavor) of each set of atoms.
3. Mass each of the atoms individually.

Data:

Name (Flavor) **à**		
Mass of atom #1		
Mass of atom #2		
Mass of atom #3		

Questions:

1. Did each atom in the set have the same mass? _____________________
2. In what ways were the sets different? ____
3. What causes atoms of the same element to have different masses? __________________

   ____
4. Define an isotope and give an example of one. ___________________________________

   ____
5. Compare and contrast a carbon-12 atom to a carbon-14 atom.

____

____

Heterogeneous vs. Homogenous

This is a very short activity that involves all students. Immediately after discussing/defining heterogeneous and homogeneous I walk around the room with a bag. Students are told to reach in the bag and without looking pull one item from the bag. They may not look at it until instructed to. After everyone in class has something they are told to look at their item and decide if it's heterogeneous or homogenous and explain why.

Items in the bag: Hershey's miniatures or kisses, Jolly ranchers, bite size Snickers, Reeses, etc. (be aware of any student with peanut/nut allergies when choosing items).

Peppermint Candy demo

Crush one peppermint candy (or jolly rancher) in a mortar and pestle. Put in a 1000mL beaker. Add an equal amount of potassium chlorate. Gently mix. Add 1-2 drops of concentrated sulfuric acid. The acid will start a reaction and the candy and potassium chlorate will burn with a large flame (violet in color). Do in a fume hood or behind a blast shield. This can be used to illustrate physical and chemical changes, chemical reactions, and exothermic reactions.

Density

Using an aquarium or clear tub, fill about ¾ full with water. Gently place a can of regular soda and a can of diet soda in the water. The diet one should float, while the regular one sinks. This can lead to discussions of density and the amount of sugar (mass the cans) in regular soda.

Charles' Law

This activity uses Pop Rocks. Pop Rocks are made by trapping the carbon dioxide gas within the crystalline structure of the candy. Have students place 3-4 individual crystals of the candy on their tongue. The candy will dissolve and the heat in the students' mouth will cause the carbon dioxide to expand and "pop" out of the candy. After the activity explain Charles' law and how it applied to the Pop Rocks.

Gas Solubility

For this demonstration you need a 2 L bottle of pop (diet Vernors is my top choice), a pair of tongs, a catch tray, a Bunsen burner or propane torch, and a piece of hollow pipe (about 15 cm long and about 1.5 cm in diameter). The pipe has to be able to fit through the opening of the bottle. Place the 2 L in your catch tray. Hold the pipe with the tongs and heat it in the burner for about 5 minutes. Just before you are ready to take the pipe out of the flame have a student come up and open the bottle of pop. Quickly drop the pipe into the bottle. The sudden increase in temperature will cause the solubility of the CO_2 to decrease and come out of solution. Foam will shoot out the top of the bottle and can go several feet in the air. This is a messy demo, but fun. Students usually bring up the Mentos and diet Coke demo, which is also a physical change because of the interaction of the diet Coke with the nucleation sites on the surface of the Mentos.

Marshmallow in a Syringe (Marshmallow Mafia)

1. Choose 2 mini-marshmallows and draw a face on each.

2. Remove the plunger on the syringe, and place ONE marshmallow inside. Cover the end of the syringe with the tan syringe cap (or your thumb) and press down on the plunger.

a. What happens? Use words AND draw the face.

Repeat with a new marshmallow, but this time place the marshmallow inside the syringe (NO CAP yet), push the plunger in until it is just touching the top, and *then* cover the end of the syringe with the tan syringe cap. Pull the plunger out.

b. What happens this time? Use words AND draw the face.

c. Explain in detail what happens to the marshmallow as you change the position of the plunger, and what this tells you about the relationship between pressure and volume.

d. Which postulate or law was observed?

REMOVE YOUR MARSHMALLOWS AND PLACE IN THE TRASH.

***note: you do not have to have the syringe caps…your thumb will work just fine.

Percent Composition for a piece of gum

Background: Percent composition is calculated by dividing the mass of the given substance by the mass of the entire sample and multiplying it by 100. In this activity different types of gum will be tested for the percent sugar in them.

Objective: To determine the percent sugar in a piece of bubble gum and compare it to other brands.

Procedure:

1. Mass a piece of gum and its' wrapper.
2. Chew gum for 20 minutes.
3. Mass of empty wrapper.
4. Mass wrapper with chewed gum.
5. Dispose of gum and wrapper in trash.

Data:

Brand of gum				
Mass of gum + wrapper				
Mass of empty wrapper				
Mass of chewed gum + wrapper				
% sugar in gum				

Calculations: Show work !

1. The change in mass of the gum is the mass of the sugar in the piece of gum.
   (Mass of gum + wrapper) – (mass of chewed gum + wrapper) = mass of sugar

2. Mass of unchewed gum = (mass of gum + wrapper) – (mass of empty wrapper)

3. % sugar = $\frac{\text{mass sugar}}{\text{Mass of unchewed gum}} \times 100$

Questions:

1. Fill in your data table with 3 other brands of gum. Which brand contains the most sugar? Is there a significant difference in % sugar between brands?

Chemical Formulas

Background: A chemical formula simply shows the number of each atom in a compound, which in essence is the same as a molecular formula. An empirical formula is a reduced form of the molecular. The Law of Definite Proportions says that elements combine in set whole number ratios. For example water is always 2 H's and 1 O, we cannot have fractions or decimals for subscripts.

Objective: To write chemical formulas, compare empirical and molecular formulas and apply the concept of definite proportions. Each person in your group will write a chemical formula for each of the compounds. Do not open the compounds.

Materials: Smarties

Procedure:
1. Get one compound and look at it.
2. Write a chemical formula for the compound (see key below). Use symbols and subscripts.
3. Repeat until you have completed all the compounds your group received.

Key for "element" symbols:

White = W Violet = V Yellow = Y Pink = P Orange = O Green = G

Data:

Compound #	Chemical/molecular formula	Empirical formula

Questions:
1. Were all the compounds the same? How did you know?

2. Did each compound have the same formula?

3. Did some of the compounds contain the same elements? If so, then what made them different?

4. Complete the following chart:

Molecular formula	Empirical formula (hint: reduced form)
H_2O_2	
$C_6H_{12}O_6$	

$K_2Cr_2O_7$	

Half – Life and Radioactive Decay

Objective: In this activity you will observe how and "atom" decays, and how much remains after 6 decay cycles. You should also be able to describe the rate at which a radioactive substance decays.

Materials: graph paper, ruler, licorice

Procedure:
1. Label the x-axis as "number of half-life cycles."
2. Start at 0 and go up to 6.
3. Label the y-axis as "number of undecayed atoms."
4. Measure the length of the licorice and record.
5. Place the licorice on the y-axis, at 0 half lives and place a mark on the graph paper.
6. Cut the licorice in half, set one piece aside, place the other on the 1 half-life spot and mark the graph paper at the top of the licorice piece.
7. Repeat this process until you reach half –life number 6. Yes, the last piece will be VERY small.

Data:

Initial length of licorice __________ Final length of licorice ___________

Questions:

1. From looking at your graph, what type of mathematically relationship explains the rate at which a radioactive element decays. ______________________________
2. Go back and label your y-axis with the initial and final lengths of the licorice.
3. Define half-life. ____
4. Using your initial length, show the math for your piece of licorice going through 6 decay cycles. How does this compare to your final length?
5. A radioactive tracer, Sodium-24, is used to study circulatory problems. If you start with 5.85×10^{23} atoms, how many will remain after 12.0 days? The half-life of this isotope is 4.0 days.

CO_2 in Pop Rocks

Background: Pop Rocks and other carbonated sweets start out as a mixture of crystalline sucrose and lactose plus corn syrup, containing the sugars glucose, maltose, and dextrin. The candy makers add a small amount of water to the cooking vessel filled with the sugars and heats the mixture to between 138 and 160 degrees C until the sugars dissolve. Then most of the water is evaporated with a vacuum pump. When the amount of moisture in the viscous sugar mixture, called a melt, is between 1% and 5% by weight, the candy maker adds flavors and colors.

Next comes the critical step, worked out over two decades by researchers at the General Food Corp. With the temperature no high than 138 C, carbon dioxide is pumped into the cooking vessel to a pressure of34 to 51 atmospheres, and the mixture is stirred for several minutes. This forces the bubbles of carbon dioxide into the candy. The bubbles are 300-350 microns in diameter to give the final product the “pop.” If the melt is carbonated at higher temperatures, the bubbles are smaller and the resulting candy fizzes more than it pops.

The melt is allowed to cool and the candy hardens into a glassy (non-crystalline) solid with carbon dioxide bubbles frozen inside. The pressure is then released rapidly from the vessel, cracking the carbonated candy into small pieces that are packaged and sold. (*Chem Matters,* October 1993).

Objective: To determine the volume of carbon dioxide stored in Pop Rocks (or another carbonated candy).

Materials: graduated cylinder (25 or 50 mL), cotton balls or one-hole stopper, balance, candy, large beaker, thermometer.

Procedure:

1. Measure the mass of the package of candy.
2. Open the package and empty the contents into the graduated cylinder.
3. Mass the empty package.
4. Fill the large beaker with tap water and record the temperature.
5. Fill the cylinder to the very top (practically over flowing) with water and QUICKLY plug the cylinder with a one-hole stopper or a cotton ball.
6. Invert (flip over) the cylinder into the beaker of water.
7. When the candy has stopped bubbling, raise or lower the cylinder to the water level in the cylinder is level with the water in the beaker. Read the volume of gas in the cylinder.
8. Empty the contents of the cylinder and beaker into the sink. Wash both with soap and water – rinse well.
9. Record the vapor pressure of water for your temperature and the barometric pressure.

Data:

Mass of unopened candy	
Mass of empty package	
Mass of candy	
Temperature of water in beaker	
Volume of gas collected in cylinder	
Vapor pressure of water at your temperature	
Barometric pressure	

Calculations: SHOW WORK!

1. Determine the amount of carbon dioxide produced per gram of candy.

2. Use Dalton's law of partial pressure and determine the pressure of the dry gas.
   $P_T = P_{CO2} + P_{H2O}$ where P_T is the barometric pressure

3. How many moles of carbon dioxide did you collect? Hint: use the ideal gas law and remember to convert your temperature into Kelvin.

4. Using your data for the initial conditions (V_1, T_1, and calc #2 as P_1) and STP conditions as the final conditions (T_2 and P_2) determine the volume of your carbon dioxide (V_2) at STP.

Questions:

1. How do your results compare to the rest of the class?

2. How would you modify this experiment if you did it again?

3. What other types of candy could we use for this experiment and how might the procedure be changed to accommodate a different candy.

Content Expectations:

Take home experiments (fudge, ice cream, hard candy)
C4.7a Investigate the difference in the boiling point or freezing point of pure water and a salt solution.

Thermal Energy of Foods
C3.1d Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.

S'mores (limiting/excess)
C5.2d Calculate the mass of a particular compound formed from the masses of starting materials.
C5.2e Identify the limiting reagent when given the masses of more than one reactant.

Bean City (avg. mass)
C4.10c Calculate the average atomic mass of an element given the percent abundance and mass of individual isotopes.

Isotope Activity
C4.10 Neutral atoms, Ions, Isotopes

Peppermint candy demo
C3.4 Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.
C5.2B Distinguish between chemical and physical changes in terms of the properties of the reactants and products.

Density of Soda
C4.7b Compare the density of pure water to that of a sugar solution.

Charles' Law & CO_2 in Pop Rocks
C4.5c Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.

Gas Solubility
C3.4g Explain why gases are less soluble in warm water than in cold water.

Marshmallow in a Syringe (Marshmallow Mafia)
C4.5a Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.

Percent composition of gum
C4.1a Calculate the percent by weight of each element in a compound based on the compound formula.

The following are not associated with a specific content standard: Heterogeneous/homogenous activity, Chemical formulas, and Half-life.

SOURCES:

Chem Matters, October, 1993.

"Confectionary Chemistry," by Elise Hilf Levine. *The Science Teacher,* May 1996.

Mackenzie, Norma N. and Mike Roadruck, Woodrow Wilson Torch Program, July 1997.

Oakland Schools Chemistry Teacher Resource Manual, October 2008

Numerous colleagues and MSTA conferences.