Sublimation

**HIGH SCHOOL**

**Green Chemistry & Sustainable Science**

Teacher Background Information:

This lab replaces the traditional naphthalene lab to demonstrate sublimation and phase change. Caffeine is a much safer molecule to sublime in an environment with students, compared to naphthalene. Naphthalene is classified as a possible carcinogen as well as an irritant to the eyes, nose, and throat.

**Safety Information:** Safety glasses should be worn at all times.

**Student Objectives:** Students will…

* Observe sublimation (physical properties of matter)
* Explain the type of change that occurred

Materials (per group of 3 students):

* Safety goggles
* 4 200-mg caffeine tablets (C8H10N4O2)
* 2 (15–20 mL) test tubes
* Test tube rack
* 2–3 (400 or 600 mL) beakers
* Hot plate
* Ice
* 2 funnels
* Ring and stand
* Filter paper
* Mortar and pestle
* Glass stirring rod
* Small spatula
* 10-mL graduated cylinder
* Test tube holder
* Wash bottle of deionized water
* Balance
* Glass petri dish

**Time Required:** 45- to 60-minute class period

NGSS Standards Met:

* **HS-PS1-5.** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
* **HS-PS1-7.** Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
* **HS-PS1-10.** Use evidence to support claims regarding the formation, properties and behaviors of solutions at bulk scales.

Teacher Preparation:

Caffeine is available as caffeine tablets at local pharmacy. Often, they are available over-the-counter.

Keys for Success:

The temperature must be closely monitored to ensure the caffeine does not burn. It may be advisable that the teacher check the hot plate temperature setting ahead of time, and then advise students of the appropriate setting. For example, let them know if setting 6 is 160 ˚C and setting 7 is 180 ˚C. That way, you can help students know the range of values to use.

Disposal Information:

All solid materials are safe to be discarded in regular classroom trash. Dissolved materials are safe to go down the drain.

Sublimation—Student Lab Sheet

Part 1: Separation of Caffeine

Materials:

* Safety goggles
* 4 200-mg caffeine tablets (C8H10N4O2)
* 2 (15–20 mL) test tubes
* Test tube rack
* 2–3 (400 or 600 mL) beakers
* Hot plate
* Ice
* 2 funnels
* Ring and stand
* Filter paper
* Mortar and pestle
* Glass stirring rod
* Small spatula
* 10-mL graduated cylinder
* Test tube holder
* Wash bottle of deionized water
* Balance
* Glass petri dish

Procedure:

1. Review the Student Worksheet to and prepare to record the required information.
2. Fill a large beaker half full of water.
3. Place the beaker on the hot plate and set the heat to make a gently boiling water bath. **CAUTION: HOT PLATE CAN BECOME VERY HOT VERY FAST!**
4. Prepare an ice water bath in a large container and place the wash bottle of deionized water in it to cool.
5. Use the mortar and pestle to grind the caffeine tablets into a fine powder.
6. Carefully pour the caffeine powder onto a piece of paper. Shape the paper so that it creates a funnel and pour the caffeine into a test tube.
7. Add 10 mL of water to the powder in the test tube and stir with a glass stirring rod.
8. Place the test tube into the water bath while it is heating to a boil. After the water reaches a gentle boil, let the test tube stay in the bath for an additional 5 minutes. Frequently stir the solution in the test tube while it is being heated.
9. Attach a metal ring to a ring stand and set up a funnel as shown on the right.
10. Fold a piece of filter paper so that it sits in the funnel. Wet the paper with deionized water to make it adhere to the side of the funnel.
11. Place a clean test tube below the funnel. It can be held underneath by placing it inside a beaker.
12. Use a test tube holder to remove the solution from the water bath and slowly pour the hot contents into the funnel. Allow the solution to filter into the test tube.

**CAUTION: This solution is extremely hot!**

1. Remove the water bottle from the ice bath and make another ice bath by filling a beaker ¾ full of ice. Pour water around the ice but do not fill the beaker.
2. Mass a new piece of filter paper. Record the mass in the data table. Put the weighed filter paper into a new funnel placed on the ring stand by repeating steps 10 and 11. Wet the filter paper with cold deionized water.
3. Using a test tube clamp, remove the test tube from below the filter and place it in the cold water bath.
4. Carefully watch the test tube for any sign of crystal formation. Once crystals begin to form, you will see cloudy areas in the clear solution. After the solution has turned entirely to crystals, pour the solution with crystals quickly into the funnel. If crystals stick to the side of the test tube, rinse the test tube with the cold deionized water. Use only a few milliliters of water so as not to dilute the caffeine.
5. Remove the funnel from the stand but DO NOT remove the filter paper. Place the funnel in a dry beaker labeled with your lab team names.
6. Place the beaker with the funnel into the drying oven overnight.
7. (Next day) Mass the dried filter paper and calculate the amount of caffeine separated. Save the filter paper in a clean glass.

Part 2: Sublimation of Caffeine

Materials:

* Hot plate
* Balance
* Spatula
* Glass petri dish
* Filter paper with isolated caffeine from Part 1

Procedure:

1. Open the glass petri dish and remove the filter paper.
2. Record the mass of the glass petri dish in the Student Worksheet.
3. Using the spatula, carefully scrape the crystallized caffeine into the petri dish.
4. Place the cover on the petri dish and place onto a COLD hot plate.
5. Turn on the hot plate to the lowest setting and slowly heat the caffeine for several minutes.
6. Watch as crystals slowly start to form on the cover of the petri dish. Be careful not to burn the caffeine.
7. Increase the heat very slowly until all of the crystals have sublimated.
8. Record your observations about the caffeine crystals in the student data sheet.
9. Mass the petri dish and calculate the final amount of caffeine purified from the original sample.

Sublimation—Student Worksheet

Part 1: Separation of Caffeine

Data and Observations:

Mass of dry filter paper: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

Mass of filter paper with dried caffeine: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

Mass of caffeine retrieved: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**Calculate the percent mass of caffeine separated.**

Each caffeine tablet contains 200 mg of caffeine.

Convert 200 mg to g = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g of caffeine

Formula for % caffeine separated:

Mass of caffeine on filter paper × 100 = % caffeine separated

Total mass of caffeine in tablet:

Show your work below:

Part 2: Sublimation of Caffeine

Data and Observations:

Mass of glass petri dish: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

Observations of crystals:

Mass of petri dish with caffeine: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

Mass of empty petri dish: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

Mass of caffeine: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

Final mass of caffeine × 100% = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ % caffeine recovered

Questions:

1. Write a phase change equation for the change that occurred.
2. Using a reference book, write the definition of *sublimation*.
3. Explain the changes in the appearance of the crushed tablet as the temperature was raised. What explains the changes in color and shape that occurred?
4. Explain how sublimation relates to this experiment. Include observations of the change that occurred.
5. Is tearing up a sheet of paper also a type of phase change? Explain your answer.
6. Are all phase changes also physical changes?
7. This caffeine tablet never fully sublimes. Can you make an educated guess as to why that is?

Sublimation—Teacher Key

1. Write a phase change equation for the change that occurred.

Caffeine (s) 🡪 Caffeine (g)

1. Using a reference book, write the definition of **sublimation**.

A phase change that occurs when matter goes from the solid state to a gaseous state.

1. Explain the changes in the appearance of the crushed tablet as the temperature was raised. What explains the changes in color and shape that occurred?

The crushed tablet was originally yellow in color. HOWEVER, the caffeine in the tablet is white. As the caffeine sublimes, it forms white crystals on top of the original crushed tablet. These crystals appear “fuzzy” or “mossy” as they form from the bottom up. The colored compounds in the tablet stay in the bottom of the petri dish, while the white caffeine sublimes and recrystallizes above.

1. Explain how sublimation relates to this experiment. Include observations of the change that occurred.

The caffeine tablet began as a solid. As it was heated, it began to sublime, or go from a solid state to a gaseous state. Evidence of this was seen by the formation of gas inside the caffeine beaker and a decreased mass in the caffeine tablet after 10 minutes of heating.

1. Is tearing up a sheet of paper also a type of phase change? Explain your answer.

No. The paper exists in the solid state, and even if you tear it up into smaller pieces, it still exists in the solid state. A phase change would occur if the paper melted or turned into a gas.

1. Are all phase changes also physical changes?

Yes. Physical changes do not result in the formation of a new substance, just a change of phase or the appearance of a substance. So, all phase changes are considered physical changes.

1. This caffeine tablet never fully sublimes. Can you make an educated guess as to why that is?

The caffeine tablet cannot fully sublime because it is not pure caffeine. Tablets such as these often have fillers and stabilizers to make them appropriate for commercial sale.