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STEAM

The Art and Science of Candle Making

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The Art and Science of Candle Making

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Goals and Objectives

The purpose of "The Art and Science of Candle Making" is to give students a better understanding of candle making while applying their scientific knowledge of both chemical and physical change in creating a candle. Students will experiment with the best combination of waxes, wicks, and fragrance oils to optimize scent throw and flame stability. They will learn how to make a safe, high-quality candle with optimal performance using science, mathematical formulas, and critical thinking skills. Through this hands-on candle-making experience, students will integrate multiple STEM/STEAM concepts into the lesson. Additionally, students can discover the science behind anxiety-reducing properties of aromatherapy, ambiance, and the reliable light source that a candle provides.

Florida Standards

Science

SC.6. E.7.9 - Describe how the composition and structure of the atmosphere protects life and insulates the planet.

SC.7. P.11.2 Investigate and describe energy transformation from one form to another.

SC.8. P.9.2 - Differentiate between physical changes and chemical changes.

Mathematics

MA.6.AR.3.5 - Solve mathematical and real-world problems involving ratios, rates, and unit rates, including comparisons, mixtures, ratios of lengths, and conversions within the same measurement system.

MA.7.GR.1.3 - Explore the proportional relationship between circumferences and diameters of circles. Apply a formula for the circumference of a circle to solve mathematical and real-world problems.

MA.7.GR.2.3 - Solve mathematical and real-world problems involving the volume of right circular cylinders.

Course Overview - The Art and Science of Candle Making

Candle Making is a great way to introduce students to combustion, thermal dynamics, and chemical change properties. Key concepts that will be covered during the lesson will be:

Combustion: Students will observe a burning candle and note how wax and wick interact to produce a steady flame. As heat from the flame melts the wax near the wick into a liquid state, the liquid wax travels up the wick and vaporizes. The vaporized wax then mixes with oxygen in a combustion reaction, generating heat, light, carbon dioxide, and water vapor. The heat keeps the candle burning by melting more wax, while the light produces the bright candle flame, we see.

Thermal Dynamics: Students will use a thermometer and will conduct 3 trials with the temperature ranges for candle making and determine the optimal temperature for melting the wax, mixing the wax with the fragrance oil, and pouring the final mixture into the container.

Students will observe how the 3 heat transfers with the wax and fragrance oil:

1. Conduction - heat transfer through the solid wax
2. Convection - heat transfer through the liquid wax
3. Radiation - heat transfer from the heating source

Fragrance Oils, Candle Dyes and Aromatherapy:
Students will determine the blend fragrances to create the optimal scent for their candles to determine the optimal percentage of fragrance oil to wax to have a great-smelling candle. They will conduct 3 trials of 8%, 9% and 10%. They will learn about various aromatherapy fragrance oils and will mix and blend various candle dyes to create their personalized colored candles.

Lesson Plans and Overview
Pre-Lesson Activities

Lesson Plan - Mathematics Component

- Calculating the wax to Oil Ratio Worksheet
- Determine the Wick Size by finding the diameter of the container

Lesson Plan - Science Component

- Conduction, Convention, and Radiation
- Heat Transfer Practice Worksheet
- Science Lab Safety Rules
- Candle Making 101

WORKSHEET
Calculating the Wax to Oil Ratio Worksheet

1. How many candles are you making (in ounces)? _____

2. What is the size of each candle (in ounces)? _____

3. Calculate the total wax and fragrance oil (in ounces) _____
   (Multiply the # of candles Q1 x the size of each candle Q2)

4. What fragrance percentage will you use (typically 6-10%) _____%?

5. Change the fragrance percentage to a decimal _____

6. Calculate the fragrance oil load needed for the batch. (Fragrance percentage in decimal X total wax and fragrance oil)

7. Determine how many ounces of wax is needed.
   _____ =_____
   Total Wax - Fragrance Oil load Wax needed.

8. Convert the wax needed to pound and ounces if the wax needed is >= to 16 ounces. _____

Determine the Wick Size

Wax Type	Extra Small	Small	Medium	Large	Extra Large
Soy Wax	1.75" - 2.19"	2.2" - 2.69	2.7" - 2.94"	2.95" - 3.29"	3.3" - 3.79"
Golden Brands 415	CD 4, ECO 4	CD 10, ECO 10	CD 14, ECO 12	CD 20, ECO 14	CD 24, ECO 16
Golden Brands 444	CD 4, ECO 4	CD 10, ECO 10	CD 14, ECO 12	CD 20, ECO 14	CD 24, ECO 16
Golden Brands 464	CD 4, ECO 4	CD 8, ECO 8	CD 12, ECO 10	CD 18, ECO 14	CD 22, ECO 16

1. Measure the circumference of the top of the jar/tin with a strip of paper. (Around the candle jar)

2. Use a ruler or tape measure to determine the circumference (around the jar/tin).

3. Calculate the diameter by. Measurement divided it by approximately 3.14 (π). Round to the nearest hundredths.

Sample Worksheet

Calculating the Wax to Oil Ratio Worksheet

1. How many candles are you making (in ounces)? 5

2. What is the size of each candle (in ounces)? 8

3. Calculate the total wax and fragrance oil 40.
   (Multiply the # of candles Q1 x the size of each candle Q2)

4. What fragrance percentage will you use (typically 6-10%)? **7%**
   Convert percent to decimal (0.07)

5. Calculate the **fragrance oil load needed** for the batch.
   0.07 x 40 = 2.8
   (Percentage X total wax and fragrance oil)

6. Determine how many ounces of wax are needed if the ounce is >= 16.

   Total Wax - Fragrance Oil load
   40 - 2.8 = 37.2 ounces of wax

Additional Explanation

16 ounces = 1 pound
32 ounces = 2 pounds
48 ounces = 3 pounds

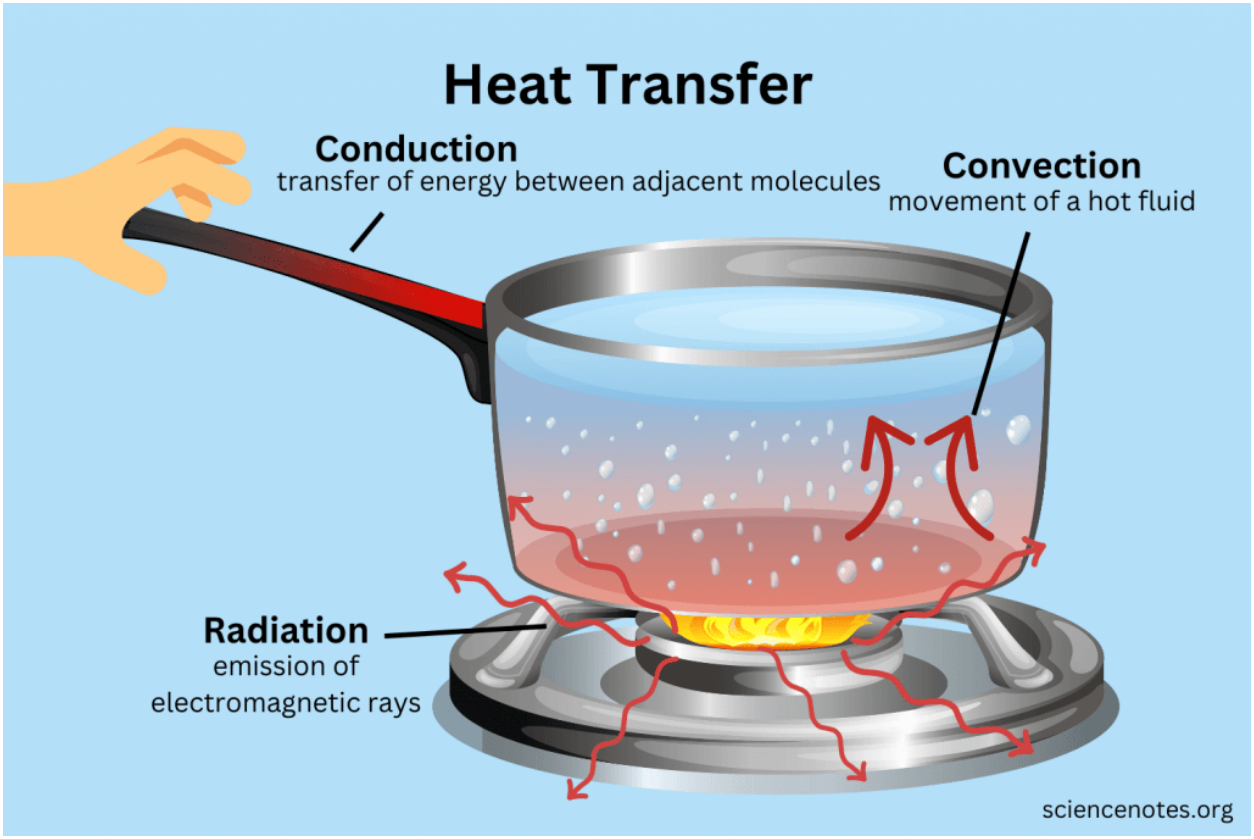
Wax needed 37.2 Ounces or **2 pounds and 5.2 ounces.**
37.2 /16 = 2.325

(The whole number tells you that there are 2 pounds in 37.2 ounces.

Determine the number of ounces remaining after calculating the pounds.

Multiply 16 x 2 = 32 (convert to ounces)
Subtract - 37.2 - 32 = 5.2 (Remaining ounces)

Conduction, Convention, and Radiation



Conduction is heat transfer directly between neighboring atoms or molecules. Usually, it is heat transfer through a solid. For example, the metal handle of a pan on a stove becomes hot due to convection. Touching the hot pan conducts heat to your hand.

Convection is heat transfer via fluid movement, such as air or water. Heating water on a stove is a good example. The water at the top of the pot becomes hot because water near the heat source rises. Another example is the movement of air around a campfire. Hot air rises, transferring heat upward. Meanwhile, the partial vacuum left by this movement draws in cool outside air that feeds the fire with fresh oxygen.

Radiation is the emission of electromagnetic radiation. While it occurs through a medium, it does not require one. For example, it's

warm outside on a sunny day because solar radiation crosses space and heats the atmosphere. The burner element of a stove also emits radiation. However, some heat from a burner comes from conduction between the hot element and a metal pan. Most real-life processes involve multiple forms of heat transfer.

Heat Transfer Practice

Directions: Which type of heat transfer is taking place? Write Conduction, Convection, or Radiation in the blank spaces to show the type of heat transfer.

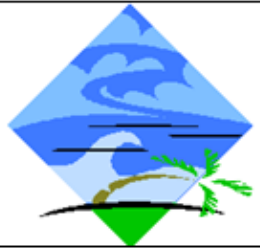
1. _____ hot water rises and cold water sinks	
2. _____ stir frying vegetables	
3. _____ a spoon in a cup of hot soup becomes warmer	
4. _____ grilling hamburgers over a charcoal flame	
5. _____ hot air balloon rises	
6. _____ You feel the heat from a campfire	

7. _____ a raw egg begins to fry as it hits a heated frying pan	
8. _____ Heated air rises, cools, then falls. Air near heater is replaced by cooler air, and the cycle repeats.	
9. _____ boiling potatoes in water	
10. _____ microwave oven	
11. _____ a person takes a warm bath	
12. _____ warm water at the surface of the swimming pool	
13. _____ wind currents	

Heat Transfer Practice Answer Key

Directions: Which type of heat transfer is taking place? Write Conduction, Convection, or Radiation in the blank spaces to show the type of heat transfer.

1. Convection hot water rises and cold water sinks	
2. Conduction stir frying vegetables	
3. Conduction a spoon in a cup of hot soup becomes warmer	
4. Radiation grilling hamburgers over a charcoal flame	
5. Convection hot air balloon rises	
6. Radiation You feel the heat from a campfire	

7. Conduction a raw egg begins to fry as it hits a heated frying pan	
8. Radiation Heated air rises, cools, then falls. Air near heater is replaced by cooler air, and the cycle repeats.	
9. Convection boiling potatoes in water	
10. Radiation microwave oven	
11. Conduction a person takes a warm bath	
12. Convection warm water at the surface of the swimming pool	
13. Convection wind currents	

SAMPLE - Science Lab Safety Rules

1. Always obtain your teacher's permission before beginning an activity. Listen for any special instructions the teacher gives you before the lab begins.
2. Read the STEPS and procedure before beginning the lab. If you have questions, ask your teacher. Be sure you understand any safety symbols shown on your lab page.
3. Use the safety equipment provided for you. Know the location and proper use of the fire extinguisher, eyewash station, fire blanket, and fire alarm.
4. Horseplay will not be tolerated and will result in immediate removal from the lab.
5. Never eat or drink in the lab, and never use glassware as food or drink containers. Never inhale chemicals. Do not taste any substances that will be used in the lab.
6. If you spill any chemical, wash it off at once with water. Report any spill to your teacher.
7. Keep all materials away from burner or hot plate. Unplug hot plate after use. Tie back long hair and do not wear loose clothing or sweaters when doing the lab. You must wear closed-toed shoes.
8. If a fire should break out in the classroom, or if your clothing should catch fire, smother it with the fire blanket. NEVER RUN.
9. Report any accident or injury, no matter how small, to your teacher.
10. When you are cleaning up…

    Turn off the water. Disconnect and ensure all hot plates are turned off and unplugged.
    Dispose of all chemicals according to the teacher's directions.
    Return all materials to their proper places.
    Place broken glass and solid substances in the proper containers.
    Never discard any wax or candle making materials in the sink.
    Clean your work area.
    Wash your hands thoroughly after working in the laboratory.

Safety Contract……

I, _____, have read and understand the safety rules listed above. I recognize my responsibility and pledge to always follow all safety rules in the science classroom.

_____ _____

Signature *Date*

What you need to make your candle!

- Thermometer
- Kitchen scale
- 464 Wax
- Measuring tape/rule
- (1) 4 or 6-ounce tin
- 1 Wick sticker
- 1 wick
- 1 wooden wick centering tool

- Wax Melt for extra wax
- Fragrance oil
- Melting pot
- Safety Labels for candles
- Dried flowers (Optional)
- Wick Trimmer

Step 1: Figure out the amount of fragrance oil needed. Use the math worksheet provided as a Guide in the pre-lesson activity. Multiply the liquid based on the size of the container by .10 for a 10% fragrance throw. For example, if making a 4-ounce candle, use .4 ounces of fragrance oil. Note that an extra amount is added for accidental spills.

Step 2: Prepare the candle jars before we start!

To prepare your candle jars (vessel), attach a wick sticker to the bottom of the wick tab, and adhere to the CENTER of the container. Please ensure that your wick is centered as best as you can.

Step 3: Melt the Wax


Melt wax in a double boiler over medium heat. A double broiler is a POT with water and a melting pot with wax inside. Stir to blend well. Ensure that the temperature is checked during the melting process and remove the wax when the temperature reaches **185°F.** **Turn off and unplug hot plate.**


Stir gently for about 2 minutes and use a thermometer to measure the temperature and then add your fragrance oil at **165°F. Stir to bind the fragrance oil and the wax.**

Step 5: Pour your wax slowly and leave at least ½ to 1 inch from the top.


Allow wax to cool to ***145-150°F***. Carefully and slowly pour melted wax into the container when the temperature drops to ***145°F.*** Pouring should be slow to avoid splashes and bubbles. Support the wick using the wick centering tool, if necessary, and allow the candle to cool completely.

OPTIONAL:

Add flowers slowly after you pour if desired. After the candle is completely cooled (do not move it for at least 2 hours), trim the wick and let it “cure" for at least 72 hours before burning.

For the best scent result, let the candle cure (not burn) for at least 2 weeks.

References - Website

https://www.youtube.com/watch?v=pXIwl34MVI8&ab_channel=NicholasMitchell
https://sciencenotes.org/heat-transfer-conduction-convection-radiation/
https://www.candlescience.com/
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