The Candle Under The Jar

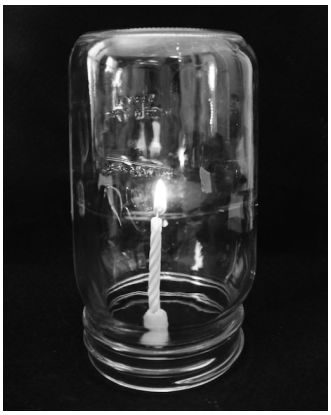


photo by Rhonda Spidell

Materials for each lab group (3-4 students):

•Three or more jars of different sizes.
•Three or more birthday candles (depending on number of jars).
•Clay to hold the candle in place.
•Stop watches for timing the burning candles.

Procedure:

Place the candle in clay on the lab table.
Light the candle and invert one of the jars over the candle.

How to measure the burning time of the candle under the jar.

1. Start timing as soon as you have inverted the jar.
2. Stop the timer when the flame goes out and smoke rises from the wick.
3. Wipe out the jar after each trial.
4. Create a data table to record your data.
5. Run several trials.
6. Average the trials for each jar size.
7. Compare the size (volume) of each jar with the burning time by graphing your data.
8. Your graph should include a dependent and an independent variable.

Graphing Tips
Independent and dependent variables are related to one another. The independent part is what you, the experimenter, changes or enacts in order to do your experiment. The dependent variable is what changes when the independent variable changes - the dependent variable depends on the outcome of the independent variable. Volume could be the independent variable (you controlled this variable by having different sized jars) and “time of burning” could be the dependent variable (the time of burning is dependent on the amount of oxygen available to the fire).

Make sure to clearly label all tables and graphs and include the units of measurement (volts, inches, grams, etc.).

Place your independent variable on the x-axis of your graph and the dependent variable on the y-axis. Use a ruler and graph paper to complete the graph.

Answer the following questions.

1. What two compounds are produced when a candle is burned?

2. Why do we measure the burning time more than once?

3. Why do we need to wipe out the jar for each trial?

4. What do you think the burning time of the candle would be if we did not wipe out the jar after the first trial?

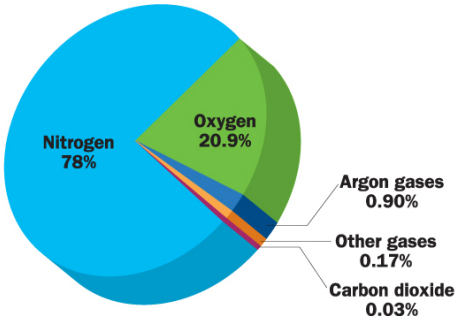
5. Why did the candle stop burning under the jar?

6. How can you measure the volume of the jar?

7. What is the relationship between size or volume of the jar and the burning time of the candle?

The Candle Under the Jar – Explanation for Reference

Atmospheric air is composed of different gases with oxygen being about 21%. The candle needs at least 16% oxygen to sustain combustion.



http://pattiisaacs.files.wordpress.com/2011/12/air-composition-pie-chart2.jpg?w=150&h=119

Oxygen is depleted from the confined volume of air by the burning candle and replaced by the primary combustion products of carbon dioxide and water vapor. You can see evidence of water vapor condensing on the cold inside surface of the jar. Several other phenomena are going on such as contraction of gases, condensation (latent heat of fusion) and the particulates (soot) being left behind due to incomplete combustion. Depending on the students' levels you can introduce the physics and chemistry of combustion/oxidation.

Before doing the next timing of the burning candle, the air or oxygen in the jar has to be replenished. You can replenish the jar by moving a crumpled piece of paper in and out of the jar several times. Students may ask why you need to wipe out the jar. It is because you need to remove the by-products of fire so that the next trial will have the same starting conditions.

Students can estimate the volume of the jar (this makes a good contest and will add some interest in determining the actual volume using the metric system). Have the students fill the jar up with water and then measure the water to calculate the volume. This needs to be done after the data is collected or it will change the measurements if the jar is wet.

The graphing component is very important and depending on your students' level you can try different ways to help students set up their graphs. For example, drawing a graph on the white board and having students physically plot their data using magnetic dots is a good way to have the whole class interacting. The black dots can be made with self-sticking magnetic strips attached to a penny-sized piece of construction paper cut in a circle. Even with all the technology available students need concrete experiences to help them connect what they are experiencing.

Students should see that a straight-line relationship exists between the volume of the jar and the burning time of the candle when the graph is complete. If there are "outliers" you can have the groups compare their methods and problem-solve to see if they can explain what may have happened or try a different experimental design to increase the accuracy of their data.

The combustion reaction for a burning candle is $C_{35}H_{74}+O_2 \rightarrow CO_2 + H_2O$ + heat and light. Wax is a hydrocarbon just like methane CH_4.