

Burning Questions About a Candle

Procedure:

Observations to make before you light the candle

Answer the following questions concisely. That is, use short sentences or sentence fragments, and only say what really needs to be recorded. You may want to work in pairs or small groups, each writing down observations, then periodically comparing notes and asking each other questions. If you do it this way, just remember: *don't make critical comments!* Be critical in your thinking, in the sense of always asking yourself "What does that mean anyway?" and not in the sense of "That's clearly wrong" or "What a dumb observation." Be positive in your approach, focus on the candle, and keep asking yourself questions in your own mind, especially questions that lead to further observations and more questions.

Give a physical description of the candle and its components. What are the individual parts and what are they made of?

How is the candle shaped? Why?

At what angle do you plan to burn the candle? Why?

Do some physical "tests" on the candle using what you have on you or laying around the room. What do these tests tell you about its properties?

Do any of these tests give you an indication of the nature of the candle components at the molecular level?

What do you know about the chemical nature and/or composition of these components?

Hypothesize what will happen when you light the candle and start it burning

Write down what you think will happen in terms of the observations you made above, especially with respect to the molecular level. Be complete but concise.

Now, light the candle and watch what happens

Record all the observations you can make regarding the lighting and burning of the candle. For this first set of observations, don't worry about asking questions so much as just making as many quick notes as you can. You should plan on spending a fair amount of time on this (more than a minute and less than an hour or two).

Hints:

- It is important that you record your observations as quickly as you can and then come back to some of them later for further thought and extended observation.
- As you look at the candle, try to separate the components into the individual elements. The flame is different from the vapor which is different from the wick and the solid and liquid wax.
- There are processes in dynamic equilibrium occurring during the burning process. Think about these processes and ask yourself questions. There are physical changes occurring as well as chemical reactions. Try to imagine what these are, list them, and ask questions about them.

- Your "observations" should also contain conjecture and hypotheses about what is occurring or why it is occurring. It is crucial that you have some of these extensions of the observation process recorded.
- Try to make at least 10 distinct and separate observations initially. (Be aware that individual observations numbering over 100 have been recorded by others.)

It may take you a while to begin to think about what is happening. Be patient and work at the process. Once you begin to see how to ask questions related to what you are seeing, a snowball effect will occur that should open up whole new areas of observation for your critical consideration. Be sure to write down all of your thoughts and observations as they occur. Don't try to be critical of the material you write down, but simply put it down as quickly as possible. You will have plenty of opportunity later for evaluation and grouping of your data.

Observations:

Take one observation that you recorded above and:

- Break it down into macroscopic versus molecular levels.
- See if you can coordinate what is happening between what you've physically observed (that is, the macroscopic level) and the molecular level.
- Most important, speculate on what is actually happening at each of these levels.
- Ask yourself, for both the macroscopic and molecular levels, why the behavior that you observed took place.
 - What was the molecular property involved?

- What changes in that property occurred during the burning process? Go into as much detail as you can.

Test Your Hypothesis by Doing an Experiment

After you feel like you have made enough observations to give you a pretty good understanding of what is actually happening during the burning process, it is time to do an experiment. An experiment results when you ask a question and then develop a method to answer that question. The experiment itself is actually the process of getting the answer.

So, here is what you need to do:

- First, try to ask a good question. Think about the observations that you made, especially those that you don't really understand, and try to formulate some kind of hypothesis (or good guess) about what is happening.
- Once you have a good question, try to think of ways that you can answer that question.
What kind of measurements or observations (either with your own eyes or with other methods) would help you get the answer?
- Think about the kind of data you'll collect - will your data be *qualitative* (that is, descriptive) or *quantitative* (with numerical measurements).
What do you have available in the lab that you could use to measure changes that occur?
- Once you have some idea of how to actually do the experiment, go ahead and do it.
- Safety First! Make sure that you consider safety at every step. (Note: NEVER put a thermometer into the flame. The high temperature of the flame will break most thermometers.)
- As you design your experiment, consider how you will present your results. A good experiment is reproducible, and so you'll need to outline your steps (procedure) very specifically. Don't get bogged down in making it perfect the first time around, just make sure that you take clear and specific notes.

Be creative - you should be able to design experiments that you can do with what you can find in the lab or that you can easily acquire with very little effort. For example, holding a piece of glass over the candle as it burns (probably at an angle would work better) can help you answer questions about what is evolved or given off during the combustion process. Think of other simple ways of investigating further what is going on and see what kind of good experiments you can come up with. Record the results of your experiment on the next page.

Hypothesis:

Description of Experiment (Procedure):

Observations/Measurements:

Results/Conclusions: