Does combustion make things heavier or lighter?

Note:
This task is designed so that it can be solved with the incremental hints.
The hints are available on the media portal for printing, or the students can use them online on a tablet or smartphone via the QR code included on the worksheet.
The worksheet for the students and the hints for printing are available as separate files on the media portal of the Siemens Stiftung. General information on using tasks with incremental hints in the classroom is provided in the “Tasks with incremental hints – an introduction” document, which is also available on the media portal.

1 Topical aspects

The task addresses the conservation of mass during chemical reactions. This is the basis of practically every chemical reaction.

2 Learning prerequisites and level of difficulty

An understanding of the conservation of mass in chemical reactions – that is, for any and all changes in substances – is a prerequisite for the observation of chemical processes. Yet this principle (seemingly) contradicts everyday experiences: Only ashes remain in the fireplace after a fire, a fuel tank is emptied as a car is driven, and a candle becomes smaller when it is burned. In view of these facts, the question pertaining to the conservation of mass is rather difficult.
Specific requirements for prior knowledge are not necessary in order to work through this question, but the students should have developed a basic level of abstract operations (Piaget) in order to permanently integrate the principle.

3 Background on the task

The question of what happens during combustion has been the subject of extremely intense controversies in science. While Georg Ernst *Stahl* (1659–1734) was still refining the theory of fire-like substances (phlogiston) that escape during combustion, a short time later Antoine Laurent de Lavoisier (1743–1794) was able to interpret combustion as a reaction with oxygen in which combustion products that contain the seemingly “lost” mass always appear.
To come up with a meaningful statement about the mass ratios, a person must picture a closed system or develop a corresponding closed apparatus. This is possible only to a limited extent with school resources.
One approach to working through the question at school is to contrast the decrease in weight of a burning candle on a scale with the increase in weight of burning steel wool. The “cognitive conflict” generated in this way can be used to have the students develop the idea of a closed apparatus for monitoring the change in mass.
However, the task employs a different method: The students are to estimate the outcome and the meaningfulness of an experiment that has already been developed. Specifically, the experiment is a variation of the combustion of a match head in a test tube sealed with a balloon.

4 The task

In the simplest form, the task can be formulated as follows:

Explain what the experiment should reveal.

Because the context from which a task is developed fosters learning, depending on the teacher's assessment, a contextual scenario can be developed, such as the following:

The topic of the class is "combustion." First, the teacher places a candle on a scale and lights the candle. As expected, the scale indicates less and less weight as the candle burns down. Next, the teacher lays a fireproof surface on the scale, places steel wool on top, and lights the steel wool. The scale indicates more weight as the steel wool burns down; apparently, the steel wool becomes heavier.

The teacher has prepared the following for an experiment:
a test tube has two matches inside, and a balloon is pulled over the opening.
"In a moment, I will heat the test tube using the burner.
What do you think will happen?
And even more important, what do you think this experiment will reveal?"

Your task

Find out what the purpose of the experiment is.
Write down step by step how the experiment should be conducted.

5 Variations

Depending on the learning group, the number of hints can be decreased or increased. With lower-achieving learning groups, the fact that a scale is sitting on the desk could be added to the preliminary text.

6 Overview of the hints

Note: The hints have been prepared as a separate file for printing or can be used online via the QR codes on the worksheet. A video showing how the experiment is conducted is available on th media portal. The video is already integrated in the online hints.

Hint 1	**Answer 1**
Explain the task to each other again in your own words. State what you understood the task to be and what is still unclear to you.	We're supposed to find out the teacher's objective in conducting the experiment and exactly how the experiment will be carried out.

Hint 2 It is best if you first describe exactly what you can recognize and what purpose the various objects probably have. 	**Answer 2** The test tube contains two matches with their heads at the bottom. When the test tube is heated from the outside, the matches will probably catch fire. The test tube is sealed with a balloon; this is probably to prevent anything from escaping.
Hint 3 Think about what this experiment might have to do with your lessons up to now.	**Answer 3** We have conducted experiments with a burning candle and ignited steel wool. The candle became lighter, the steel wool heavier. The question afterwards was: Do substances become lighter or heavier when they are burned? The answer can be checked with this experiment because the test tube is sealed.
Hint 4 The purpose of the experiment is to check whether the mass of the involved substances changes when they react with each other during combustion. How exactly does the teacher have to proceed in order for this to be revealed?	**Answer 4** First, the test tube with its contents and the balloon must be weighed. Next, it is heated so that the matches burn. Finally, the test tube is weighed again.
Hint 5 Now you have all the information you need to answer the question coherently.	**Answer 5** The experiment is intended to reveal whether the mass of the involved substances changes during combustion. To find this out, the test tube must first be weighed, then heated so that a reaction takes place, and then weighed again. Because nothing can get in or out of the test tube, we expect that the mass will stay the same. (You can also watch the related video named “Does combustion make things heavier or lighter?”)