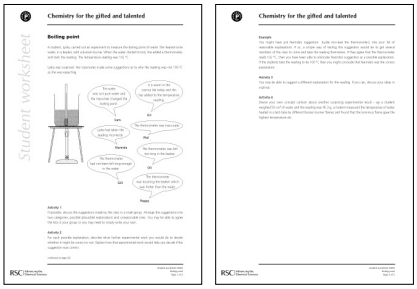
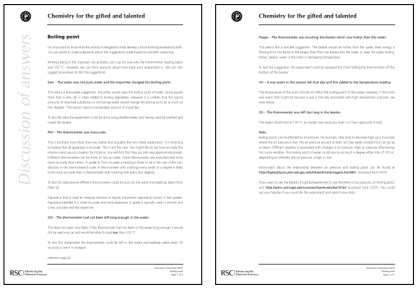
Boiling point



Student worksheet: CDROM index 02SW



Discussion of answers: CDROM index 02DA

Topics

Boiling points and measurement and errors. The link between boiling point and atmospheric pressure is also discussed in the *Discussion of answers* sheet.

Level

Middle to high ability students in the 11–13 age range.

Prior knowledge

The boiling point of water.

Rationale

This activity is designed to help students develop their critical thinking (evaluative) skills. They are presented with a surprising measurement for the boiling point of water and several suggestions as to why it might be. The main task is to evaluate the different suggestions. The experimental nature of science is reinforced by asking them how each suggestion could be tested practically in Activity 2, which could be approached as a class discussion. Creative thinking skills are used in Activity 3 when students add suggestions of their own.

In Activity 4 they are asked to devise a concept cartoon. One scenario is presented with diagrams and as few words as possible – alternative explanations, suggestions or questions are presented in speech bubbles. Any good concept cartoons generated could be tried out on other students to evaluate the alternative suggestions. Good examples of concept cartoons to show the students can be found in *Concept cartoons in science education*[1] or from other activities in this publication such as *Candle investigation*. A good idea might be to do a group effort on one together on the board before the students produce their own.

Use

This activity is best used as a whole class task. Although it was written with more able students in mind it is accessible for most abilities with support. It could be used when boiling points are taught or after an experiment where qualitative data are recorded as it facilitates a discussion on the reliability of data.

When the students have completed the worksheet they should be given the *Discussion of answers* sheet. They could check their own work or conduct a peer review of the work of another student or group.

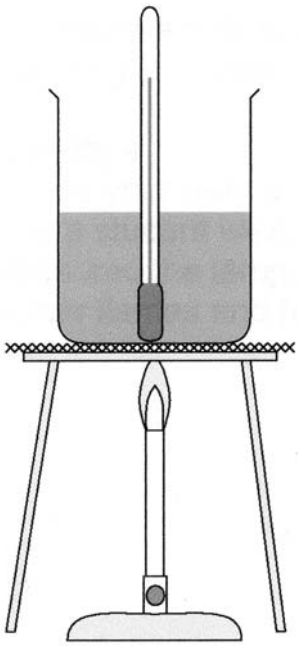
[1] S. Naylor and B. Keogh, *Concept cartoons in science education*, Sandbach: Millgate House, 2000.

Student worksheet

Boiling point

A student, Lydia, carried out an experiment to measure the boiling point of water. She heated some water, in a beaker, with a Bunsen burner. When the water started to boil, she added a thermometer, and took the reading. The temperature reading was 102 °C.

Lydia was surprised. Her classmates made some suggestions as to why the reading was not 100 °C as she was expecting.



The water was not pure water and the impurities changed the boiling point. — Sam

It is warm in the science lab today and this has added to the temperature reading. — Uri

Lydia had taken the reading incorrectly. — Narinda

The thermometer was inaccurate. — Phil

The thermometer was left too long in the beaker. — Oli

The thermometer had not been left long enough in the water. — Gill

The thermometer was touching the beaker which was hotter than the water. — Poppy

Activity 1

If possible, discuss the suggestions made by the class in a small group. Arrange the suggestions into two categories, possible (plausible) explanations and unreasonable ones. You may be able to agree the lists in your group or you may need to simply write your own.

Activity 2

For each possible explanation, describe what further experimental work you would do to decide whether it might be correct or not. Explain how that experimental work would help you decide if the suggestion was correct.

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Example

You might have put Narinda's suggestion (Lydia mis-read the thermometer), into your list of reasonable explanations. If so, a simple way of testing this suggestion would be to get several members of the class to come and take the reading themselves. If they agree that the thermometer reads 102 °C, then you have been able to eliminate Narinda's suggestion as a possible explanation. If the students take the reading to be 100 °C then you might conclude that Narinda's was the correct explanation.

Activity 3

You may be able to suggest a different explanation for the reading. If you can, discuss your ideas in a group.

Activity 4

Devise your own concept cartoon about another surprising experimental result – *eg* a student weighed 50 cm^3 of water and the reading was 45.3 g, a student measured the temperature of water heated in a test-tube by different Bunsen burner flames and found that the luminous flame gave the highest temperature *etc*.

Discussion of answers

Boiling point

It is important to know that this activity is designed to help develop critical thinking (evaluation) skills. You are asked to make judgments about the suggestions made based on scientific reasoning.

Without being in the classroom we probably can't say for sure why the thermometer reading taken was 102 °C. However, we can form opinions about how likely each explanation is. We can also suggest procedures to test the suggestions.

Sam – The water was not pure water and the impurities changed the boiling point.

This seems a reasonable suggestion. Impurities would raise the boiling point of water. Some people think that is why salt is often added to boiling vegetables. However it is unlikely that the typical amounts of dissolved substances in normal tap water would change the boiling point by as much as two degrees. That would need a considerable amount of impurities.

To test this idea the experiment could be done using distilled water and having carefully washed and rinsed the beaker.

Phil – The thermometer was inaccurate.

This is probably more likely than you realise and arguably the most likely explanation. It is tempting to believe that all apparatus is accurate. This is not the case. You might like to see how accurate the volume marks are on a beaker, for instance. You will find that they are only very approximate guides. Different thermometers can be more, or less accurate. Some thermometers are manufactured to be more accurate than others. A guide to how accurate a reading is likely to be is the size of the sub-divisions in the thermometer's scale. A thermometer with markings every tenth of a degree is likely to be more accurate than a thermometer with marking only every two degrees.

To test this idea several different thermometers could be put into the water and readings taken from them all.

Apparatus that is used to measure volumes of liquids (volumetric apparatus) comes in two grades. Apparatus labelled A is more accurate and more expensive. B grade is typically used in schools and is less accurate and less expensive.

Gill – The thermometer had not been left long enough in the water.

This does not seem very likely. If the thermometer had not been in the water long enough it would still be warming up and would be likely to read **less** than 100 °C.

To test this explanation the thermometer could be left in the water and readings taken every 30 seconds to see if it changed.

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Poppy – The thermometer was touching the beaker which was hotter than the water.

This seems like a sensible suggestion. The beaker would be hotter than the water, heat energy is flowing from the flame to the beaker then from the beaker into the water to keep the water boiling. Flame, beaker, water is the order in decreasing temperature.

To test this suggestion, the experiment could be repeated this time holding the thermometer off the bottom of the beaker.

Uri – It was warm in the science lab that day and this added to the temperature reading.

The temperature of the room should not affect the boiling point of the water. However, if the room was warm that might be because it was a fine day associated with high atmospheric pressure, see note below.

Oli – The thermometer was left too long in the beaker.

The water should boil at 100 °C no matter how long you heat it or how vigorously it boils.

Note

Boiling points can be affected by air pressure. For example, they tend to decrease high up a mountain where the air pressure is low. The air pressure around us does not stay rigidly constant but can go up or down. Different weather is associated with changes in air pressure. High air pressure often brings hot sunny weather. The boiling point of water could vary by as much a degree either side of 100 oC depending on whether the air pressure is high or low.

Information about the relationship between air pressure and boiling point can be found at *http://hyperphysics.phy-astr.gsu.edu/hbase/kinetic/vappre.html#c5* (accessed April 2007)

If you want to see the details of a global experiment to see the effect of air pressure, on boiling point, visit *http://astro.uchicago.edu/cara/southpole.edu/boil.html* (accessed April 2007). You could ask your teacher if you could do the experiment and submit your data.