

How Is This Module Organized?

This module is written as an educator guide. This approach makes it possible to give it a conceptual and pedagogical structure while still providing educators the flexibility to tailor the activities to the needs of their classes. The educator guide prepares educators to conduct classes around core questions, and it outlines investigations that explore those questions.

Activity 1

Is There Water on Mars? An Educator's Guide With Activities for Physical and Earth and Space Science

Background

Why start a unit on Mars by boiling water? Interestingly, a lot of the boiling water seems to have boiled away, and studying boiling can help us understand why Mars has no liquid water. You should remember how water can boil when the average temperature on Mars is -60 degrees Celsius. The way to understand this apparent contradiction is to better understand boiling. Our day-to-day experiences give us a decidedly limited understanding of boiling. To better understand boiling, students need to experience the existence of the phase change plateau (Figure 1.1).

← Organization →

← Particles' Kinetic Energy →

Figure 1.1. As a material's temperature changes, the spacing and energy level of its particles change.

In this activity, it is important to understand how liquids change into vapor (Figure 1.1). Molecules remain in the liquid phase until they gain sufficient kinetic energy (vibrational motion) to overcome the forces keeping them together. These forces include the attraction between molecules and the air pressure above the liquid. Adding heat to a liquid is an easy way to increase the kinetic energy of its particles. At some particular temperature, the particles will have become energetic enough to dissociate themselves from their neighbors and become a vapor. This is called the **boiling point**.

At the boiling point, any heat added to the liquid is absorbed by the molecules and the liquid changes to the vapor phase. Because these molecules escape into the air and carry away this extra heat, the temperature of the liquid never rises beyond the boiling point. In a graph showing the temperature history of some heating water (Figure 1.2), the boiling point graphs as a plateau.

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Learning Activities

Clear, detailed activity procedures (with reproducible student sheets, when required) facilitate planning and classroom implementation.

Background

Thorough, easy-to-understand background information enables you to understand the key concepts in an activity.

Activity 1

Is There Water on Mars? An Educator's Guide With Activities for Physical and Earth and Space Science

Preassessment

- (a) *Students Take a Position and Become Aware of Their Preconceptions:* Ask students how hot they could heat water given unlimited time and heating equipment.
- (b) *Students Express Their Beliefs:* Have each student write down his or her prediction, sign his or her name, and hand it in to the teacher.

Procedure to Test Students' Preconceived Ideas

1. Present the problem, "How hot can you heat water?" and as a class discuss how to control variables such as the amount of water, the number of burners, the height of the ring, etc.

Consider using 100–150 milliliters of water because it: (a) is easy to measure; (b) comes to a boil in 5–8 minutes; (c) does not boil away during a class period; (d) does not make too big a mess if spilled; (e) will not burn as badly as larger amounts of water if spilled on the skin; and (f) will cover the thermometer bulb. Make sure to read the safety notes on page 5 before beginning the activity.
2. Have student teams set up the equipment for the activity (Figure 1.3):
 - Measure the agreed-upon amount of water
 - If using Bunsen or alcohol burners, adjust the lower ring to fit the burner properly and set a wire gauze on the lower ring
 - Place the beaker or flask containing the water on the wire gauze or on the hot plate (turned off)
 - Attach the thermometer above the beaker with a clamp or string
 - Adjust the thermometer so that the thermometer bulb is completely submerged and just above the bottom of the beaker (So it can measure the water temperature rather than the temperature of the glass, it should not touch the bottom of the beaker)
3. Have students take the starting water temperature.

Teams of two students work well because there is little opportunity for off-task behavior when each student is totally engaged monitoring the time and temperature.
4. After you check each group's setup, have students either light their burners or switch on their hot plates.
5. Using a string rod (not the thermometer), have students stir and record the water temperature every 15 seconds.

Noticing a temperature plateau is a surprise that challenges students' intuition. Thus, the activity becomes a rich experience upon which to challenge old ideas and to develop new understandings. At some point between 97 and 105 degrees Celsius (depending on the weather and your elevation), students find that the temperature no longer changes. The crucial element in the discovery that, although the burner will quit in heat, the temperature stops rising. Do not let on that this is the result students are meant to achieve.

Figure 1.3. Activity 1 set up with (a) a burner and (b) a hot plate.

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Teaching Pointers

To assist you in conducting hands-on, inquiry-based activities, you will find pointers, classroom management strategies, discussion suggestions, extensions, and answers to the questions presented throughout the module.

Assessment Suggestions

This module outlines several options for assessing students, including preassessment questions, question sets, case studies, and suggestions for alternate ways of exhibiting student understanding.

Activity 1

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Preassessment

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 - Attach the thermometer above the beaker with a clamp or string.
 - Adjust the thermometer so that the thermometer bulb is completely submerged and just above the bottom of the beaker. (So it can measure the water temperature rather than the temperature of the glass, it should not touch the bottom of the beaker.)
- Have students take the starting water temperature.

Teams of two students work well because there is little opportunity for off-task behavior when each student is totally engaged monitoring the time and temperature.
- After you check each group's setup, have students either light their burners or switch on their hot plates.
- Using a stirring rod (not the thermometer), have students stir and record the water temperature every 15 seconds.

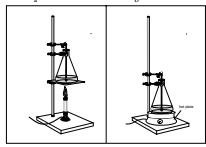



Figure 1.3. Activity 1 set up with (a) a burner and (b) a hot plate.

Heating a temperature plateau is a surprise that challenges students' intuition. Thus, the activity becomes a rich experience upon which to challenge old ideas and to develop new understandings. At some point between 97 and 105 degrees Celsius (depending on the weather and your elevation), students find that the temperature no longer changes. The crucial element is the discovery that, although the burner still puts its heat, the temperature stops rising. Do not let us see that this is the result students are meant to achieve.

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Technology and Internet Recommendations

Computers and the Web can give students access to a rich set of support materials. The module lists pertinent Web sites, CD-ROM's, and videos and how to get actual Martian data and images. However, this module does not require the use of any classroom technology.

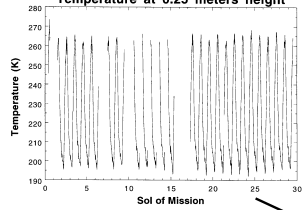
Case Study

Each activity in this module provides some of the information needed to answer the question: Is there water on Mars? In Activity 6, students take a position on this question and apply and integrate the module's concepts. This synthesis can be used as an assessment.

Activity 6

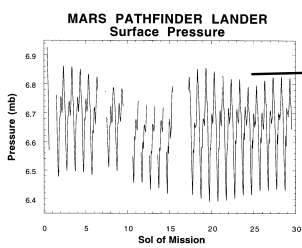
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MARS PATHFINDER LANDER
Temperature at 0.25 meters height




Courtesy of Dr. Jim Murphy, Mars Pathfinder ASIMET Team

MARS PATHFINDER LANDER
Surface Pressure



Courtesy of Dr. Jim Murphy, Mars Pathfinder ASIMET Team


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