TEMI

The Book of Science Mysteries

A flower hidden by the cold

CLASSROOM SCIENCE ACTIVITY TO
SUPPORT STUDENT ENQUIRY-BASED LEARNING

This classroom-tested teaching plan uses the four innovations of the TEMI project, as detailed in the Teaching the TEMI Way (TEMI, 2015).

You should read this companion book to get the most from your teaching. The **TEMI** techniques used in this teaching plan are: **1)** productive science mysteries, **2)** the **5E model** for engaged learning, **3)** the use of presentation skills to engage your students, and **4)** the apprenticeship model for learning through gradual release of responsibility. You might also wish to use the hypothesiser lifeline sheet (available on the **TEMI** website) to help your students document their ideas and discoveries as they work.

To know more about **TEMI** and find more resources **www.teachingmysteries.eu**

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teachingmysteries.eu

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What's the mystery?

A toy balloon filled with air is immersed in liquid nitrogen and the air seems to disappear: the balloon shrinks completely. The air seems to have disappeared.

DOMAIN(S)

Physics.

SUBDOMAIN KEYWORDS

Phase transitions, gas laws.

AGE GROUP

12 to **18** years old.

EXPECTED TIME FOR THE MYSTERY

Approximate time for teacher preparation:
One hour.

Approximate time in classroom:
Three or **four** individual **50 min.** lessons.

SAFETY/SUPERVISION

Liquid nitrogen requires local health and safety precautions and pupils should be supervised at all time during its use.

Disclaimer: the authors of this teaching material will not be held responsible for any injury or damage to persons or properties that might occur in its use.

PREPARATION AND LIST OF MATERIALS

» Dewar with liquid nitrogen
» Toy balloons
» Air pump
» Toy balloon filled with helium gas
» Cryogenic gloves
» Syringes with one end plugged
» Temperature sensor
» Weights
» Supports for syringes
» Electric hotplate
» Thermal cups
» Glycerol
» Graduated cylinder (at least 60-70 cm height)
» Thin plastic tube (usually used for aquariums).

LEARNING OBJECTIVES

» Qualitative graphical representation of a certain thermodynamic variable in the function of another: in particular, representation of the volume of a gas as a function of the temperature or pressure.

» Introduction to phase transitions.

Guidance notes for teachers

THE 5E MODEL

Engage

CAPTURE STUDENTS' ATTENTION

This phase has to be prepared a few minutes before the lesson. Inflate two or three toy balloons and put them in liquid nitrogen gently closing their aperture with a clamp. Then extract them, let them to swell up again, open their aperture, allow them to deflate, and finally close them with a knot. Inflate a toy balloon (of a different and recognisable colour, e.g. red), close it with a knot, and then put it in the liquid nitrogen together with the other balloons you just closed. Do the same thing with a toy balloon shaped like a flower: a long thin balloon can be used for this, since this kind of balloon can be twisted into a flower shape. You can start the lesson by extracting the empty balloons first, which will not swell, and then the balloon of the recognisable (red) colour, which will swell. What is the reason for this different behaviour? Extract the flower-shaped balloon to conclude the presentation of the mystery.

Explore

COLLECT DATA FROM EXPERIMENTS

Insert the balloon in liquid nitrogen and let the students observe what happens to the volume. The experiment can be interrupted at subsequent steps and students may make some qualitative observations about the progressive reduction of the balloon volume and the appearance of a liquid air drop.

Moreover, students may continue their investigation with syringes. One end should be plugged (melting one end with a flame, for example) and the syringes should be filled with air and put in beakers filled with some water: it is possible to study the volume variation of the air inside the syringe when the water (and also the gas) temperature varies, but not the pressure.

It is then possible to investigate the behaviour of a toy balloon filled with helium and immersed in liquid nitrogen; in this latter case, the volume will be reduced, but no phase transition will take place.

Explain

WHAT'S THE SCIENCE BEHIND THE MYSTERY?

This mystery can trigger off a discussion about the behaviour of gas and its relation to temperature. Moreover, it is possible to note a phase transition when the balloon is filled with air, but not when it is filled with helium.

Students first have to explain that the gas inside the balloon cannot be a consequence of a chemical reaction: then they can relate the volume of the gas to its temperature. Using the balloon filled with helium, they can appreciate the qualitative behaviour of the volume in relation to temperature. With the balloon filled with air, the teacher can also describe what happens in a phase transition from gas to liquid. It is possible to achieve a quantitative explanation after having read textbooks or after a discussion within the class.

Extend

WHAT OTHER RELATED AREAS CAN BE EXPLORED?

This phase can initially stimulate reflection about the relation between the volume of a gas and its pressure. This can be done using a cylinder filled with glycerol from the bottom: small air bubbles are released into this via a syringe connected to a thin plastic tube, with the other end inside the bottom of the cylinder.

It is also possible to investigate more quantitatively the relationship between the volume of a gas and the pressure: this can be carried out by means of a plugged syringe filled with air and kept vertical by a support. An increasing number of weights should be placed on its top.

Further extensions may relate to the definition of absolute temperature, a statement of the general law of perfect gas, and the differences between a perfect and a real gas.

Evaluate

CHECK THE LEVEL OF STUDENT SCIENTIFIC UNDERSTANDING

The present mystery is principally useful for stimulating a qualitative form of reasoning among students. Therefore teachers can evaluate students during oral interviews in which pupils have to state what they can and cannot deduce from the experimental phase. Students can use a graphical representation of what they saw and also ascertain what elements they are lacking in order to get a more detailed representation.

Teachers may also investigate students' reasoning about the shape of the air bubbles that go up into the glycerol or do more quantitative investigations about what the students have experienced with the changing pressure on the plugged syringe (see the extend phase).

THE 5E MODEL

Showmanship

TIPS ON HOW TO TEACH AND PRESENT THIS MYSTERY

The mystery proposed always engages students a great deal. They can be left to play with liquid nitrogen (using the due safety precautions) and become familiar with the physics of low temperatures.

It is possible to surprise students by inflating two identical toy balloons (possibly of an elongated and thin shape: it is easy to put this kind of balloon into the Dewar containing the liquid nitrogen): one will be filled with air and the other with helium. If the latter balloon is inflated with helium about two or three hours before the lesson, some of the air of the room will enter the balloon through osmosis and it will not go upwards, thus behaving in exactly the same way as the other balloon.

GRR

TEACHING SKILLS USING GRADUAL RELEASE OF RESPONSIBILITY

Setting up the mystery: tell the class how it is possible that only one of the balloons extracted from the liquid nitrogen swells while the other remains deflated.

Demonstrated enquiry (level 0).
Teacher-as-model: you show how to carry out an enquiry process which the students the copy. Explain your hypothesis and tests by 'talking aloud'. Students can record your thinking onto their hypothesiser lifeline worksheet.

Since a certain amount of care must be taken when handling liquid nitrogen, this is a mystery that could be fruitfully used in a level 0-enquiry lesson.

Moreover, the teacher will very quickly provide the solution of the mystery. This can be proposed by both extracting the balloons out of the liquid nitrogen and inserting them into the Dewar. Therefore, it will be very easy to understand the methodology and how to use the worksheet.

It is important that the teacher explains when it is and is not possible to get quantitative information from a certain experiment, because students often tend to invent graphs that represent a certain physical law.

Structured enquiry (level 1).

'We do it'. Students then use their Hypothesiser Lifeline sheet to record their own alternative ideas when the teacher asks "where does the air go?" or "where does the air come from?" Since it is likely that there will be one Dewar, personal experimentation may be a little difficult; however, the students can still participate in a class discussion. A more fruitful level 1 enquiry lesson can take place when studying the behaviour of a gas in relation to its pressure. In this case, students can be left safely with the glycerol in the graduated cylinder, observing the air bubbles that change their shape as they go up; in this step, it is possible to speak about the 'you do it' phase of the GRR.

Solving the mystery: students are led towards the explanation by using ideas about the behaviour of the volume of a gas in relation to its temperature and the behaviour of a gas in relation to its pressure.

Resources

To become familiar with the most common phase transitions, it is possible to observe what happens for water. This video shows how the phases depend on temperature. TEMI Youtube Channel:
www.goo.gl/tUDaq5
playlist > phase transition of water

In the following video, the dependence of the phase on the pressure is shown.
TEMI Youtube Channel:
www.goo.gl/tUDaq5
playlist > pressure induced phase transition of ice

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STUDENT WORKSHEET

You have seen that many of the balloons extracted from the liquid nitrogen do not inflate when at room temperature; however, one behaves differently. How is this possible?
Where does the air come from?

Engage

WHAT'S INTERESTING?

Task 1: Take the two inflated balloons and put them carefully in a Dewar containing liquid nitrogen. What is similar in the two cases? What is different?

Task 2: The air seems to diminish or disappear inside the balloons. Can you explain why this happens?

Explore

WHAT'S HAPPENING?

Task 1: Explore what happens to the first balloon when you insert it into the liquid nitrogen.

Task 2: Explore what happens to the second balloon when you insert it into the liquid nitrogen.

Task 3: Explore what happens inside the two balloons when you extract them from the liquid nitrogen. Hint: look sharply and quickly, because the changes in a gas are very fast!

Task 4: Explore what happens to a syringe filled with air which is plugged at one end and placed into a beaker filled with heated water.

Task 5: (Facultative) At home, explore what happens to a toy balloon filled with air when you put it carefully next to a heater or into the fridge or what happens to a packet of salad when you move it from the supermarket fridge to your car on a hot summer day. Equally, what happens to the pressure in your bike tires during summer and winter?

Explain

WHAT'S CAUSING IT?

Task 1: Describe the observed behaviour of the gas inside the balloon when the temperature of the gas changes.

Task 2: Do you have enough data to draw a graph of the volume as a function of the temperature? If not, why not?

Task 3: Write down your explanation about what is happening during the process that causes the apparent disappearance of the air inside the balloon. Compare this to what happens to the balloon filled with helium.

Extend

WHAT'S SIMILAR?

Task 1: What happens to the volume of a gas when its pressure changes? Try with a syringe with one end closed by glue.

Task 2: If you have a support for your syringe and some weights that you can add to the top of your syringe, describe and represent the behaviour of the volume as a function of the pressure.

Task 3: Conduct an experiment using a graduated cylinder at least 60-70 cm height, in which you can insert a thin plastic tube with one end in the bottom of the cylinder and the other end outside the cylinder connected to a small syringe. Blow little air bubbles into the glycerol with the syringe. Describe qualitatively the shape of the bubbles.

Evaluate

WHAT'S MY UNDERSTANDING?

Task 1: Suggest or design experiments for the visualisation of other gas laws. In the present example, we have considered the qualitative relationships between the volume and the temperature and between the volume and the pressure. Can you suggest other possibilities? How can you explore them?

Task 2: Since the experiments might be too challenging from a practical point of view, you can limit yourself to designing experiments.