The mystery of the

disappearing laboratory report

A TEMI LESSON PLAN





Overview

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| What’s the mystery? | This mystery deals with a laboratory report in which the written results suddenly vanished. The students need to find out how the writing vanished, how to recover the vanished data and what the secret of the pen is. |
| Domain(s) | Chemistry  Energy (exothermic & endothermic reactions), chemical equilibrium, thermodynamics. |
| Age group | Grades 11-12 (16-17 years old) |
| Expected time for the mystery | Approx. Time for teacher preparation – One hour to prepare the lab reports (writing them and warming them up to make the ink disappear). If not pens are available time needs to be allocated to purchasing the pens.  Approx. Time in classroom - Up to 6 periods of 45mn. One period to engage and explore; one to explain, 3 for open enquiry and one to present the enquiry in class. |
| Safety/Supervision | None. If there is use of liquid Nitrogen, safety regulations related to its use are necessary |
| Preparation & List  of Materials | * A pilot friXion ball erasable ink pen for each group of 3-4 students * A lab report with missing/erased data * Different equipment to heat and cool the paper (such as a kettle, hair dryer, liquid nitrogen) |
| Learning objectives | Exposing students to reversible chemical reactions. Experimenting with the conditions that influence such reactions. |
| Authors | Malka Yayon, Dvora Katchevich, Ran Peleg, Rachel Mamlok-Naaman, Avi Hofstein and David Fortus, Weizmann Institute of Science |



L Guidance notes for teachers

Engage: Capture student’s attention

The teacher tells a story about how she/he left students' lab reports in a hot place (such as in a car in summer, in front of a fire place) and how the next day when the looked at the report, most of the data disappeared. Alternatively, the teacher can hand out students greeting cards (for the new school year, for a holiday, etc.) in which half the text disappeared.

Explore: Collect data from experiments

Students try to make the ink reappear. They can suggest and try their own ways of making the ink reappear. Students often suggest actions such as heating, cooling at different temperatures, exposing the paper to different pH-s, exposing the paper to light at different intensities.

Explain : What’s the science behind the mystery?

The ink is made of thermochromic pigment which is sensitive to temperature changes. As the ink is exposed to high temperatures it changes from coloured to colourless. This property is exploited to make erasable ink – when ink applied onto paper rubbed with a special plastic (on the cap of the pen) the heat caused by the friction makes the ink disappear.

However, this is a reversible reaction and the colour can be made to reappear upon cooling.

Further data can be found in the following link:

<http://www.tmchallcrest.com/chromazone/Thermochromism.htm>

Extend: What other related areas can be explored?

Students design their own enquiry based experiments based on their knowledge related to Thermodynamics, Energy and Le Chatellier principle to explore the thermochromic properties of the ink. This enquiry is open ended and the enquiry questions should come from the students.

Sample questions could be: "At what temperature does the ink disappear?", "At what temperature does the ink reappear?", "Can the process be made non-reversible (e.g. by overheating the ink)", "If the pen is heated, can it be used to write invisible scripts?".

Evaluate: Check the level of student scientific understanding

Students are assessed using two methods. They prepare a formal written lab report and they prepare an oral presentation of the lab report in class. The written and oral lab reports assess skills such as making observations, asking questions, designing experiments, writing scientific explanations and propose hypotheses. The oral presentation further allows for discussion and allows presenters to improve their lab reports.

Tips on how to teach and present this mystery

The engaging story has to be relevant to the teacher and the scenario in class. It can relate to a recent lab report they did, to a holiday coming up, etc.

As an additional exercise, students may draw a picture that "uses" the phenomena of the disappearing/reappearing ink to express an idea and show it; it could be a good idea to encourage students to involve some showmanship in the presentation.

Teaching Skills using Gradual Release of Responsibility

Notes: Most Mysteries can also be used to teach Enquiry skills. A ‘Skill-teaching ’ TEMI lesson needs to use a modified 5E cycle where the Explain stage precedes the Explore. This is because it is necessary for the teacher to model the skill before, students practice it, as described in the box below:

The activity begins with the presentation of the mystery. In the first stage (explore) students conduct structured enquiry (level 1) in order to understand the phenomenon and solve the mystery.

In the extend stage, students conduct open ended enquiry (level 2). Here, with the help of the teacher, they learn to ask research questions, design an experiment, carry the experiment out, process the data and reach conclusions based on the data.

**THE STUDENT WORKSHEET CAN BE COPIED AND USED IN THE CLASSROOM**

 Student worksheet

Introduction to mystery

Yesterday we had great results at the lab! We explored different kinds of reactions, measured the temperature vs time for all of them and organized the data in beautiful tables. We thought about every detail! Titles, units, observations-everything was there!! We were so tired and proud, that we decided that we deserve a break on the beach in this hot summer day.

When we came back and opened our notebook, we were shocked to see that our data was gone! The outline of the table was there, but the data was gone!

Engage What’s interesting?

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| **Task 1** | Suggest relevant observations or questions that need to be considered to resolve the mystery of the missing data, to write "the story of the table". |
| **Task 2** | Suggest how to re-appear the missing data in the lab report that you received. |

Explore What’s happening?

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| **Task 1** | Ask for materials and equipment and try to make the ink reappear. Explore the behavior of the ink. |
| **Task 2** | Describe what you did and what happened. |

Explain What’s causing it?

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| **Task 1** | Hypothesize: How does the ink work? |
| **Task 2** | Give a reasonable explanation for your hypothesis based on concepts related to energy transfer in chemical reactions. |
| **Task 3** | Brainstorm with the class and explain how the ink works. |

Extend What’s similar?

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| **Task 1** | Write five questions that arose while exploring the ink? |
| **Task 2** | Choose one of the questions that you would like to investigate regarding the "ink" and formulate this question clearly as an enquiry question? |
| **Task 3** | Clearly formulate a hypothesis that relates to the question that you chose to investigate. Give reasons for your hypothesis, based on correct and relevant scientific knowledge. |
| **Task 4** | Plan an experiment that will check your hypothesis.  • Detail all the steps of the experiment, including the control stage.  • List the equipment and materials needed on the equipment request form.  • Consult with the teacher and make changes if necessary.  • Submit the list of equipment and materials to the laboratory technician. |

Evaluate What’s my understanding?

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| **Task 1** | Prepare a lab report. |
| **Task 2** | Draw a picture that "uses" the phenomena of the disappearing/reappearing ink to express an idea. If you want, think of a creative way to present the change to the class. |
| **Task 3** | Present the enquiry and your drawing in class. |