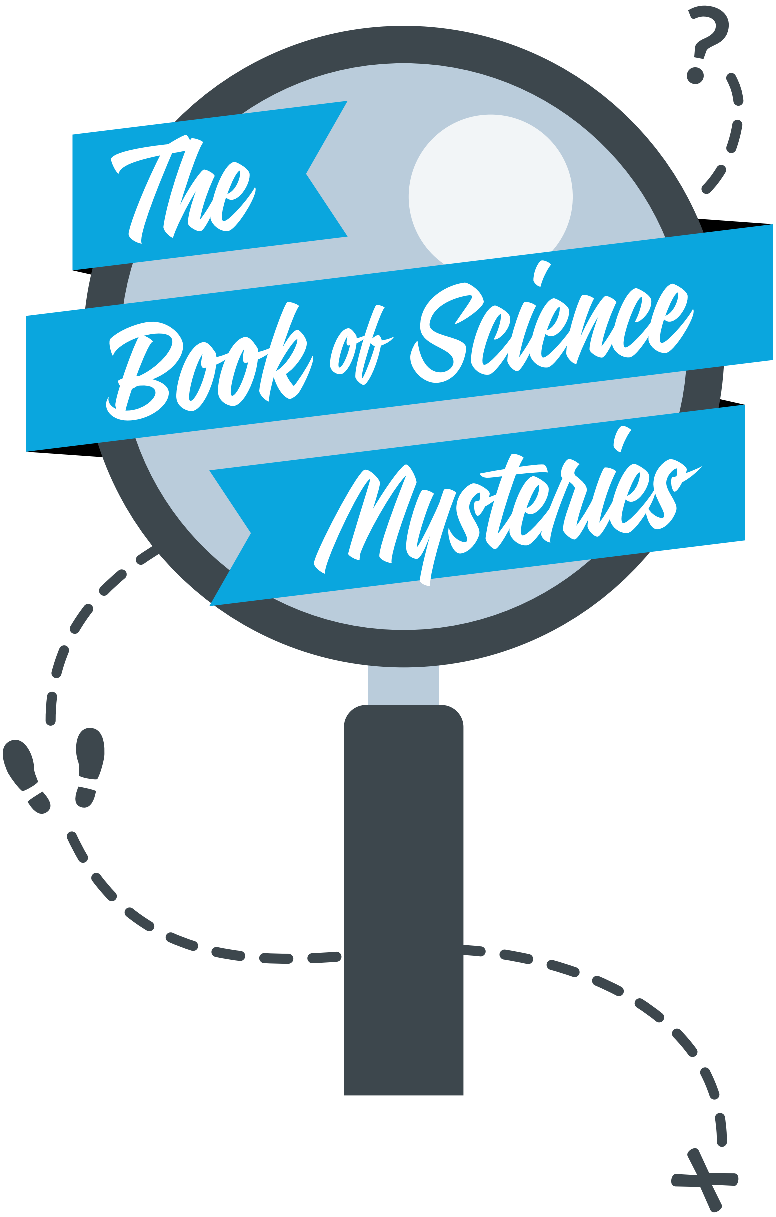
TEMI



The clock reaction

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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The clock reaction

What's the mystery?

Two translucent liquids are mixed. At first, nothing happens: the resulting solution is still translucent. Suddenly, with no warning, the solution turns blue-black all at once.

DOMAIN(S)

Chemistry.

SUBDOMAIN KEYWORDS

Redox reactions, rate of reaction (kinetics).

AGE GROUP

15 to **17** years old.

EXPECTED TIME FOR THE MYSTERY

Approximate time for teacher preparation: up to **one hour** for preparation of the solutions and trials to ensure that the reaction takes place as planned.

Approximate time in classroom: up to **six periods of 45 mins** each (one period to engage and explore, one to explain, and three to plan, perform, and present the creative activity that incorporates the colour change).

SAFETY/SUPERVISION

Iodine (I_2) is produced in the reactions. The reaction vessels should be tapped. At the end of the reaction, the iodine produced should be neutralised with $Na_2S_2O_3$ solution.

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

- Potassium iodide, KI 0.1M (solution A).
- Hydrogen peroxide, 3 % $H_2O_{2\,(aq)}$ in an acidic environment + starch (solution B).
- Sodium thiosulphate, $Na_2S_2O_3 \bullet 5H_2O$ ~0.05M (solution C).
- Neutralising solution: sodium thiosulphate, $Na_2S_2O_3 \bullet 5H_2O$ ~0.05M (the solution is the same as solution C. It is written separately to remind that an additional amount for neutralisation is necessary).
- 3 × 10 ml graduated cylinders
- 3 large test tubes
- Suitable test tube rack
- 3 rubber stoppers for the test tubes
- 3 plastic pipettes

LEARNING OBJECTIVES

Introduction of interesting Redox reactions.

Introduction of reaction rates, the effects of fast and slow reactions, and their uses.

Guidance notes for teachers

THE 5E MODEL

Engage

CAPTURE STUDENTS' ATTENTION

The student watch the following silent movie on the TEMI Youtube Channel: www.goo.gl/tUDaq5
Playlist> Engage pantomime (Video 1)

While watching, they write down observations and questions.

If the movie cannot be shown, the teacher can conduct the experiment live. Suitable amounts of solutions A and C are mixed in a jug. Solution B is poured into a wine glass. The solutions in the jug and in the wine glass are mixed and poured back and forth until the solution has changed colour.

During the process, the teacher tells a short story; for example, "I ran out of blackcurrant juice, so I bought water; with magic and some chemistry, I have turned it into juice."

Explore

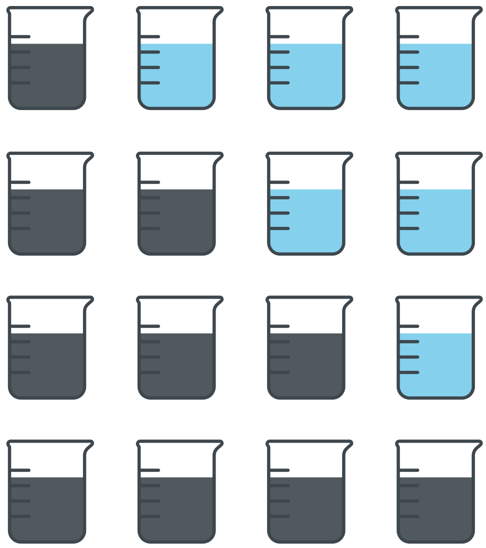
COLLECT DATA FROM EXPERIMENTS

Students are asked to perform experiments which will guide them step by step (1–3) to understanding the clock reactions.

1 Students mix solutions A and B. This immediately generates a black colour.

2 Students mix solutions A and B in the presence of solution C; the appearance of colour is delayed. Each student group receives a different volume of solution C, causing different delays in the appearance of the colour.

3 A representative from each group is asked to perform experiment (2) together with all the other representatives before the class. The black colour appears at different times, thus forming a visual 'xylophone' (see on the TEMI Youtube Channel: www.goo.gl/tUDaq5
4 Explore 3 Explain (Video 3))



Explain

WHAT'S THE SCIENCE BEHIND THE MYSTERY?

Students are given information regarding the reactions that occur. They are also told that starch is an indicator for the presence of iodine and that the presence of both in a solution causes it to change to a black colour. Students are then asked to explain the phenomenon.

The full explanation is as follows.

Two competing reactions are taking place in the reaction vessel:

1 $H_2O_{2\,(aq)} + 2H_3O+_{(aq)} + 2I^-_{(aq)} \rightarrow I_{2(aq)} + 4H_2O_{(l)}$

2 $2S_2O_3{}^{2-}{}_{(aq)} + I_{2(aq)} \rightarrow S_4O_6{}^{2-}{}_{(aq)} + 2I^-_{(aq)}$

Reaction 1: oxidised iodide, I-(aq), into iodine, I2. The latter appears black in the presence of starch.

Reaction 2: the reduction of the iodine back into colourless iodide.

Since reaction **2** is faster than reaction **1**, the solution remains colourless: any iodine formed is quickly transformed into iodide.

These two reactions occur simultaneously until the thiosulphate ions ($S_2O_3^{2-}$), the limiting agents, run out. When this happens, only reaction 1 takes place: all iodide turns to iodine and the solution becomes black.

Extend

WHAT OTHER RELATED AREAS CAN BE EXPLORED?

The teacher collects data from the different groups regarding the time at which the black colour appeared and the volume of the inhibiting solution. The class analyses the data using a table on the board and draws a graph of the inhibitory solution's volume against the time of the black colour's appearance.

The trend line and the mathematical equation of the slope on the graph are used to explain the concept of the calibration graph and its use.

Students are asked to design an experiment in which the appearance of the black colour is synchronised with a sound change in a song or with any other creative element.

Each group presents the plan of the experiment before the class.

Evaluate

CHECK THE LEVEL OF STUDENT SCIENTIFIC UNDERSTANDING

Students prepare a lab report which assesses skills such as making observations, asking questions, designing an experiment, writing explanations, and hypothesising. Students have to explain why the experiment is called the 'clock reaction'.

THE 5E MODEL

Showmanship

TIPS ON HOW TO TEACH AND PRESENT THIS MYSTERY

The engage stage can be completed by showing **video 1** or by performing the clock reaction on a large scale. If the teacher feels comfortable, we suggest and encourage telling a story relevant to the students.

The explore stage **(1–2)** is self-explanatory (**video 2)**. While performing in front of the class **(3)**, the teacher has to direct the performance in the following way:

1. All the students stand in a line and wait to mix solution B at the same time. The teacher may order them by the volume of solution C or in a random manner.
2. The 'stage' should help students focus on the reaction **(video 3)**; this can be done by:
   a. Putting white paper as a background below and behind the reaction containers.
   b. The reaction takes time, so think what to say while the reaction occurs: "what do you expect to see?", "which will appear next?", etc.

The extend stage should be an event in class. Each group presents their chosen song and there should be 'tension' over whether the colour change is synchronised with the music.

GRR

TEACHING SKILLS USING GRADUAL RELEASE OF RESPONSIBILITY

The lesson begins with a demonstration of the mysterious phenomenon (the engage stage). During the demonstration, students also see the teacher mix the reaction.

In the explore stage, they imitate the teacher's actions and follow strict instructions. The students need to use and understand the idea of a calibration curve to perform the extend stage. In the extend stage, they are encouraged to 'own' the reaction and control it so that it 'performs' in accordance with a song they like.

Students thus gain control of planning and engineering the reaction.

During the activity, students learn the following enquiry skills: engagement in scientific questions, giving priority to evidence, formulating explanations from evidence, connecting explanations to knowledge, graphic representations, and calibration graphs and their meaning.

Resources

The following videos suggest ways in which the mystery can be presented. TEMI Youtube Channel: www.goo.gl/tUDaq5

>Playlist

For the engage stage:

Video 1: Video 1 Engage pantomime

For the explore stage:

Video 2: Video 2 2 Explore 1

Video 3: Video 3 4 Explore 3 Explain Engage

The clock reaction

STUDENT WORKSHEET

Two translucent liquids are mixed. At first, nothing happens: the resulting solution is still translucent. Suddenly, with no warning, the solution turns blue-black all at once.

You will see a demonstration of a mysterious chemical reaction. How does the reaction know when to turn black? Is there some magical ingredient that can't be seen? Does the teacher add some mysterious chemical when we aren't looking, or is the mysterious chemical already in the reaction vessel?

We will try to decipher a reaction that 'has a mind of its own'.

Engage

WHAT'S INTERESTING?

Task: Watch the following silent movie on the TEMI Youtube Channel:
www.goo.gl/tUDaq5
Playlist> Engage pantomime

What happens in the video? Why do you think this happens?

While watching, write what you see and pose some questions relating to what is happening. You may watch the video more than once.

Explore

WHAT'S HAPPENING?

Task: You will get three solutions:
Solution A – Potassium iodide, KI 0.1M

Solution B – Hydrogen peroxide, 3 % $H_2O_{2\,(aq)}$ in an acidic environment + starch

Solution C – Sodium thiosulphate, $Na_2S_2O_3 \bullet 5H_2O$ ~0.05M

You will also get the following materials:
» 3 × 10 ml graduated cylinders
» 3 large test tubes
» Suitable test tube rack
» 3 rubber stoppers for the test tubes
» 3 plastic pipettes
» Stopwatch
» Gloves, which must be worn at all times

Mark the three cylinders with the letters **'A'**, **'B'**, and **'C'**. Make sure that you always use one cylinder for each solution.

a. Measure 5 ml of solution A using the graduated cylinder marked 'A' and pour it into a large test tube.

b. Measure 10 ml of solution B using the graduated cylinder marked 'B'.

c. Pour solution B into the test tube containing A. Close the test tube with a stopper, mix lightly, and write your observations.

d. Measure 5 ml of solution A using the graduated cylinder marked 'A' and pour it into a clean large test tube.

e. Measure 3 ml of solution C using the graduated cylinder marked 'C' and add them to the test tube containing A.

f. Measure 10 ml of solution B using the graduated cylinder marked 'B'.

g. Pour solution B into the test tube containing solutions A and C. Start the stopwatch, close the test tube with a stopper, mix lightly, and write your observations.

h. Repeat instructions d–g in the class presentations according to the teacher's instructions.

Explain
WHAT'S CAUSING IT?

Task 1: Try to explain your observations based on the following reactions:

1. $H_2O_{2\,(aq)} + 2H_3O^{+}_{(aq)} + 2I^{-}_{(aq)} \rightarrow I_{2(aq)} + 4H_2O_{(l)}$
2. $2S_2O_22^{-}_{(aq)} + I2_{(aq)} \rightarrow S_4O_6{}^{2-}_{(aq)} + 2I^{-}_{(aq)}$

Task 2: The teacher will gather the findings of all groups in class. How do you suggest we present the data?

Extend
WHAT'S SIMILAR?

Task: In your groups, plan a creative activity that is based on and incorporates the colour change. For example, so that the solution changes its colour at a highlight in a song.

Plan an experiment, including the following stages:

» Detail all the steps of the experiment.

» List the equipment and materials needed on the equipment request form.

» Consult the teacher and make changes if necessary.

» Submit the list of equipment and materials to the laboratory technician.

Evaluate
WHAT'S MY UNDERSTANDING?

Task 1: Present the creative activity that incorporates the colour change.

Task 2: Prepare a formal lab report that includes an explanation of the phenomenon and the details of your methods and procedures.