Education
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Iodine clock reaction demonstration

In association with Nuffield Foundation

Introduce your students to rates of reaction and kinetics with the iodine ‘clock’ reaction. Mix a solution of hydrogen peroxide with potassium iodide, starch and sodium thiosulfate to see a colourless solution suddenly turn dark blue

This demonstration can be used at secondary level as an introduction to some of the ideas about kinetics. It can be used to stimulate discussion about what factors affect the rate of reaction. It also makes a useful starting-point for a student investigation.

Watch a video of this demonstration

This experiment is featured in our Get set … demonstrate video. A version of the experiment for students is used in our Rates of reaction video, 16-18 years, along with supporting resources, including illustrated technician notes, questions, worksheets and more.

The procedure described below outlines this experiment as a demonstration, best done on a large scale for the greatest visual impact. The demonstration itself takes less than one minute. For a student investigation, the quantities required would be smaller and they would have to measure the quanities quite accurately with, for example, disposable plastic syringes.

Equipment

Apparatus

- Eye protection
- Balance (1 or 2 decimal places)
- Beaker (1 dm^3)
- Beaker (250 cm^3)

- Volumetric flasks (1 dm^3) x2
- Measuring cylinder (50 cm^3)
- Measuring cylinders (100 cm^3) x2
- Stirring rod or magnetic stirrer and follower (optional)
- Stopwatch/timer

Chemicals

- Deionised or distilled water, 2 dm^3.
- Solution A (note 1):
  - Soluble starch, 0.2 g
  - Anhydrous sodium ethanoate (sodium acetate), 4.1 g
  - Potassium iodide, 50 g
  - Sodium thiosulfate–5–water, 9.4 g
- Solution B (note 1):
  - Glacial (concentrated) ethanoic acid (CORROSIVE), 30 cm^3 (note 2)
  - Hydrogen peroxide solution, 20 volume (IRRITANT), 500 cm^3 (note 2)

Chemical notes

1. Solutions A and B should be made up before the demonstration. The solutions will keep overnight, but best results are obtained if the solutions are made up on the day. Sodium thiosulfate will react with acids to give sulfur dioxide and a precipitate of sulfur, hence the sodium thiosulfate and ethanoic acid are separated in solutions A and B respectively.
2. If you have access to 1 M dilute ethanoic acid, use 500 cm^3 of this to make solution B. Mix 500 cm^3 of 20 volume hydrogen peroxide with 500 cm^3 of 1M ethanoic acid.

Health, safety and technical notes

- Read our standard health and safety guidance

- Wear eye protection.
- Anhydrous sodium ethanoate, $CH_3CO_2Na(s)$ – see CLEAPSS Hazcard HC038a.
- Potassium iodide, KI(s) – see CLEAPSS Hazcard HC047a.
- Sodium thiosulfate–5–water, $Na_2S_2O_3.5H_2O(s)$ – see CLEAPSS Hazcard HC095.
- Ethanoic acid, $CH_3CO_2H(l)$, (CORROSIVE) – see CLEAPSS Hazcard HC038a and CLEAPSS Recipe Book RB039. Handling glacial ethanoic acid requires care and should be done in a fume cupboard using gloves and eye protection.
- Hydrogen peroxide, $H_2O_2(aq)$ (IRRITANT) – see CLEAPSS Hazcard HC050 and CLEAPSS Recipe Book RB045.

Procedure

Solution A is made up as follows

1. Make a paste of 0.2 g of soluble starch with a few drops of water in a beaker. Pour onto this approximately 100 cm^3 of boiling water and stir.
2. Pour the resulting solution into a 1 dm^3 beaker and dilute to around 800 cm^3.
3. Add 4.1 g of sodium ethanoate, 50 g of potassium iodide and 9.4 g of sodium thiosulfate. Stir until all the solids have dissolved and allow to cool to room temperature.
4. Pour the mixture into a 1 dm^3 volumetric flask and make up to 1 dm^3 with water.

Solution B is made up as follows

1. In a 1 dm^3 volumetric flask mix 500 cm^3 of 20 volume hydrogen peroxide with 30 cm^3 of glacial ethanoic acid and dilute to 1 dm^3 with water.

The demonstration

1. Measure 100 cm^3 of solution A and 100 cm^3 of solution B in separate 100 cm^3 measuring cylinders.
2. Both solutions are colourless although solution A will be slightly cloudy.

3. Pour both solutions simultaneously into a 250 cm^3 beaker to mix. Ensure thorough mixing with a stirring rod or magnetic stirrer.

4. After about 20 seconds at room temperature the mixture will suddenly turn dark blue. The appearance of the blue colour may be timed – an assistant or a student can start and stop the timer.

Additional notes

- Hydrogen peroxide is capable of oxidising thiosulfate ions to tetrathionate ions but the reaction is too slow to affect this demonstration.
- The ethanoic acid/sodium ethanoate is added to buffer the pH.
- The acid will react slowly with sodium thiosulfate and produce a cloudy suspension of sulfur and release sulfur dioxide which is TOXIC - see CLEAPSS Hazcard HC097. To avoid this, the acid and sodium thiosulfate are separated in solutions A and B.
- The CLEAPSS Guide L195 ‘Safer chemicals, safer reactions’ gives useful information about how to carry out rates experiments involving acid/thiosulfate mixtures more safely.

Teaching notes

A white background will help so that the impact of the sudden and spectacular colour change is not lost. Scaling up the volumes of solution that are mixed may help in a large room. There is no warning of when the blue colour is about to appear.

It may help understanding if the students are already familiar with the reactions of starch and iodine, and iodine and sodium thiosulfate, so it may be worth demonstrating these beforehand.

The basic reaction is:

$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$

(For more advanced discussions or investigations – this reaction is the rate determining step and is first order with respect to both H_2O_2 and I^-.)

As soon as the iodine is formed, it reacts with the thiosulfate to form tetrathionate ions and recycles the iodide ions by the fast reaction:

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2\ I^{-}\ (aq)$

As soon as all the thiosulfate is used up, free iodine (or, strictly, I_3^- ions) remains in solution and reacts with the starch to form the familiar blue-black complex.

The time for the blue colour to appear can be adjusted by varying the amount of thiosulfate in solution A so a 'clock' of any desired time interval can be produced.

Additional information

This is a resource from the Practical Chemistry project, developed by the Nuffield Foundation and the Royal Society of Chemistry. This collection of over 200 practical activities demonstrates a wide range of chemical concepts and processes. Each activity contains comprehensive information for teachers and technicians, including full technical notes and step-by-step procedures. Practical Chemistry activities accompany Practical Physics and Practical Biology.

Health & Safety checked, 2016