Rates of reaction

Equipment (per group)

- Sodium thiosulfate solution, 40 g dm^{-3} (this is equivalent to about 0.2 mol dm^{-3}), 450 cm^3 if repeated 3 times
- Hydrochloric acid, 1 mol dm^{-3}, 150 cm^3 if repeated 3 times
- Distilled water, 450 cm^3 if repeated 3 times
- Stop bath: sodium carbonate solution, about 0.5 mol dm^{-3} containing an acid-base indicator, 250 cm^3 in a 800 cm^3 beaker to top up if necessary
- Plastic dropping pipettes x 3
- Conical flasks, 100 cm^3 x 4 if possible or 1 to be rinsed between each experiment
- Measuring cylinder, 10 cm^3
- Measuring cylinder, 50 cm^3 x 2
- Wash bottle with distilled or deionised water
- Stop clock
- Printed black cross, laminated
- Watch glass
- Thermometer
- Eye protection: safety glasses to EN166 F

Find the full method in the supporting resources, available from: rsc.li/40PFiXM.

Additional optional equipment

- Clamp and stand
- Water bath, electrically controlled
- Light sensor and data logger
- Black paper to shield the conical flask

Safety

- Read our standard health and safety guidance (available from: rsc.li/3MwtYKg) and carry out a risk assessment before running any live practical.
- Refer to SSERC/CLEAPSS Hazcards and recipe sheets. Hazard classification may vary depending on supplier.
- The thiosulfate-acid reaction causes problems because it produces sulfur dioxide gas which is toxic and can cause breathing difficulties (CLEAPSS Hazcard HC097). Use an alkaline stop bath to neutralise the used reaction mixtures. This minimises the production of sulfur dioxide gas and sulfur particles.
- Work in a well-ventilated laboratory and do not inhale directly over apparatus. View the black cross from ~20 cm above the conical flask.
- Only trained technicians and teachers should prepare chemicals.

Chemical supplied for the practical	Preparation
Sodium thiosulfate solution, 40.0 g dm^{-3} $Na_2S_2O_3(aq)$ Not currently classified as hazardous. CLEAPSS Hazcard HC095A.	Sodium thiosulfate pentahydrate solid $Na_2S_2O_3.5H_2O(s)$ MW = 248.18 g mol^{-1} Not currently classified as hazardous. CLEAPSS Hazcard HC095A. To prepare 1 dm^3 of solution: Wear eye protection. Weigh 40 g of $Na_2S_2O_3.5H2O(s)$. Add the solid to about 750 cm^3 of distilled water in a beaker. Stir to dissolve. Pour the solution into a 1000 cm^3 measuring cylinder or laboratory jug and add distilled water to the 1000 cm^3 mark.
Hydrochloric acid solution, 1.0 mol dm^{-3} HCl(aq) Not currently classified as hazardous. CLEAPSS Hazcard HC047A.	Hydrochloric acid concentrated HCl(aq), 35–38% (w/w) solution, which is about 12 mol dm^{-3} depending on the supplier.  **DANGER** Causes severe skin burns and eye damage. May cause respiratory irritation. Wear splash proof goggles when using concentrated hydrochloric acid and always add the concentrated acid to the water. Protect the face when opening bottles of the concentrated acid (pressure may have built up) or when transferring or dispensing large volumes. Use a fume cupboard. Avoid contact with skin. The exact concentration of a hydrochloric acid solution prepared can be determined by titrating against a standard solution of sodium carbonate. CLEAPSS recipe sheet RB043. To prepare 1 dm^3 of solution: Wear splash-proof goggles or a face shield and chemical-resistant gloves. Use a fume cupboard and avoid inhaling the vapour. The acid has a sharp odour and can cause respiratory irritation. Measure out 84 cm^3 of concentrated hydrochloric acid in a 100 cm^3 measuring cylinder. Slowly add the liquid to about 750 cm^3 of water in a beaker or laboratory jug. Stir well using a long glass rod. If you used a beaker, pour the solution into a 1000 cm^3 measuring cylinder or laboratory jug and add distilled water to the 1000 cm^3 mark.

Chemical supplied for the practical	Preparation
Sodium carbonate solution, 0.5 mol dm^{-3} $Na_2CO_3(aq)$ Currently not classified as hazardous CLEAPSS Hazcard HC095A.	Sodium carbonate decahydrate solid $Na_2CO_3.10H_2O(s)$ MW = 286.14 g mol^{-1}  **WARNING** Irritant (eyes) CLEAPSS recipe sheet RB080. To prepare 1 dm^3 of solution: Wear eye protection. Weigh 143.07 g of $Na_2CO_3.10H_2O(s)$. Add the solid to about 750 cm^3 of distilled water in a beaker. Stir to dissolve. Pour the solution into a 1000 cm^3 measuring cylinder or laboratory jug and add distilled water to the 1000 cm^3 mark.
Examples of acid-base indictors for stop bath: Phenolphthalein indicator solution  **DANGER** Highly flammable liquid and vapour Causes serious eye irritation. Suspected of causing genetic defects. May cause cancer. CLEAPSS Hazcards HC032 and HC040A. *or* Universal indicator solution  **DANGER** Highly flammable liquid and vapour. Harmful if swallowed. May cause damage to organs. CLEAPSS Hazcards HC032 and HC040A.	Usually purchased as a ready-made solution from an educational supplier but it can also be prepared by following instructions on the CLEAPSS recipe sheet RB000, recipe 46. To prepare 100 cm^3 of indicator: Wear eye protection and use a fume cupboard when dispensing from bottles of solid indicators to avoid raising dust. Use gloves to avoid staining the skin. Dissolve 0.1 g solid phenolphthalein in 60 cm^3 of industrial denatured alcohol (IDA) given in the table in a suitable beaker. Transfer solution to a 100 cm^3 measuring cylinder and make up to 100 cm^3 with distilled water. Usually purchased as a ready-made solution from an educational supplier but it can also be prepared by following instructions on the CLEAPSS recipe sheet RB000, recipe 47. To prepare 1000 cm^3 of indicator: Wear eye protection and use a fume cupboard (not switched on) to avoid raising dust when dispensing from bottles of solid indicators. Use gloves to avoid staining the skin. Weigh and place 0.25 g of bromothymol blue, 0.025 g of thymol blue, 0.063 g of methyl red and 0.5 g of phenolphthalein in a large beaker. Add 500 cm^3 of ethanol and stir to dissolve the dye then 500 cm^3 of distilled water.

Disposal

- Ensure that the stop bath mixture is still alkaline and add more sodium carbonate solution if needed before pouring down a foul-water drain.
- Rinse all equipment with distilled water.

Alternative methods

Learners can measure the endpoint with a light sensor connected to a data logger too. They should use the same volumes of each reactant. They might need to shield the conical flask using black paper so that the sensor only detects light above the flask. Learners should start recording when they add the acid. When the solution becomes opaque, the sensor will no longer detect any light from above the solution and they will be able to note the time. This method improves accuracy and reduces the risk of breathing in sulfur dioxide as learners don't have to peer down the flask.

They could also use a water bath to improve temperature control and accuracy. Keep the temperature constant and below 50°C to limit the toxic sulfur dioxide produced.

A microscale version of the experiment is available from CLEAPSS: bit.ly/49GAeJ2.

Learners could also use colorimeters and reduced volumes of the reactants to measure the light absorbance. Read the SSERC document, available from bit.ly/415s1dN, for more information.