

A visible activated complex

Introduction

Hydrogen peroxide oxidises potassium sodium tartrate (Rochelle salt) to carbon dioxide. The reaction is catalysed by cobalt(II) chloride. When solutions of hydrogen peroxide and Rochelle salt are mixed, carbon dioxide is slowly evolved. The addition of cobalt(II) chloride causes the reaction to froth, indicating a large increase in the reaction rate. At the same time the colour of the cobalt(II) chloride turns from pink to green (an activated complex), returning to pink again within a few seconds as the reaction dies down. This indicates that catalysts actually take part in the reaction and are returned unchanged when the reaction is complete. Pre-16 as a simple demonstration of catalysis, post-16 to introduce the idea of an activated complex and to allow discussion of the mechanism of catalysis

Equipment

Apparatus

- Eye protection
- Bunsen burner
- Tripod
- Gauze
- Heat-proof mat
- Beaker, 250 cm³
- Thermometer, 0-100 °C
- Measuring cylinder, 25 cm³
- Pipette

Chemicals

The quantities given are for one demonstration

- Potassium sodium tartrate-4-water, 5 g (Rochelle salt, potassium sodium 2,3-dihydroxybutanedioate, $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$).
- Cobalt(II) chloride-6-water, 0.2 g ($\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$).
- Hydrogen peroxide solution, 20 cm³ of 20 volume (ie approximately 6 %) ($\text{H}_2\text{O}_2(\text{aq})$).
- Deionised water, 65 cm³.
- Crushed ice, 200 cm³ (optional).

Health, safety and technical notes

- Read our standard health and safety guidance here <https://rsc.li/3XggQDi>
- Always wear eye protection.
- Cobalt(II) chloride-6-water, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ (s), is a carcinogen, mutagen, reproductive toxin and a skin & respiratory sensitiser. It is also harmful to the aquatic environment (see CLEAPSS Hazcard [HC025](#)).
- Hydrogen peroxide solution, 20 vol H_2O_2 (aq) is a skin/eye irritant (see CLEAPSS azc card [HC050](#)).
- Potassium sodium tartrate-4-water is of low hazard (see CLEAPSS Hazcard [HC095a](#)).

Procedure

Before the demonstration

- Make a solution of 0.2 g of cobalt chloride-6-water in 5 cm³ of deionised water.
- Make a solution of 5 g of Rochelle salt in 60 cm³ of deionised water in a 250 cm³ beaker.

The demonstration

- Add 20 cm³ of 20 volume hydrogen peroxide to the solution of Rochelle salt and heat the mixture to about 75 °C over a Bunsen burner.
- There will be a slow evolution of gas showing that the reaction is proceeding.
- Stirring the solution makes the evolution of gas more obvious.
- Now add the cobalt chloride solution to the mixture.
- Almost immediately, the pink solution will turn green and after a few seconds vigorous evolution of gas starts and the froth will rise almost to the top of the beaker.
- Within about 30 seconds, the frothing subsides and the pink colour returns.

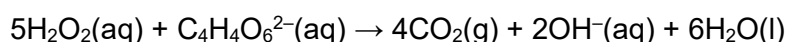
Notes

The green activated complex can be trapped if a sample of the green solution is withdrawn with a dropping pipette and then transferred to a test-tube that is cooled in crushed ice.

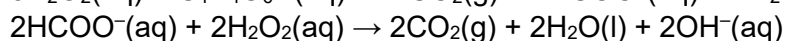
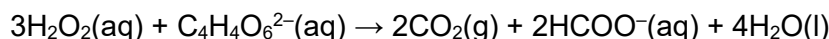
The solution remains green for some time. If the reaction is considered to be going too fast for easy observation, carry it out at a lower temperature (although this will make it less easy to see the evolution of CO₂ before adding the catalyst).

Theory

The basic reaction appears to be:



The equation may also be written in two parts:



The reaction is catalysed by pink Co²⁺ ions which are first oxidised to green Co³⁺ ions (complexed by tartrate ions) and then reduced back to Co²⁺.

While the majority of the gas evolved is carbon dioxide, oxygen will also be produced from the decomposition of some of the hydrogen peroxide.

The gas mixture will turn limewater milky, but does not extinguish a glowing splint.