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58. Catalysts for the decomposition of hydrogen peroxide

Topic

Reaction rates, catalysis, enzymes.

Timing

About 5 min.

Level

Pre-16.

Description

Several measuring cylinders are set up each containing a little washing up liquid and a small amount of a catalyst for the decomposition of hydrogen peroxide. Hydrogen peroxide is poured into the cylinders and a foam rises up the cylinders at a rate that depends on the effectiveness of the catalyst.

Apparatus

- Several 250 cm^3 measuring cylinders – one for each catalyst to be used.
- A large tray to catch any foam that spills over the top of the cylinders.
- Stopwatch or clock with second hand.

Chemicals

The quantities given are for one demonstration.

- 75 cm^3 of **100 volume hydrogen peroxide** solution.
- About 0.5 g of powdered manganese(IV) oxide (manganese dioxide, MnO_2).
- About 0.5 g of **lead(IV) oxide** (lead dioxide, PbO_2).
- About 0.5 g of iron(III) oxide (red iron oxide, Fe_2O_3).
- A small piece (about 1 cm^3) of potato.
- A small piece (about 1 cm^3) of liver.

Method

Before the demonstration

Line up five 250 cm^3 measuring cylinders in a tray. Add 75 cm^3 of water to the 75 cm^3 of 100 volume hydrogen peroxide solution to make 150 cm^3 of 50 volume solution.

The demonstration

Place about 1 cm^3 of washing up liquid into each of the measuring cylinders. To each one add the amount of catalyst specified above. Then add 25 cm^3 of 50 volume hydrogen peroxide solution to each cylinder. The addition of the catalyst to each cylinder should be done as nearly simultaneously as possible – using two assistants will help. Start timing. Foam will rise up the cylinders. The lead dioxide will probably

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be fastest, followed by manganese dioxide and liver. Potato will be much slower and the iron oxide will barely produce any foam. This order could be affected by the surface areas of the powders. Time how long each foam takes to rise to the top (or other marked point) of the cylinder. The foam from the first three cylinders will probably overflow considerably.

Place a glowing spill in the foam; it will re-light confirming that the gas produced is oxygen.

Teaching tips

Some students may believe that the catalysts – especially the oxides – are reactants because hydrogen peroxide is not noticeably decomposing at room temperature. The teacher could point out the venting cap on the peroxide bottle as an indication of continuous slow decomposition. Alternatively s/he could heat a little hydrogen peroxide in a conical flask with a bung and delivery tube, collect the gas over water in a test-tube and test it with a glowing spill to confirm that it is oxygen. This shows that no other reactant is needed to decompose hydrogen peroxide.

NB: Simply heating 50 volume hydrogen peroxide in a test-tube will not suceed in demonstrating that oxygen is produced. The steam produced will tend to put out a glowing spill. Collecting the gas over water has the effect of condensing the steam. It is also possible to 'cheat' by dusting a beaker with a tiny, almost imperceptible, amount of manganese dioxide prior to the demonstration and pouring hydrogen peroxide into it. Bubbles of oxygen will be formed in the beaker.

Theory

The reaction is :

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

This is catalysed by a variety of transition metal compounds and also by peroxidase enzymes found in many living things.

Extensions

Repeat the experiment but heat the liver and the potato pieces for about five minutes in boiling water before use. There will be almost no catalytic effect, confirming that the catalyst in these cases is an enzyme that is denatured by heat.

Investigate the effect of using lumpy or powdered manganese dioxide. The powdered oxide will be more effective because of its greater surface area.

Try using other metal oxides or iron filings as catalysts.

Animal blood may be used instead of liver if local regulations allow this.

One teacher suggested measuring the height of the foam over suitable time intervals and plotting a graph.

Further details

The experiment can be done with 20 volume hydrogen peroxide, but is less spectacular. It is, however, easier to time.

It has been suggested that manganese dioxide is not in fact the catalyst for this reaction, but that the catalysts are traces of other oxides found on the surface of manganese dioxide.

Safety

Wear eye protection.

Used liver should be wrapped up in paper and placed in the dustbin.

It is the responsibility of teachers doing this demonstration to carry out an appropriate risk assessment.