Catalysts, energy and reaction rates

Student activity • rate investigation

YEAR 10 / LESSON 40 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

How can a solid change reaction speed without being consumed overall?

Compare the action of three solids on dilute hydrogen peroxide using class data from paired repeats and a teacher control. Interpret temperature and pressure effects separately. A clearly marked Chemistry-only extension covers reaction profiles.

Equipment

- Eye protection; checked 100 cm^3 gas syringe, stand, 100 cm^3 flask and connecting tube/bung
- 10.0 cm^3 of 1% w/v hydrogen peroxide per run, issued by staff
- Staff-preloaded 0.05 g solid per run: MnO_2, Fe_2O_3 or CuO; no pupil handling of loose powders
- 10 cm^3 cylinder, timer and tray; graph paper; teacher no-solid control

Wear eye protection. Avoid peroxide/oxide contact; report splashes and use the laboratory eye-rinse procedure for eye exposure. Keep powders in staff-preloaded flasks. Keep away from flames; oxygen supports combustion. Stop if gas flow is obstructed or foam reaches tubing.

Course coverage: Shared core: 3.9–3.13 and practical 3.16. Chemistry-only extension: 3.14C reaction profiles, activation energy and ΔH.

Plan, model or apparatus sketch

Sketch the gas collection apparatus and identify the catalyst.

Method and reasoning

Read the whole sequence before starting

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1. Wear eye protection and check the free-moving syringe and unobstructed gas path with the teacher. Do not begin with blocked or sticking equipment.

2. Each pair receives two flasks preloaded by staff with 0.05 g of its assigned solid. Record the solid identity and the initial temperature; do not transfer or blow on powders.

3. Measure 10.0 cm^3 of 1% w/v hydrogen peroxide. Add it to the solid, start timing and fit the bung promptly. Record the delay. Keep the flask in the tray, with no shaking or heating.

4. Record gas volume every 15 seconds for three minutes, or longer if the teacher directs. Stop and call staff if foam approaches the tubing, the syringe sticks or a leak appears; do not force apparatus.

5. After the reaction has stopped, staff direct disconnection and collection of residues. Use the second preloaded flask for a repeat and compare your curves with other pairs and the teacher's no-solid control.

6. Use the gas-volume curves to compare observed rates. Qualify the conclusion: equal masses do not guarantee equal particle surface areas. Do not infer catalyst mass recovery from the gas-volume test.

7. Explain how higher temperature and higher gas pressure can affect rate in suitable systems. Chemistry-only extension: draw two energy paths with common endpoints, label E_a and ΔH, and show the lower catalysed barrier.

Cleanup

• Wait for reaction to stop; staff direct collection of oxide residues and rinses. Do not return mixtures to stock. Wash hands.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Reaction: $2H_2O_2 \rightarrow 2H_2O + O_2$. 1% w/v means 1 g H_2O_2 per 100 cm^3 solution; 10.0 cm^3 contains 0.10 g and could produce about 35 cm^3 O_2 at room conditions. This is an apparatus-capacity estimate, not a predicted classroom reading. Record the solid, temperature, start delay and actual volumes.

Time / s	Run 1 / cm^3	Run 2 / cm^3
0		
15		
30		
45		
60		
75		
90		
105		
120		
135		
150		
165		
180		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Compare your repeat curves and the class control; what evidence supports a rate effect?

2. Write the balanced decomposition equation and identify the measured product.

3. Explain why a fixed mass comparison does not prove one solid is intrinsically the best catalyst.

4. Explain why higher temperature can increase rate and why pressure mainly matters for gaseous reactants.

5. Explain what “chemically unchanged at the end” means and why this test does not prove exact mass recovery.

6. Chemistry only (3.14C): draw and label catalysed/uncatalysed profiles with E_a and ΔH; explain which quantities change.