

Mechanisms, catalysts and activation energy

AP Chemistry · Lab answers

Model answers follow. The calculated total matches the measured plateau within 1 %, which supports the stoichiometry. Using $\ln(106 - V)$ against t gives a straight line, so the decomposition is first order in peroxide, and the rate constant comes from the slope.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 5

Question 1 Theory yield

$2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2$. Mass $\text{H}_2\text{O}_2 = 0.30 \text{ g}$; $n = 0.30/34.0 = 8.82 \times 10^{-3} \text{ mol}$; $n(\text{O}_2) = 4.41 \times 10^{-3} \text{ mol}$; $V = 4.41 \times 10^{-3} \times 24\,000 = \mathbf{106 \text{ cm}^3}$.

Question 2 Shape of the curve

The volume rises steeply at first and then levels off at 106 cm^3 . The slope falls because $[\text{H}_2\text{O}_2]$ decreases as it is used, so the rate falls; the reaction ends when the peroxide has gone: **decreasing slope, plateau at 106 cm^3** .

Question 3 Average rates

0–20 s: $42/20 = \mathbf{2.1 \text{ cm}^3/\text{s}}$. 100–120 s: $(101 - 97)/20 = \mathbf{0.20 \text{ cm}^3/\text{s}}$. The rate is about ten times smaller later.

Question 4 Order and rate constant

$106 - V = 64, 39, 24, 14, 9, 5 \text{ cm}^3$, so $\ln = 4.16, 3.66, 3.18, 2.64, 2.20, 1.61$. The plot is a straight line; slope = $(1.61 - 4.16)/100 = -0.0255 \text{ s}^{-1}$, so $k \approx \mathbf{0.026 \text{ s}^{-1}}$ and the reaction is first order.

Question 5 Is the catalyst used up?

The residue still has a mass of **0.20 g**, the same as at the start, and the dried residue can catalyse a new sample at the same speed (reuse test). Without it the control gave no gas.

Question 6 Control variables

Same volume and concentration of H_2O_2 ; same mass and particle size of catalyst; same temperature (water bath) and same stirring. **Three of these** are enough.

Question 7 Improving the lab

Use a water bath to hold temperature, add the catalyst with a tube to avoid losing gas, and repeat each run. Doubling the mass of powder gives more surface, so the rate is **higher (about twice the initial rate)** while the final volume stays 106 cm^3 .