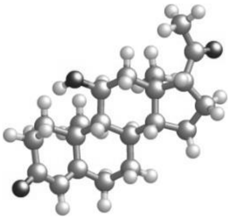

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Rate of Reaction – Worksheet

Learning Outcomes

Candidates should be able to:

a) Describe the effect of concentration, pressure, particle size and temperature on the speeds of reactions and explain these effects in terms of collisions between reacting particles.

b) Define the term catalyst and describe the effect of catalysts (including enzymes) on the speeds of reactions.

c) Explain how pathways with lower activation energies account for the increase in speeds of reactions.

d) State that some compounds act as catalysts in a range of industrial processes and that enzymes are biological catalysts.

e) Suggest a suitable method for investigating the effect of a given variable on the speed of a reaction.

f) Interpret data obtained from experiments concerned with speed of reaction.

1. What is meant by “speed” or “rate” of reaction?

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2. Give examples of reactions that are *fast* and examples of reactions that are *slow*.

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3. Explain why it is important to measure and control the speed of a reaction.

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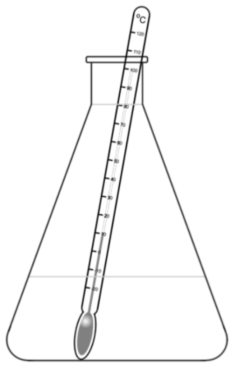
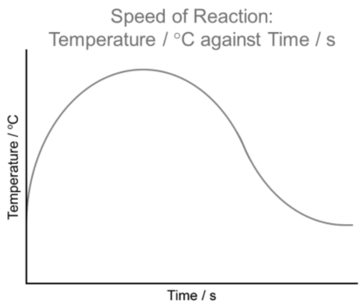
4. How can *temperature* be used to measure the speed of a reaction? Give examples.





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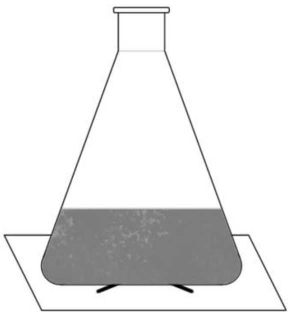
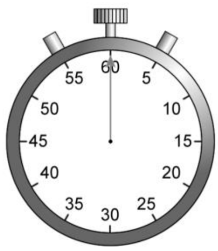
5. How can a *precipitate* be used to measure the speed of a reaction? Give examples.





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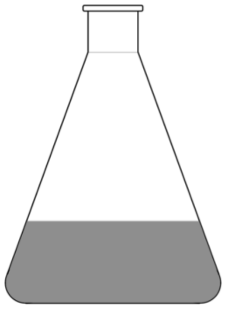
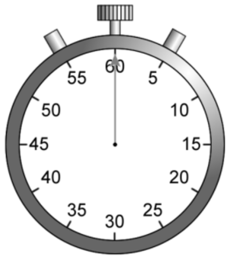
6. How can *colour* be used to measure the speed of a reaction? Give examples.





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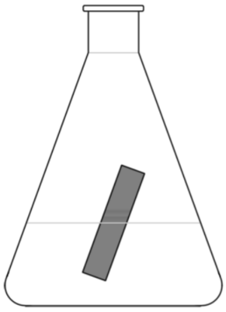
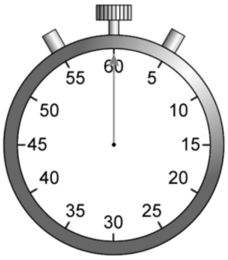
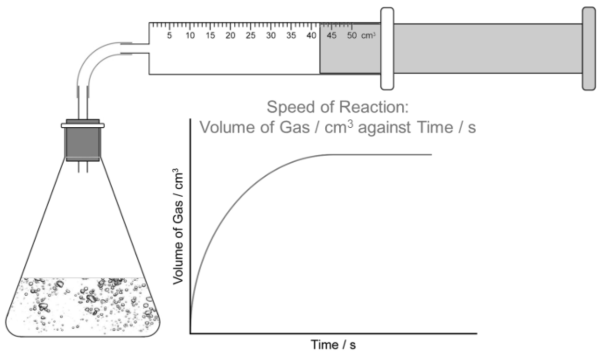
7. How can *pH* be used to measure the speed of a reaction? Give examples.

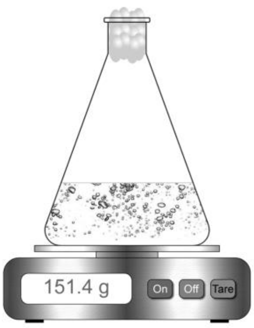


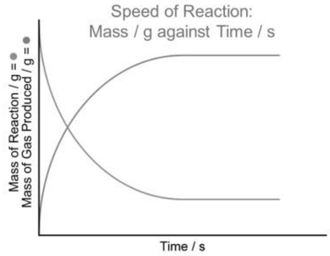


8. How can the *formation of a gas* be used to measure the speed of a reaction? Give examples.

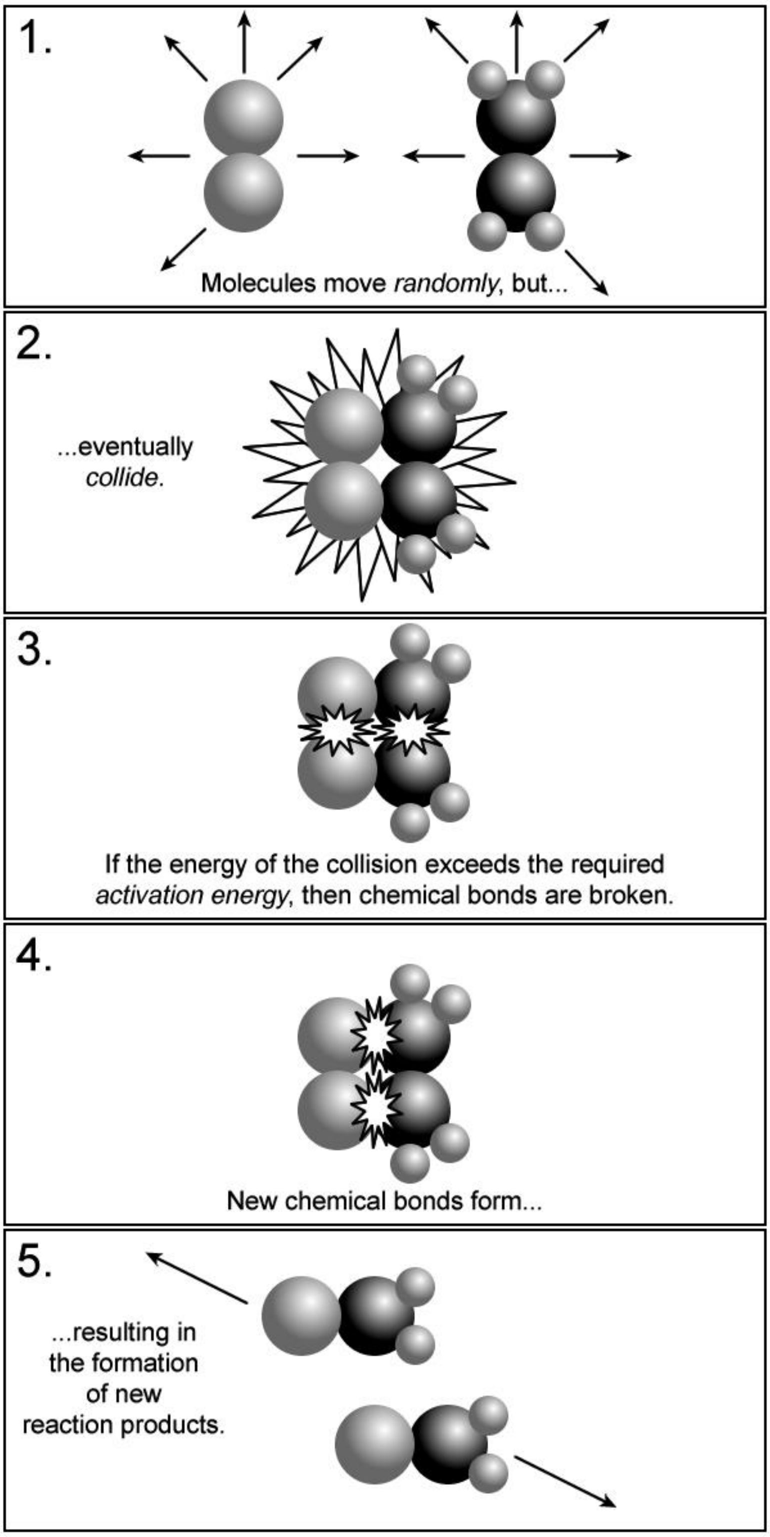


9. How can *mass* be used to measure the speed of a reaction? Give examples.

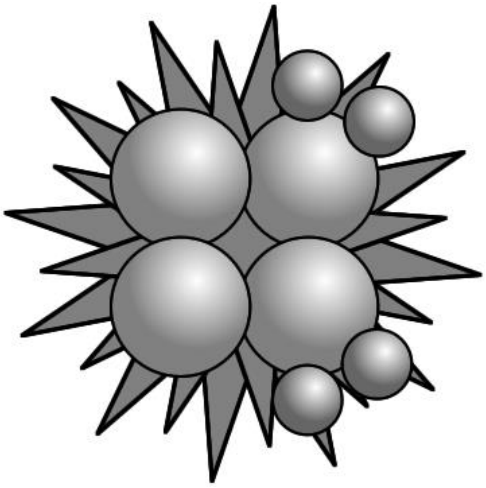




10. What must happen in order for two chemicals to react?



11. How does *temperature* affect the speed of a chemical reaction?



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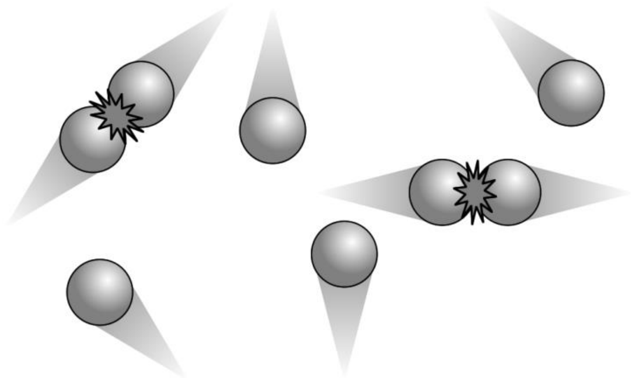
12. How does *concentration* affect the speed of a chemical reaction?



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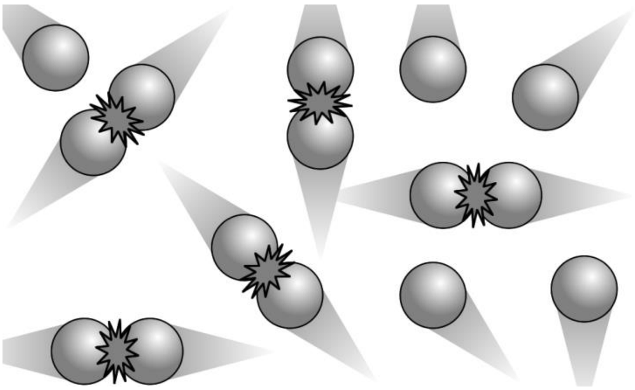
13. How does *pressure* affect the speed of a chemical reaction?



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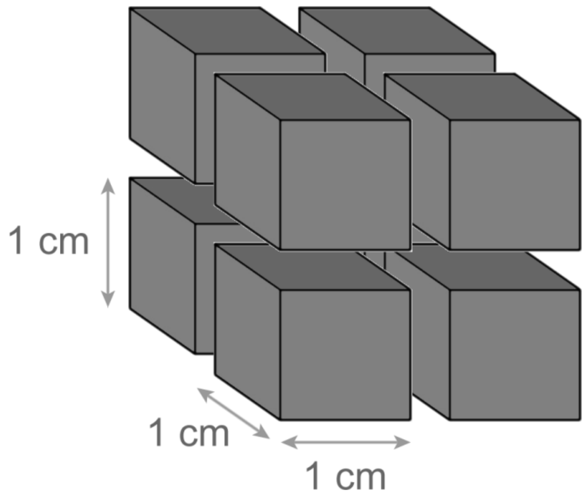
14. **How does *surface area* affect the speed of a chemical reaction?**



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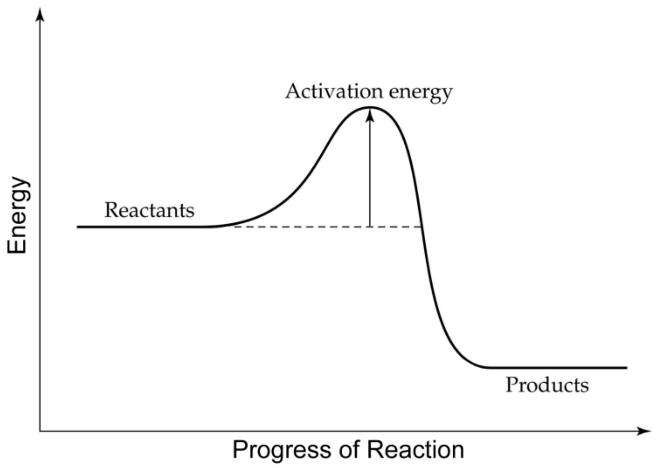
15. **How does *a catalyst* affect the speed of a chemical reaction?**



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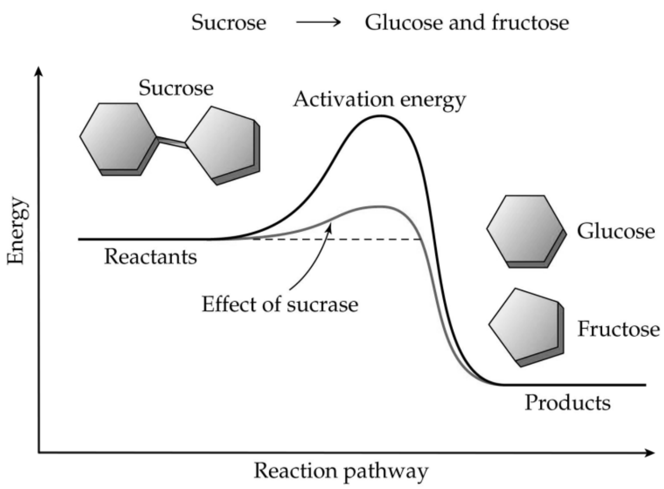
16. **What are *enzymes*?**
In what ways are they i) similar to ii) different from inorganic catalysts?



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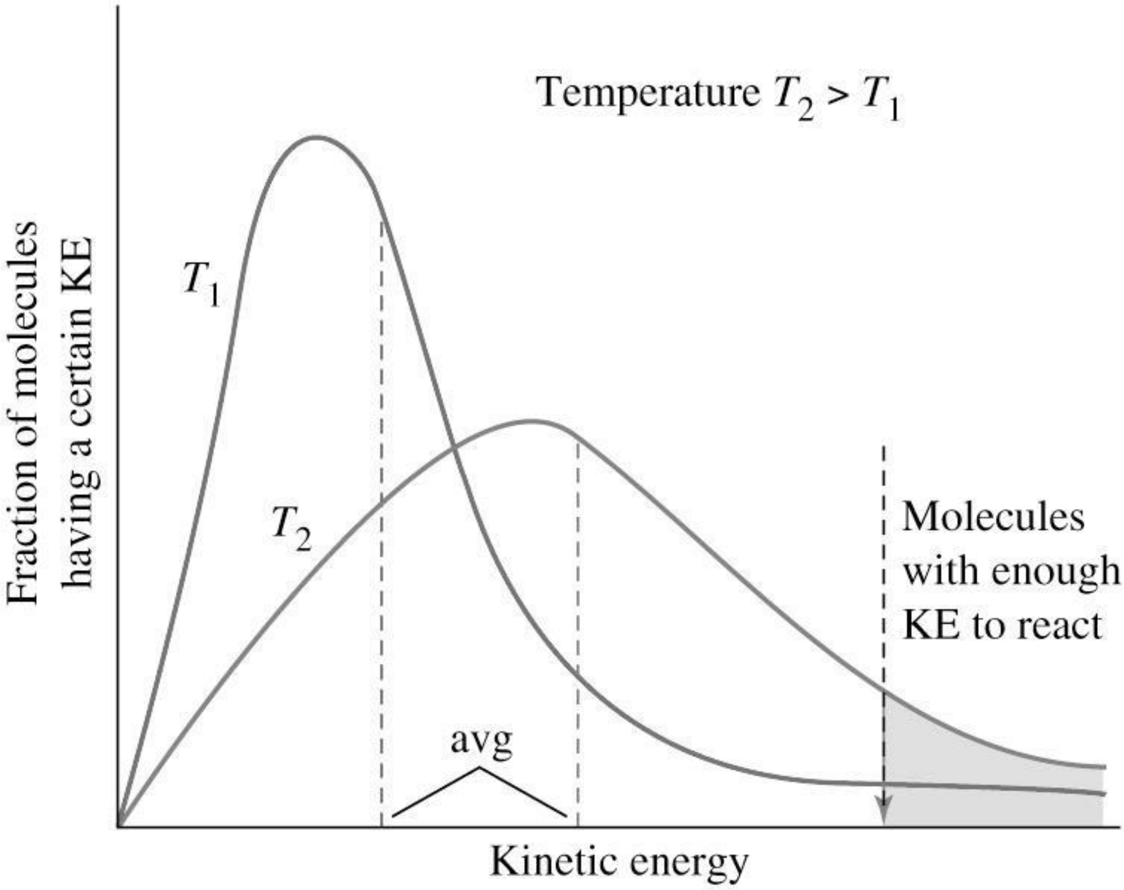
17. Enrichment: Maxwell-Boltzmann Distribution of Molecular Energies



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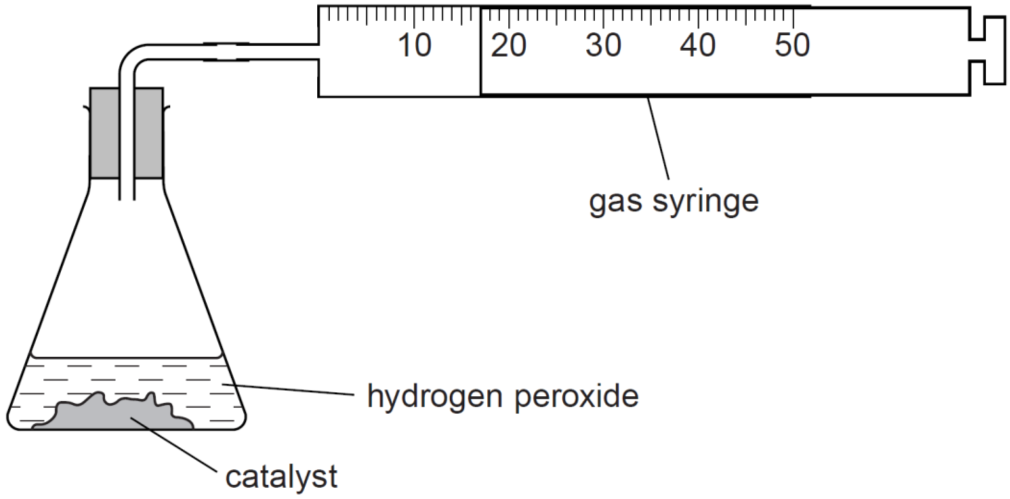
18. Hydrogen peroxide, H_2O_2, decomposes slowly at room temperature to form water and oxygen:

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

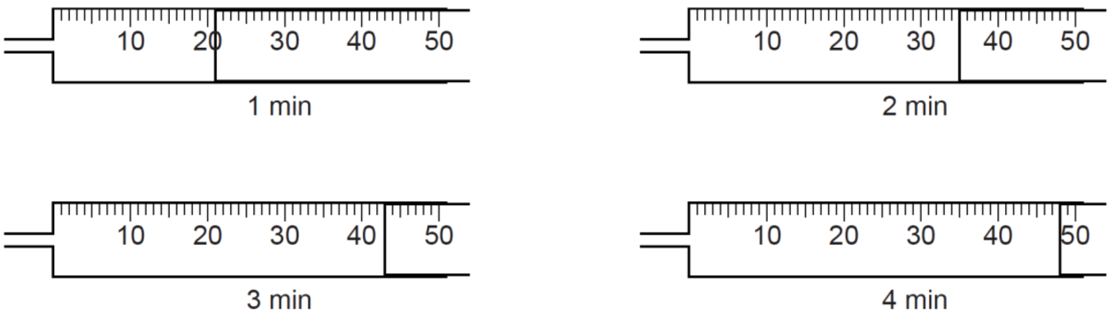
A student investigated how the rate of decomposition changed by using two catalysts, manganese(IV) oxide and copper.

The volume of oxygen produced was measured at intervals using the apparatus shown below:



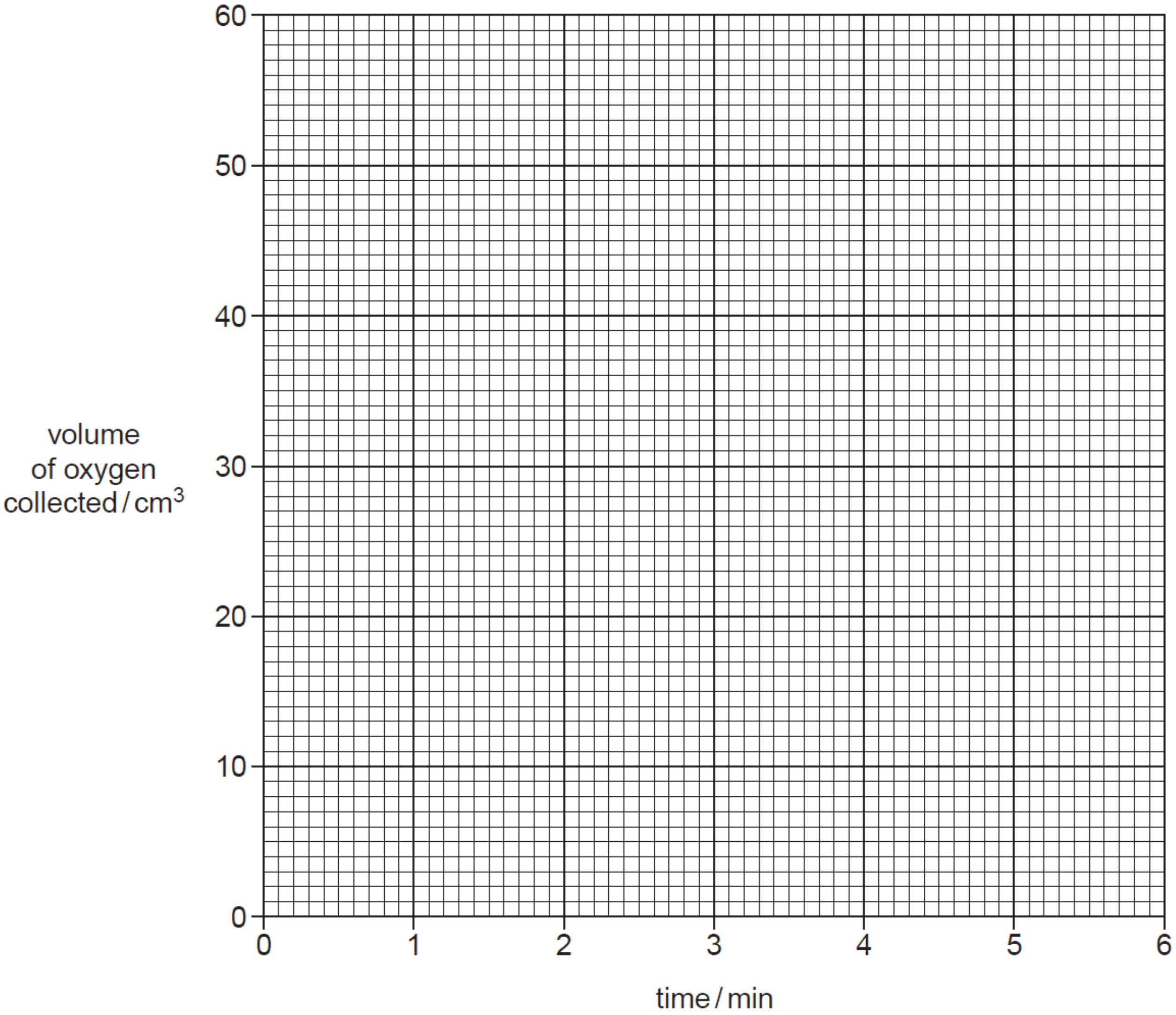
The student carried out two experiments using the same volume of hydrogen peroxide but with the same mass of a different catalyst in each experiment.

a) The results for experiment **1** and some of the results for experiment **2** are shown in the table. Use the diagrams to complete the results for experiment **2**.



Time / min	1	2	3	4	5	6
Volume of oxygen collected in experiment **1** / cm^3	9	17	24	29	32	35
Volume of oxygen collected in experiment **2** / cm^3					50	50

b) Plot the results for experiment **1** and **2** on the grid below and draw a smooth curve through each set of points. Label the curves **1** and **2**.



c) Which of the experiments first reached completion? Explain your answer.

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d) Use your graph to estimate the time taken in experiment **1** (using manganese(IV) oxide) to double the volume of oxygen produced from 15 cm^3 to 30 cm^3. Record your answers in the table below.

	Experiment **1**
Time taken to produce 30 cm^3 / min	
Time taken to produce 15 cm^3 / min	
Time taken to double the volume from 15 cm^3 to 30 cm^3 / min	

e) The rate of a reaction can be calculated using the formula:

$$\text{speed of reaction} = \frac{\text{volume of gas produced / cm}^3}{\text{time taken / min}}$$

Using the two graphs and the above formula, calculate the rate of each reaction after the first 2.5 minutes.

i) Rate of reaction using manganese(IV) oxide (experiment **1**).

ii) Rate of reaction using copper (experiment **2**).

iii) Using your answers to **i)** and **ii)**, suggest which is the better catalyst, manganese(IV) oxide or copper. Explain your answer.

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f) At the end of experiment **2** the copper was removed from the solution by filtration. It was dried and weighed. How does this mass of copper compare with the mass of copper used at the start of the experiment? Explain your answer.

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g) Suggest two ways by which the rate of decomposition in either experiment could be further increased.

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