# Catalysts and Reaction Rates

Name: _____ Class: _____ Date: _____

**Learning targets**

- Explain how catalysts increase reaction rates and lower activation energy.
- Identify industrial and biological catalysts.
- Compare catalysed and uncatalysed reactions.
- Explain the importance of catalysts in industry.

Instructions: Answer in complete sentences where appropriate. Show working and include units in calculations.

## A • Catalysts and successful collisions

**1.** Define a catalyst in terms of reaction rate and what happens to it overall.

**2.** Explain why not every collision between reactant particles leads to a reaction.

**3.** Complete the sentences: A catalyst provides an alternative reaction _____ with a lower _____ energy. More collisions can therefore be _____.

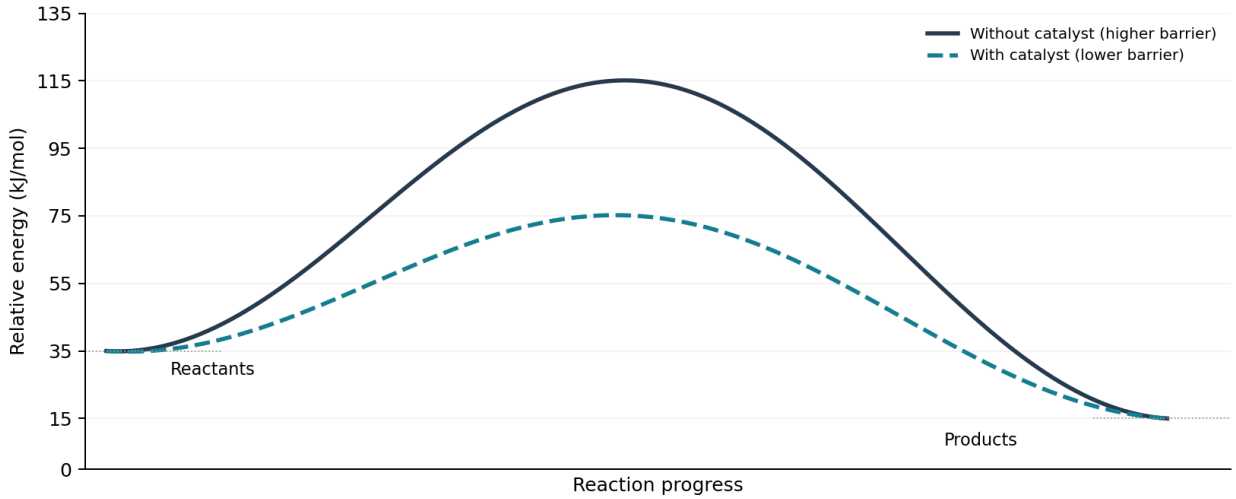
**4.** True or false? For each statement, write T or F and correct any false statement.

| Statement | T / F |
|---|---|
| a. A catalyst may take part in reaction steps but is regenerated overall. | |
| b. A catalyst adds extra energy to every reactant particle. | |
| c. A catalyst can speed up the forward and reverse reactions. | |
| d. A catalyst changes the enthalpy change (ΔH) of a reaction. | |

**5.** Why might a reaction be slow even when particles collide frequently?

## B • Reading an activation-energy diagram

Study the two energy pathways for the same exothermic reaction. The energy scale is illustrative.




**6.** Identify the catalysed and uncatalysed curves. Which has the lower peak?

**7.** From the diagram, estimate the forward activation energy for each pathway. Show how you calculated each value.

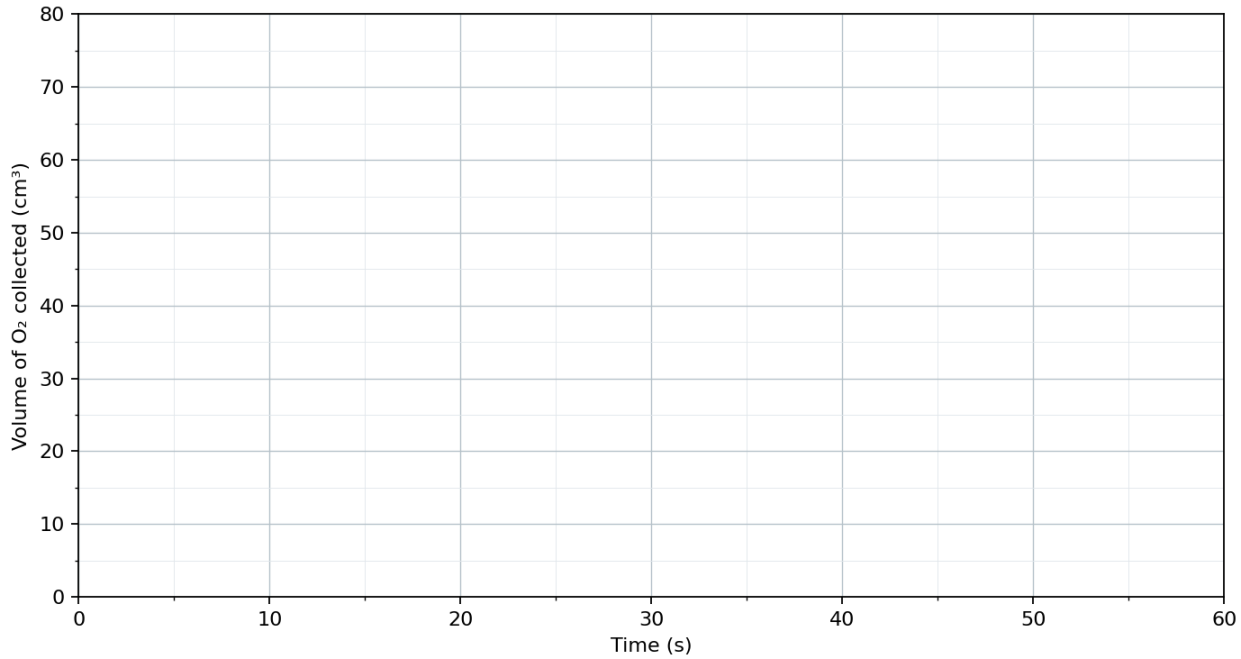
**8.** Explain why both curves begin and end at the same energies. Does the catalyst change ΔH?

## C • Comparing a catalysed and uncatalysed reaction

Two identical samples of hydrogen peroxide decompose into water and oxygen. One sample contains a suitable catalyst; both start with the same amount of hydrogen peroxide. The data below are hypothetical and are measured at the same temperature.

| Time (s) | With catalyst: $O_2$ ($cm^3$) | Without catalyst: $O_2$ ($cm^3$) |
|---|---|---|
| 0 | 0 | 0 |
| 10 | 34 | 10 |
| 20 | 58 | 22 |
| 30 | 73 | 38 |
| 40 | 80 | 54 |
| 50 | 80 | 68 |
| 60 | 80 | 80 |

**9.** Plot both data sets on the same axes below. Join points using smooth lines or straight segments; include a legend.




**10.** Calculate the average oxygen-production rate from 0 to 20 s for each reaction. Show working and units.

**11.** At 40 s, how much more oxygen has been collected in the catalysed reaction?

**12.** The final oxygen volumes are the same. Explain what this tells you about the effect of a catalyst.

**13.** Why can the catalysed curve become horizontal earlier than the uncatalysed curve?

## D • Catalysts in biology and industry

Match each catalyst to its main application. Use each letter once.

Applications: A — ammonia production (Haber process); B — reducing harmful vehicle exhaust gases; C — starch digestion; D — sulfuric acid production (Contact process); E — decomposition of hydrogen peroxide; F — hydrogenation of vegetable oils.

| Catalyst | Letter | Type: industrial or biological? |
|---|---|---|
| 14a. Iron | | |
| 14b. Catalase | | |
| 14c. Vanadium(V) oxide ($V_2O_5$) | | |
| 14d. Amylase | | |
| 14e. Platinum / palladium / rhodium | | |
| 14f. Nickel | | |

**15.** Explain what an enzyme is and why enzymes are described as biological catalysts.

**16.** Give two possible industrial benefits of using a suitable catalyst, explaining each benefit.

**17.** Why might an industrial catalyst be expensive to install but still economical to use over many production cycles?

**18.** What is catalyst poisoning? Give one possible effect it has on an industrial process.

## E • Predicting and explaining outcomes

**19.** A catalyst is added to a reaction at the same temperature. Predict what happens to: (a) activation energy; (b) successful collisions per second; (c) the energy difference between reactants and products.

**20.** A factory increases both temperature and uses a catalyst. Explain how these two changes speed up a reaction in different ways.

**21.** A biological enzyme works well at 35°C but poorly at 80°C. Explain why heating too much can slow an enzyme-catalysed reaction.

## F • Analysing evidence and planning a fair comparison

A student compares decomposition of hydrogen peroxide with and without a catalyst. Both trials use 50 $cm^3$ of the same hydrogen peroxide solution at 25°C. They collect 60 $cm^3$ of oxygen in 25 s with catalyst and 100 s without catalyst.

**22.** Calculate the average gas-production rate in each trial ($cm^3/s$).

**23.** How many times faster is the catalysed trial based on these average rates?

**24.** Identify the independent variable, dependent variable, and three control variables for this investigation.

**25.** Give two ways to improve the reliability or accuracy of the gas measurements.

**26.** Explain why a gas syringe should be connected tightly before the reaction begins.

## G • Scientific reasoning challenge

A student claims: “Adding more catalyst must always give more product, because the reaction becomes faster.”

**27.** Evaluate this claim. Distinguish reaction rate from total amount of product, and explain the role of the limiting reactant.

Extension: Many industrial reactions can run in both directions and may reach chemical equilibrium.

**28.** A catalyst helps an equilibrium reaction reach equilibrium faster. Does it change the equilibrium position at the same temperature? Explain.

Self-check: Circle the learning target you feel most confident about and underline one that needs more practice.