Catalysts and Reaction Rates

Teacher answer key • Suggested responses. Accept scientifically equivalent explanations and appropriate rounding.

A • Catalysts and successful collisions

1. A catalyst increases the rate of a chemical reaction and is regenerated overall (not consumed in the net reaction).

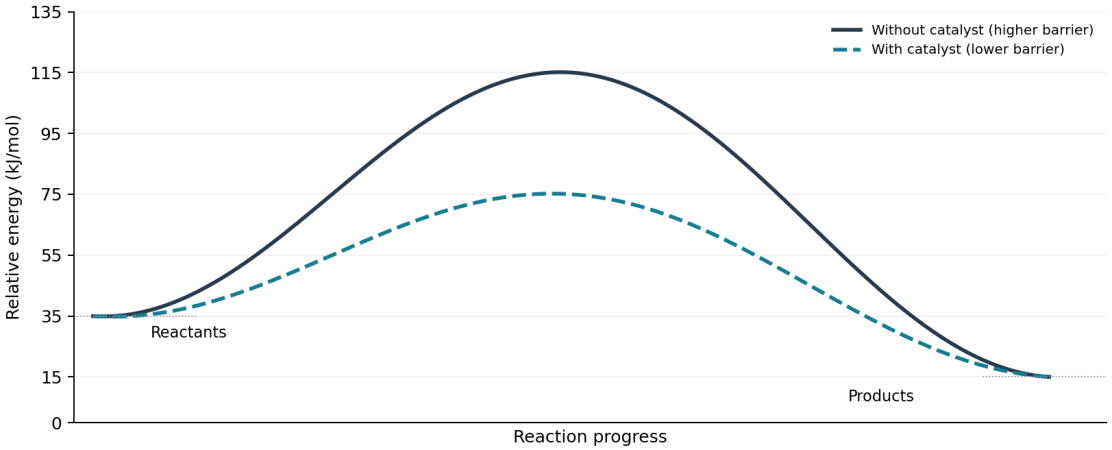
2. A collision must have sufficient energy to overcome the activation barrier and a suitable orientation; not every collision meets both conditions.

3. Pathway; activation; successful (or effective).

4. a T; b F—catalysts do not supply energy to every particle, they provide a lower-barrier pathway; c T; d F—ΔH is unchanged for the same reaction.

5. Even frequent collisions may fail because reactants lack sufficient energy or have an unfavourable orientation.

B • Activation-energy diagram

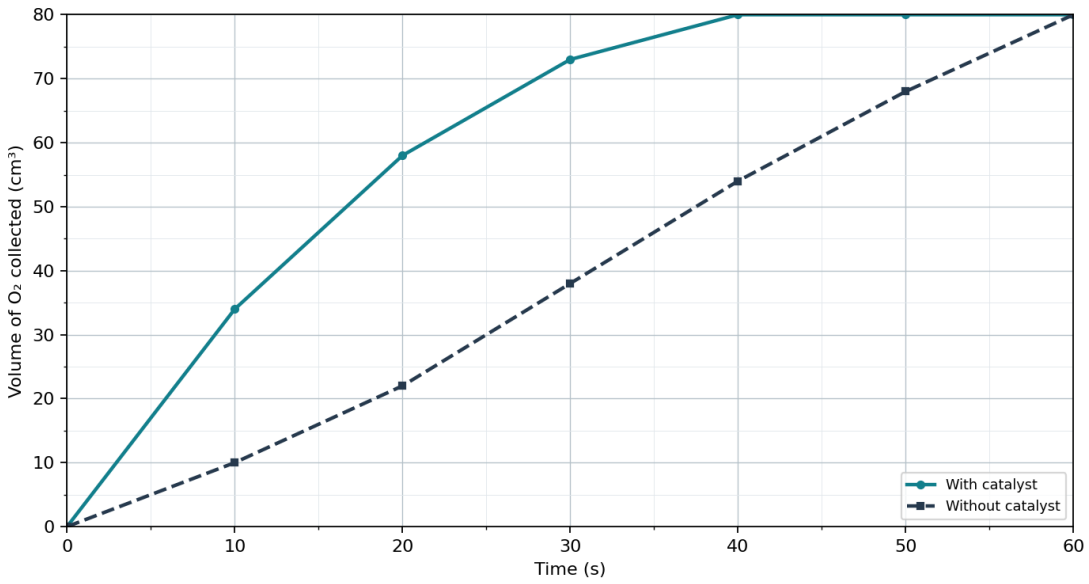


6. Solid dark line: uncatalysed. Dashed teal line: catalysed; the catalysed peak is lower.

7. Approximate reactants = 35 kJ/mol; uncatalysed peak ≈ 115 kJ/mol, Ea ≈ 80 kJ/mol; catalysed peak ≈ 75 kJ/mol, Ea ≈ 40 kJ/mol. Rounded estimates are acceptable.

8. The catalyst provides a different path between the same reactants and products. ΔH ≈ 15 − 35 = −20 kJ/mol in either case; a catalyst does not alter ΔH.

C • Experimental data and graph



9. Both labelled curves plotted with correct points, axes, units and a legend. The catalyst curve rises faster and levels off at 80 cm^3 by 40 s.

10. With catalyst: (58−0)/(20−0) = 2.9 cm^3/s. Without: (22−0)/(20−0) = 1.1 cm^3/s.

11. 80 − 54 = 26 cm^3 more oxygen.

12. Both reach 80 cm^3; the catalyst increases speed but does not increase the amount produced by the same limiting reactant.

13. The catalysed trial uses up the limiting reactant earlier; no further gas is formed after completion.

D • Catalysts in biology and industry

Item	Application	Type
14a. Iron	A — Haber process	Industrial
14b. Catalase	E — hydrogen peroxide decomposition	Biological
14c. V_2O_5	D — Contact process	Industrial
14d. Amylase	C — starch digestion	Biological
14e. Pt / Pd / Rh	B — catalytic converter	Industrial
14f. Nickel	F — hydrogenation of oils	Industrial

15. An enzyme is a biological catalyst (usually a protein) that accelerates a reaction through a lower-energy pathway while being regenerated overall.

16. Any two with explanation: lower operating energy costs; faster production / higher throughput; reduced emissions and waste; improved selectivity and less unwanted product; economically feasible reaction conditions.

17. Even if initially costly, a catalyst can be reused over many cycles and reduce ongoing energy costs or improve throughput; real catalysts may slowly deactivate.

18. Catalyst poisoning occurs when impurities bind to or block active sites, reducing activity and decreasing production rate or requiring replacement.

E • Predictions

19. (a) Lower activation-energy barrier for the catalysed pathway; (b) greater number of effective collisions per second, even if total collision frequency remains similar; (c) unchanged reaction ΔH.

20. Heating increases particle kinetic energies and the fraction able to overcome the barrier. A catalyst supplies an alternative lower-energy pathway. Each can increase successful collision events per second.

21. High temperature can denature the enzyme, altering its active site and reducing binding/catalytic activity despite greater particle kinetic energy.

F • Fair testing and rate calculations

22. Catalysed: 60/25 = 2.4 cm^3/s. Uncatalysed: 60/100 = 0.60 cm^3/s.

23. 2.4/0.60 = 4; rate is four times as high over these intervals.

24. IV: presence/absence of catalyst. DV: oxygen volume per time or average gas-production rate. Controls: hydrogen peroxide concentration, volume, temperature, apparatus, and consistent gas-volume endpoint (any three).

25. Repeat each condition and average consistent results; ensure gas-tight apparatus; use a calibrated gas syringe and read at eye level; keep timing and setup consistent (any two).

26. Gas lost before collection gives artificially low volume and calculated rate; tight, sealed connections help collect the gas generated.

G • Challenge and extension

27. Not necessarily. A catalyst changes the speed of conversion, not the number of available reactant moles. With the same limiting reactant and completion, the final amount of product is generally the same. Adding catalyst may have diminishing returns and could create practical limits.

28. No. At fixed temperature, a catalyst accelerates both forward and reverse reactions and does not change the equilibrium constant or equilibrium composition; equilibrium is reached sooner.