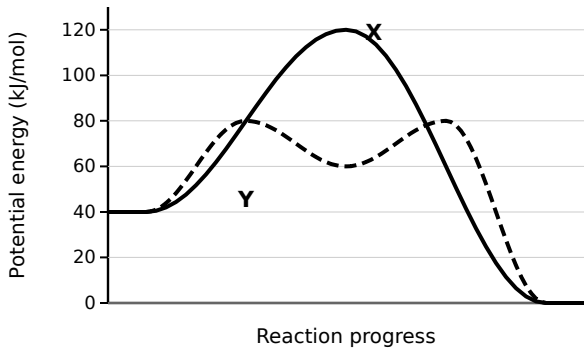
ANSWER KEY.

5.11 Catalysis

AP Chemistry | ANSWER KEY

Justify each answer using energy profiles, collisions, or the mechanism.

1. The energy profile shows the same reaction with and without a catalyst.



(a) Which curve, X or Y, shows the catalyzed reaction? Justify.
(b) Find E_a for the uncatalyzed reaction and for the first step of the catalyzed reaction.
(c) Find ΔH for each path.
(d) How many steps and how many intermediates does the catalyzed path have?
(e) Does the catalyst also speed up the reverse reaction? Explain.

(a) Y. Its hills are much lower, so it has a lower E_a. It is a different pathway (a new mechanism).
(b) Uncatalyzed: 120 − 40 = 80 kJ/mol. Catalyzed step 1: 80 − 40 = 40 kJ/mol.
(c) Both: ΔH = 0 − 40 = −40 kJ/mol. A catalyst does not change ΔH.
(d) 2 steps (two hills) and 1 intermediate (one valley).
(e) Yes. The hill is lower from both sides, so the reverse E_a is lower too.

2. Iodide ions speed up the decomposition of hydrogen peroxide. A proposed mechanism is shown.

Step 1: $H_2O_2 + I^- \rightarrow H_2O + IO^-$

Step 2: $H_2O_2 + IO^- \rightarrow H_2O + O_2 + I^-$

(a) Identify the catalyst. Justify.
(b) Identify the intermediate. Justify.
(c) Write the overall reaction.

(a) I^-. It is used in step 1 and made again in step 2.

(b) IO^-. It is made in step 1 and used in step 2.

(c) $2H_2O_2 \rightarrow 2H_2O + O_2$ (I^- and IO^- cancel).

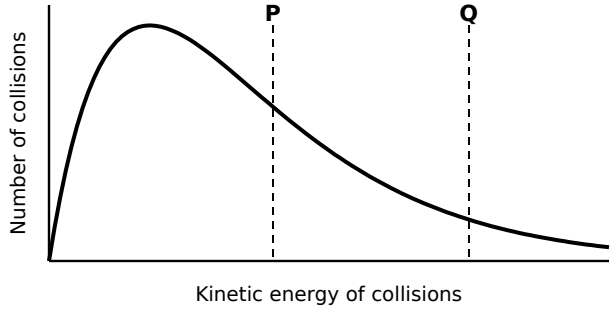
3. Classify each example as acid-base catalysis, surface catalysis, or an enzyme.

(a) Platinum and rhodium metal in a car's catalytic converter
(b) Amylase, a protein in saliva that breaks down starch
(c) Sulfuric acid adds an H^+ to a reactant so it reacts more easily
(d) Solid nickel metal that H_2 sticks to when hydrogen is added to vegetable oil

(a) surface catalysis (b) enzyme (c) acid-base catalysis (d) surface catalysis

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4. The graph shows the distribution of collision energies for a reaction mixture at one temperature. Lines P and Q mark the activation energy with and without a catalyst.



(a) Which line, P or Q, is the activation energy with the catalyst?

(b) When the catalyst is added at the same temperature, does the curve change? Explain.

(c) Use the graph to explain why the catalyzed reaction is faster.

(a) P (the lower activation energy).

(b) No. The temperature did not change, so the distribution of collision energies stays the same. Only the E_a line moves.

(c) Many more collisions have energy ≥ E_a past line P than past line Q. A larger fraction of collisions succeed each second, so the rate increases.

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5. Enzymes and metal surfaces both bind to reactant molecules. Describe two ways this binding can lower the activation energy.

1. It holds the reactants in the right orientation to react.
2. It weakens or strains bonds in the reactant (for example, a metal surface pulls on the H–H bond and breaks it).
Either way, a new intermediate forms where the catalyst is bound to the reactant.

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6. A student says, "A catalyst speeds up a reaction because it makes the reaction release more energy, and the catalyst gets used up as it works." Identify the two errors and give a correct explanation.

Error 1: a catalyst does not change ΔH; reactants and products stay at the same energies. Error 2: a catalyst is not used up; it is used in one step and made again in a later step.
Correct: the catalyst provides a new pathway with a lower E_a, so a larger fraction of collisions have enough energy to react.

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