

# Mechanisms, catalysts and activation energy

AP Chemistry · Test

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_ Mark: \_\_\_\_ / 20

This test lasts 45 minutes and covers mechanisms, energy profiles, catalysts and the Arrhenius equation. A calculator is allowed;  $R = 8.314 \text{ J/(mol K)}$ . Show your working. The total is 20 marks.

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

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

## Question 1 Elementary steps (2 marks)

For the elementary step  $2 \text{ NO}_2 \rightarrow \text{NO}_3 + \text{NO}$ :

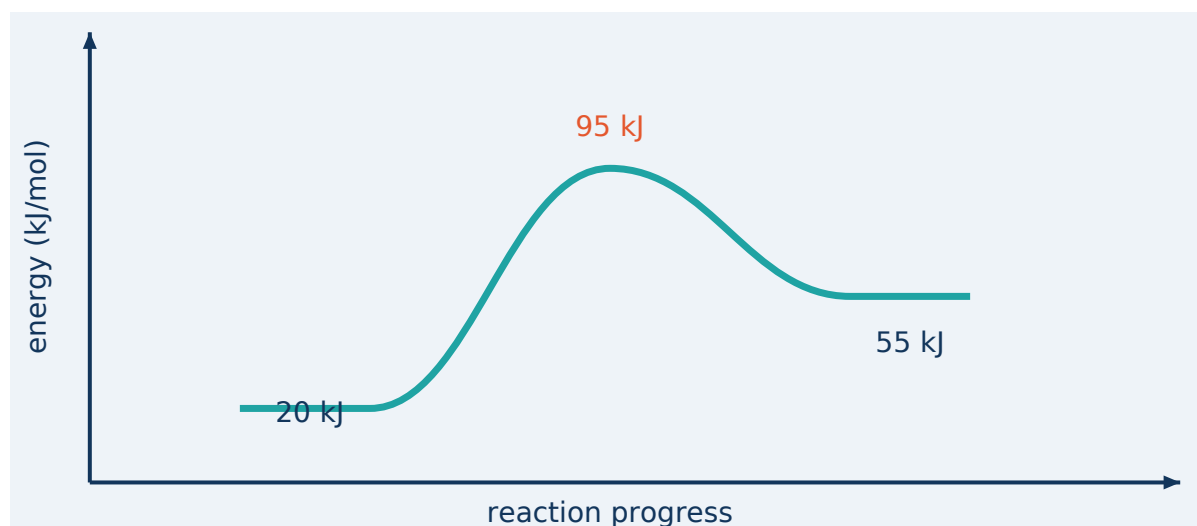
- State its molecularity. (1 mark)
- Write its rate law. (1 mark)

## Question 2 Testing a mechanism (3 marks)

$2 \text{ NO}_2\text{Cl} \rightarrow 2 \text{ NO}_2 + \text{Cl}_2$  has the mechanism: step 1 (slow)  $\text{NO}_2\text{Cl} \rightarrow \text{NO}_2 + \text{Cl}$ ; step 2 (fast)  $\text{NO}_2\text{Cl} + \text{Cl} \rightarrow \text{NO}_2 + \text{Cl}_2$ .

- Show that the steps give the overall equation. (1 mark)
- Identify the intermediate. (1 mark)
- Write the rate law predicted. (1 mark)

## Question 3 Energy profile (3 marks)



*Energies are relative to a common zero.*

- a. Calculate  $E_a$  for the forward reaction. (1 mark)
- b. Calculate  $\Delta H$  and state whether it is endothermic. (1 mark)
- c. Calculate  $E_a$  for the reverse reaction. (1 mark)

**Question 4 Role of a catalyst** (2 marks)

Explain how a catalyst increases the rate and state its effect on  $\Delta H$ .

**Question 5 Activation energy** (3 marks)

A first-order reaction has  $k = 2.0 \times 10^{-2} \text{ s}^{-1}$  at 350 K and  $8.0 \times 10^{-2} \text{ s}^{-1}$  at 370 K. Calculate  $E_a$  in kJ/mol.

**Question 6 Fast equilibrium** (3 marks)

For  $2 \text{ NO} + \text{O}_2 \rightarrow 2 \text{ NO}_2$  the proposed steps are: (1) fast equilibrium  $2 \text{ NO} \rightleftharpoons \text{N}_2\text{O}_2$ ; (2) slow  $\text{N}_2\text{O}_2 + \text{O}_2 \rightarrow 2 \text{ NO}_2$ .

- a. Derive the rate law in terms of reactants only. (2 marks)
- b. State the overall order. (1 mark)

**Question 7 Catalyst or intermediate** (2 marks)

A mechanism for  $2 \text{ H}_2\text{O}_2 \rightarrow 2 \text{ H}_2\text{O} + \text{O}_2$  is: step 1,  $\text{Br}^- + \text{H}_2\text{O}_2 + \text{H}^+ \rightarrow \text{HOBr} + \text{H}_2\text{O}$ ; step 2,  $\text{HOBr} + \text{H}_2\text{O}_2 \rightarrow \text{H}^+ + \text{Br}^- + \text{H}_2\text{O} + \text{O}_2$ . Identify one catalyst and the intermediate.

**Question 8 Temperature and collisions** (2 marks)

Use the idea of the energy distribution of particles to explain why raising the temperature increases  $k$ .