

5.10 Energy Profiles for Many Steps

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS transition state 过渡态 • intermediates 中间体 • energy profile 能量图
 • rate-determining step 决速步骤 • activation energy 活化能

Objective

Build the skills to answer exam questions on **energy profiles for multi-step reactions**.

You must be able to:

- read a profile with **two (or more) peaks**
- identify the **rate-determining step** as the highest peak
- locate **intermediates** in the valleys between peaks

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Many peaks = many steps

A multi-step reaction has **one peak per step**. Between two peaks sits a **valley** — a relatively stable **intermediate**.

■ The tallest barrier is rate-determining

The step with the **highest** peak (largest E_a measured from the valley/reactant before it) is the slowest — the **rate-determining step**.

■ Intermediates vs transition states

- **Peaks** are transition states (unstable, cannot be isolated).
- **Valleys** between peaks are intermediates (real species, briefly formed).

■ Overall ΔH

ΔH is still just **products minus reactants** (the start and end heights), regardless of how many peaks lie between.

2 Practice

Now apply the methods above.

2.1 How many steps does a profile with two peaks show? [1]

2.2 What does a valley between two peaks represent? [1]

2.3 Which step is rate-determining on a two-peak profile? [1]

3 Exam-style questions

3.1 On an energy profile, an intermediate is found at a [1]

A	B
C	D

A peak

B valley between peaks

C the reactant position

D the product position

3.2 A two-step profile: reactants at 40 kJ, peak 1 at 100 kJ, valley at 70 kJ, peak 2 at 90 kJ, products at 30 kJ.

(a) Find E_a for step 1 and for step 2 (each measured from the species before its peak).[2]

(b) Which step is rate-determining? [1]

(c) Find the overall ΔH . [1]

3.3 Explain the difference between a transition state and an intermediate on the profile.[2]