

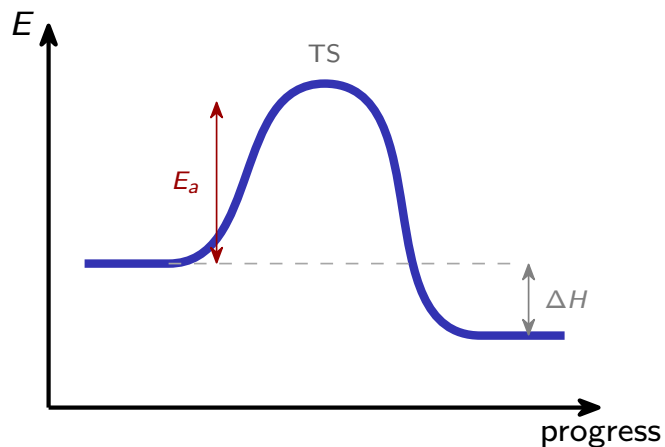
Exercise walk-through

5.10

Multistep Reaction Energy Profile

AP Chemistry

Energy profiles and Arrhenius



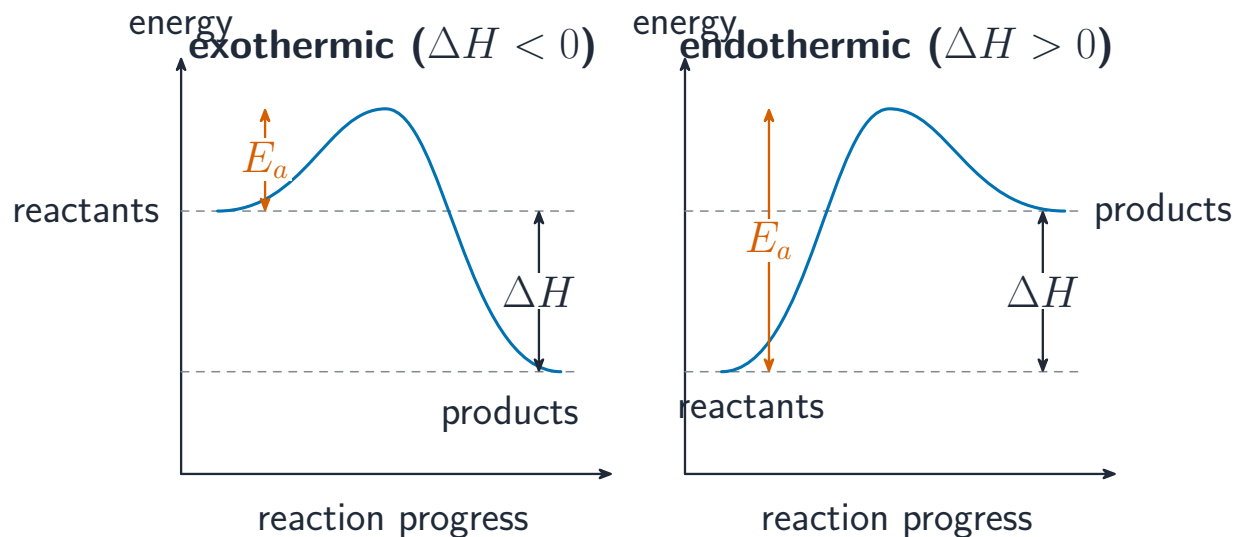
The **transition state** is the peak. Forward E_a = reactants to peak.

Arrhenius equation

$$k = A e^{-E_a/(RT)}$$

Larger $E_a \Rightarrow$ smaller k . Products lower = **exothermic**.

Reading an Energy Profile

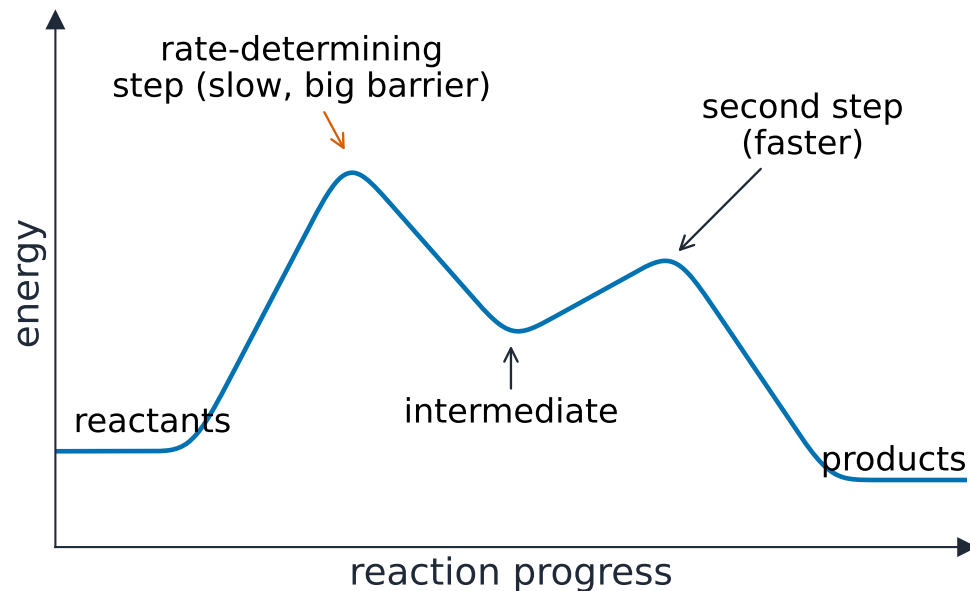


Exothermic reactions end lower than the reactants; endothermic end higher

The Sequence of Steps

In a multi-step mechanism, the steps must **add up** to the overall balanced equation (intermediates cancel).

Each step has its own energy hill; the tallest hill is the slowest step.



Exercises 2.1-2.3

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]

Exercises 2.1-2.3

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

2.1

- Two steps
-

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

2.2

- An intermediate
-

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

2.3

- The step with the higher peak (larger activation energy)

Exercise 3.1

3.1 On an energy profile, an intermediate is found at a

[1]

☐

A peak

B valley between peaks

C the reactant position

D the product position

Exercise 3.1

3.1 On an energy profile, an intermediate is found at a

[1]

☐

A peak

B valley between peaks

C the reactant position

D the product position

3.1 B

- a valley between peaks

Exercise 3.2 (a)

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]

Exercise 3.2 (a)

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]

(a)

- step 1: $100 - 40 = 60$ kJ; step 2: $90 - 70 = 20$ kJ

Exercise 3.2 (b)

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.

(b) Which step is rate-determining?

[1]

Exercise 3.2 (b)

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.

(b) Which step is rate-determining?

[1]

(b)

- Step 1 (higher barrier)

Exercise 3.2 (c)

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.

(c) Find the overall ΔH .

[1]

Exercise 3.2 (c)

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.

(c) Find the overall ΔH .

[1]

(c)

- $\Delta H = 30 - 40 = -10 \text{ kJ}$

Exercise 3.3

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

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3.3

- A transition state (peak) is an unstable maximum that cannot be isolated; an intermediate (valley) is a real, briefly-stable species formed between steps