Exercise walk-through

Thermodynamic and Kinetic Control ▪ 9.4

eXercise

You must be able to

- distinguish **thermodynamic favorability** ($\Delta G < 0$) from **kinetic** speed
- explain why a favorable reaction can still be slow
- link a slow favorable reaction to a high **activation energy**

Method — Two separate questions

- **Thermodynamics** (ΔG) asks: *will* it happen (is it favorable)?
- **Kinetics** (E_a) asks: *how fast* will it happen?

A reaction can be favorable ($\Delta G < 0$) but extremely **slow**.

Method — A worked example

Diamond $\rightarrow$ graphite has $\Delta G < 0$ (favorable), yet diamonds do not visibly change — the activation energy is enormous, so the rate is effectively zero.

Method — Why favorable can be slow

A large **activation-energy barrier** blocks the reaction even when the products are lower in free energy. A catalyst can speed it up without changing ΔG.

Method — The takeaway

"Favorable" (spontaneous) does **not** mean "fast". Both a negative ΔG and a surmountable E_a are needed for a reaction to proceed noticeably.

Practice 2.1 ▪ 1 mark

What does a negative ΔG tell you?

Solution 2.1

Method: The takeaway

Worked steps

The reaction is thermodynamically favorable (spontaneous) B1.

Practice 2.2 ▪ 1 mark

What controls how fast a reaction goes?

Solution 2.2

Worked steps

The activation energy (kinetics) B1.

Practice 2.3 ▪ 1 mark

Can a favorable reaction be slow?

Solution 2.3

Worked steps

Yes B1.

Exam-style 3.1 ▪ 1 mark

A reaction with $\Delta G < 0$ that proceeds very slowly is limited by

A thermodynamics

B a high activation energy (kinetics)

C a negative ΔH

D a positive entropy

Solution 3.1

A thermodynamics

B a high activation energy (kinetics) ✓

C a negative ΔH

D a positive entropy

Worked steps

B — a high activation energy (kinetics).

Exam-style 3.2 ▪ 1 mark

The conversion of diamond to graphite has $\Delta G < 0$ but is not observed.
(a) State whether it is thermodynamically favorable.
(b) Explain why it does not happen at a noticeable rate.

Solution 3.2

Method: A worked example

Worked steps

(a) Yes ($\Delta G < 0$) B1. (b) The activation energy is extremely high, so almost no molecules can cross the barrier and the rate is effectively zero M1 A1.

Exam-style 3.3 ▪ 2 marks

Explain how a catalyst can make a favorable-but-slow reaction proceed, and what it does **not** change.

Solution 3.3

Worked steps

A catalyst lowers the activation energy, providing a faster pathway; it does **not** change ΔG (the favorability) M1 A1.