

Exercise walk-through

9.4

Thermodynamic and Kinetic Control

AP Chemistry

Gibbs free energy

Favorability depends on **both** energy and entropy:

Gibbs free energy

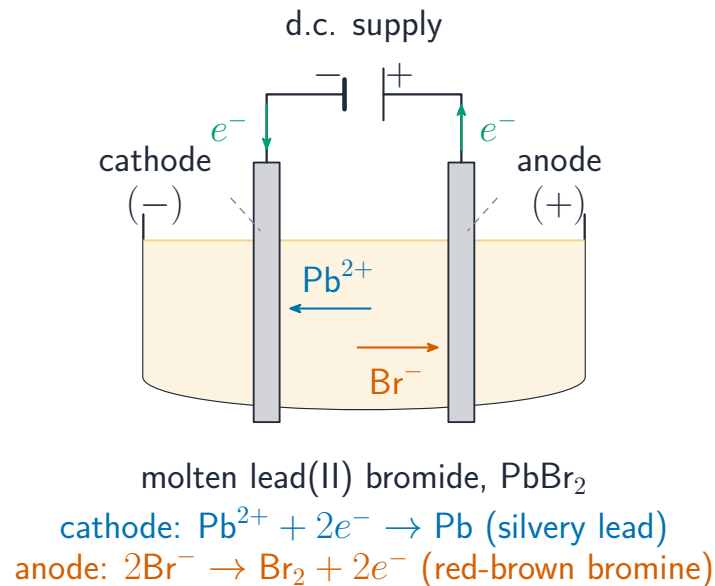
$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$\Delta G^\circ < 0$ is **thermodynamically favorable**. If ΔH and ΔS oppose, T can flip it.



Free energy drives spontaneous change

Electrolysis



Electrolysis: ions move to the electrodes and are discharged

Exam tips

- A process is **thermodynamically favourable** when $\Delta G < 0$; combine enthalpy and entropy with $\Delta G = \Delta H - T\Delta S$ (match units – kJ vs J).
- Entropy **increases** solid→liquid→gas and when more gas moles are produced.
- Favourable does **not** mean fast – a high activation energy can make a $\Delta G < 0$ reaction extremely slow (kinetic control).
- In electrochemistry a **positive** $E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ}$ means a spontaneous (galvanic) cell; oxidation is at the **anode**, reduction at the **cathode**.
- In electrolysis the charge passed ($Q = It$) fixes the amount deposited (Faraday's law).

Exercises 2.1-2.3

2.1 What does a negative ΔG tell you?

[1]

2.2 What controls how fast a reaction goes?

[1]

2.3 Can a favorable reaction be slow?

[1]

Exercises 2.1-2.3

2.1 What does a negative ΔG tell you? [1]

2.1

- The reaction is thermodynamically favorable (spontaneous)
-

2.2 What controls how fast a reaction goes? [1]

2.2

- The activation energy (kinetics)
-

2.3 Can a favorable reaction be slow? [1]

2.3

- Yes

Exercise 3.1

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

[1]

☐

A thermodynamics

B a high activation energy (kinetics)

C a negative ΔH

D a positive entropy

Exercise 3.1

3.1 A reaction with $\Delta G < 0$ that proceeds very slowly is limited by [1]

☐

A thermodynamics

B a high activation energy (kinetics)

C a negative ΔH

D a positive entropy

3.1 B

- a high activation energy (kinetics)

Exercise 3.2 (a)

3.2 The conversion of diamond to graphite has $\Delta G < 0$ but is not observed.

(a) State whether it is thermodynamically favorable.

[1]

Exercise 3.2 (a)

3.2 The conversion of diamond to graphite has $\Delta G < 0$ but is not observed.

(a) State whether it is thermodynamically favorable.

[1]

(a)

- Yes ($\Delta G < 0$)

Exercise 3.2 (b)

3.2 The conversion of diamond to graphite has $\Delta G < 0$ but is not observed.

(b) Explain why it does not happen at a noticeable rate.

[2]

Exercise 3.2 (b)

3.2 The conversion of diamond to graphite has $\Delta G < 0$ but is not observed.

(b) Explain why it does not happen at a noticeable rate. [2]

(b)

- The activation energy is extremely high, so almost no molecules can cross the barrier and the rate is effectively zero

Exercise 3.3

3.3 Explain how a catalyst can make a favorable-but-slow reaction proceed, and what it does **not** change. [2]

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3.3

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