

Exercise walk-through

Coupled Reactions ■ 9.7

eXercise

You must be able to

- add a favorable reaction to an unfavorable one to drive it
- add the ΔG values
- decide whether the coupled reaction is favorable overall

Method — Coupling reactions

An **unfavorable** reaction ($\Delta G > 0$) can be driven by **coupling** it to a **favorable** one ($\Delta G < 0$) that shares a species, if the total ΔG is negative.

Method — Adding the ΔG values

Like Hess's law, when reactions are added their ΔG values add:

$$\Delta G_{\text{total}} = \Delta G_1 + \Delta G_2.$$

Method — A worked coupling

Reaction 1: $\Delta G = +30$ kJ (unfavorable). Reaction 2: $\Delta G = -50$ kJ (favorable).

Coupled: $\Delta G = +30 + (-50) = -20$ kJ — now favorable.

Method — Biological example

Cells couple the very favorable hydrolysis of ATP ($\Delta G \ll 0$) to otherwise-unfavorable reactions to make them go — the basis of metabolism.

Practice 2.1 ■ 1 mark

When two reactions are added, how do their ΔG values combine?

Solution 2.1

Method: Adding the ΔG values

Worked steps

They add **B1**.

Practice 2.2 ■ 1 mark

Reaction A (+20 kJ) is coupled to B (−35 kJ). Find the total ΔG .

Solution 2.2

Method: A worked coupling

Worked steps

$$20 + (-35) = -15 \text{ kJ } \text{B1}.$$

Practice 2.3 ■ 1 mark

Is the coupled reaction in 2.2 favorable?

Solution 2.3

Method: A worked coupling

Worked steps

Yes ($\Delta G < 0$) **B1**.

Exam-style 3.1 ■ 1 mark

An unfavorable reaction can be driven by coupling it to a reaction with

- A** a larger positive ΔG
- B** a sufficiently negative ΔG
- C** zero ΔG
- D** a higher activation energy

Solution 3.1

Method: Coupling reactions

- A a larger positive ΔG
- B a sufficiently negative ΔG 
- C zero ΔG
- D a higher activation energy

Worked steps

B — a sufficiently negative ΔG to make the sum negative.

Exam-style 3.2 ■ 2 marks

Reaction 1 ($\Delta G = +25$ kJ) is coupled with reaction 2 ($\Delta G = -40$ kJ).

- (a) Find the total ΔG .
- (b) State whether the coupled process is favorable.

Solution 3.2

Method: A worked coupling

Worked steps

(a) $25 + (-40) = -15$ kJ **M1** **A1**. (b) Favorable ($\Delta G < 0$) **B1**.

Exam-style 3.3 ■ 2 marks

Explain how cells use ATP hydrolysis to drive unfavorable reactions.

Solution 3.3

Method: Biological example

Worked steps

ATP hydrolysis is strongly favorable ($\Delta G \ll 0$); coupling it to an unfavorable reaction makes the combined ΔG negative, so the overall process proceeds **M1** **A1**.