AP CHEMISTRY • EXERCISE SHEET

9.7 Coupled Reactions

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

Objective

Build the skills to answer exam questions on **coupled reactions**.

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

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.

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.

Adding the ΔG values

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

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

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.

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.

2 Practice

Now apply the methods above.

2.1 When two reactions are added, how do their ΔG values combine? [1]

2.2 Reaction A (+20 kJ) is coupled to B (−35 kJ). Find the total ΔG. [1]

2.3 Is the coupled reaction in 2.2 favorable? [1]

3 Exam-style questions

3.1 An unfavorable reaction can be driven by coupling it to a reaction with [1]

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

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

(a) Find the total ΔG. [2]

(b) State whether the coupled process is favorable. [1]

3.3 Explain how cells use ATP hydrolysis to drive unfavorable reactions. [2]

4 Go further

You are now ready for the real exam questions on this subtopic:

- work through the **9.7 Coupled Reactions** lesson on the **Learn** page;

- read the **Coupled Reactions** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 They add.

2.2 $20 + (-35) = -15$ kJ.

2.3 Yes ($\Delta G < 0$).

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

3.2 (a) $25 + (-40) = -15$ kJ. (b) Favorable ($\Delta G < 0$).

3.3 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.