AP CHEMISTRY • EXERCISE SHEET

9.5 Free Energy and Equilibrium

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

Objective

Build the skills to answer exam questions on **free energy and equilibrium**.

You must be able to:

- use $\Delta G^\circ = -RT \ln K$
- relate the sign of ΔG° to whether $K > 1$ or $K < 1$
- reason about the connection

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.

The link

$$\Delta G^\circ = -RT \ln K,$$

with $R = 8.314$ J mol^{-1}K^{-1} and T in kelvin. Free energy and the equilibrium constant carry the same information.

Sign and K

- $\Delta G^\circ < 0 \quad K > 1$ (products favored);
- $\Delta G^\circ > 0 \quad K < 1$ (reactants favored);
- $\Delta G^\circ = 0 \quad K = 1$.

A worked value

If $K = 100$ at 298 K: $\Delta G^\circ = -(8.314)(298)\ln(100) = -(8.314)(298)(4.605) = -11\,400$ J $= -11.4$ kJ.

Reading the connection

A large positive ΔG° means a very small K (little product). The more negative ΔG°, the larger K and the further the equilibrium lies toward products.

2 Practice

Now apply the methods above.

2.1 Write the equation linking ΔG° and K. [1]

2.2 If $\Delta G^\circ < 0$, is K greater or less than 1? [1]

2.3 If $\Delta G^\circ = 0$, what is K? [1]

3 Exam-style questions

3.1 A reaction with $K < 1$ has ΔG° that is [1]

- **A** negative
- **B** positive
- **C** zero
- **D** equal to K

3.2 A reaction has $K = 1 \times 10^{-3}$ at 298 K.

(a) State the sign of ΔG°. [1]

(b) Calculate ΔG° (use $R = 8.314$, $\ln(10^{-3}) = -6.9$). [3]

3.3 Explain why a more negative ΔG° corresponds to a larger equilibrium constant. [2]

4 Go further

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

- work through the **9.5 Free Energy and Equilibrium** lesson on the **Learn** page;
- read the **Free Energy and Equilibrium** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 $\Delta G^\circ = -RT \ln K$.

2.2 Greater than 1.

2.3 $K = 1$.

3.1 B —positive.

3.2 (a) Positive. (b) $\Delta G^\circ = -(8.314)(298)(-6.9) = +17\,100$ J $\approx +17$ kJ.

3.3 $\Delta G^\circ = -RT \ln K$: a more negative ΔG° requires a larger $\ln K$, hence a larger K — the equilibrium lies further toward products.