AP CHEMISTRY • EXERCISE SHEET

9.6 Free Energy of Dissolution

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

Objective

Build the skills to answer exam questions on the **free energy of dissolution**.

You must be able to:

- split dissolution into ΔH_{soln} and ΔS_{soln}
- use $\Delta G = \Delta H - T\Delta S$ to judge whether a salt dissolves
- reason about temperature dependence

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.

■ Dissolution has an enthalpy and entropy part

Dissolving a salt has ΔH_{soln} (may be + or −) and usually $\Delta S_{\text{soln}} > 0$ (ions spread out into solution —more disorder).

■ Judging with ΔG

The salt dissolves spontaneously when $\Delta G_{\text{soln}} = \Delta H_{\text{soln}} - T\Delta S_{\text{soln}} < 0$. Because ΔS is usually positive, higher T makes $-T\Delta S$ more negative —favoring dissolution.

■ A worked case

$\Delta H_{\text{soln}} = +25$ kJ (endothermic), $\Delta S_{\text{soln}} = +0.10$ kJ/K: at 300 K, $\Delta G = 25 - 300(0.10) = 25 - 30 = -5$ kJ —dissolves.

■ Why some salts dissolve more when heated

Many salts have endothermic dissolution but positive ΔS; heating makes ΔG more negative, so they dissolve **more** at higher temperature.

2 Practice

Now apply the methods above.

2.1 What is usually the sign of ΔS_{soln} for a dissolving salt? [1]

2.2 A salt dissolves when ΔG_{soln} is what sign? [1]

2.3 For $\Delta H = +20$ kJ, $\Delta S = +0.10$ kJ/K, $T = 300$ K, find ΔG_{soln}. [2]

3 Exam-style questions

3.1 An endothermic dissolution with positive ΔS becomes favorable at [1]

- **A** low temperature
- **B** high temperature
- **C** all temperatures
- **D** no temperature

3.2 A salt has $\Delta H_{\text{soln}} = +15$ kJ and $\Delta S_{\text{soln}} = +0.060$ kJ/K.

(a) Find ΔG_{soln} at 250 K and state if it dissolves. [3]

(b) Find the temperature at which $\Delta G_{\text{soln}} = 0$. [2]

3.3 Explain why many salts dissolve more readily in hot water than cold water. [2]

4 Go further

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

- work through the **9.6 Free Energy of Dissolution** lesson on the **Learn** page;
- read the **Free Energy of Dissolution** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 Positive.

2.2 Negative.

2.3 $\Delta G = 20 - 300(0.10) = 20 - 30 = -10$ kJ.

3.1 B —high temperature.

3.2 (a) $\Delta G = 15 - 250(0.060) = 15 - 15 = 0$ kJ —at the borderline (just favorable above this T). (b) $T = \dfrac{15}{0.060} = 250$ K.

3.3 Their dissolution is endothermic but has positive ΔS; raising T makes $-T\Delta S$ more negative, so ΔG becomes negative and more salt dissolves.