

Exercise walk-through

Free Energy of Dissolution ■ 9.6

eXercise

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

Method — 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).

Method — 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.

Method — A worked case

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

Method — 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.

Practice 2.1 ■ 1 mark

What is usually the sign of ΔS_{soln} for a dissolving salt?

Solution 2.1

Method: Dissolution has an enthalpy and entropy part

Worked steps

Positive **B1**.

Practice 2.2 ■ 1 mark

A salt dissolves when ΔG_{soln} is what sign?

Solution 2.2

Method: Judging with ΔG

Worked steps

Negative **B1**.

Practice 2.3 ■ 2 marks

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

Solution 2.3

Worked steps

$$\Delta G = 20 - 300(0.10) = 20 - 30 = -10 \text{ kJ} \quad \text{M1} \quad \text{A1}.$$

Exam-style 3.1 ■ 1 mark

An endothermic dissolution with positive ΔS becomes favorable at

A low temperature

B high temperature

C all temperatures

D no temperature

Solution 3.1

Method: Why some salts dissolve more when heated

A low temperature

B high temperature



C all temperatures

D no temperature

Worked steps

B — high temperature.

Exam-style 3.2 ■ 3 marks

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

- (a) Find ΔG_{soln} at 250 K and state if it dissolves.
- (b) Find the temperature at which $\Delta G_{\text{soln}} = 0$.

Solution 3.2

Method: Judging with ΔG

Worked steps

(a) $\Delta G = 15 - 250(0.060) = 15 - 15 = 0$ kJ — at the borderline (just favorable above this T) **M1 M1 A1**. (b) $T = \frac{15}{0.060} = 250$ K **M1 A1**.

Exam-style 3.3 ■ 2 marks

Explain why many salts dissolve more readily in hot water than cold water.

Solution 3.3

Method: Why some salts dissolve more when heated

Worked steps

Their dissolution is endothermic but has positive ΔS ; raising T makes $-T\Delta S$ more negative, so ΔG becomes negative and more salt dissolves **M1** **A1**.