

Exercise walk-through

9.6

Free Energy of Dissolution

AP Chemistry

Free energy and equilibrium

Free energy connects to the equilibrium constant:

Standard and nonstandard

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

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$\Delta G^\circ < 0 \Rightarrow K > 1$. At **equilibrium**, $\Delta G = 0$ and $Q = K$.

Coupled reactions

Add the ΔG° values. An unfavorable step (+20) coupled to -50:

$$+20 + (-50) = -30 \text{ kJ}$$

In cells, the “downhill” partner is ATP breakdown.

Exercises 2.1-2.3

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

Exercises 2.1-2.3

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

2.1

- Positive
-

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

2.2

- Negative
-

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

2.3

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

Exercise 3.1

3.1 An endothermic dissolution with positive ΔS becomes favorable at

[1]

☐

A low temperature

B high temperature

C all temperatures

D no temperature

Exercise 3.1

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[1]

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A low temperature

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3.1 B

- high temperature

Exercise 3.2 (a)

3.2 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.

[3]

Exercise 3.2 (a)

3.2 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.

[3]

(a)

- $\Delta G = 15 - 250(0.060) = 15 - 15 = 0 \text{ kJ}$ – at the borderline (just favorable above this T)

Exercise 3.2 (b)

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

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

[2]

Exercise 3.2 (b)

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

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

[2]

(b)

- $$T = \frac{15}{0.060} = 250 \text{ K}$$

Exercise 3.3

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

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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