

Exercise walk-through

9.5

Free Energy and Equilibrium

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 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]

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2.1

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

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

2.2

- Greater than 1

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

2.3

- $K = 1$

Exercise 3.1

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

[1]

☐

A negative

B positive

C zero

D equal to K

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3.1 B

- positive

Exercise 3.2 (a)

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

(a) State the sign of ΔG° .

[1]

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[1]

(a)

- Positive

Exercise 3.2 (b)

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

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

[3]

Exercise 3.2 (b)

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

[3]

(b)

- $\Delta G^\circ = -(8.314)(298)(-6.9) = +17\,100 \text{ J} \approx +17 \text{ kJ}$

Exercise 3.3

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

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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