Exercise walk-through

Absolute Entropy and Entropy Change ▪ 9.2

eXercise

You must be able to

- use $\Delta S^\circ = \Sigma S^\circ(\text{products}) - \Sigma S^\circ(\text{reactants})$
- weight each S° by its coefficient
- interpret the sign of the result

Method — Standard molar entropy

Every substance has a positive **standard molar entropy** S° (unlike ΔH_f, elements are **not** zero). Gases have the largest S°.

Method — The entropy-change formula

$$\Delta S^\circ = \sum S^\circ(\text{products}) - \sum S^\circ(\text{reactants}),$$

each weighted by its coefficient.

Method — A worked calculation

For $N_2 + 3H_2 \to 2NH_3$, with S°: $N_2 = 192$, $H_2 = 131$, $NH_3 = 193$ J mol^{-1}K^{-1}:

$$\Delta S^\circ = 2(193) - [192 + 3(131)] = 386 - 585 = -199 \text{ J K}^{-1}.$$

Negative — consistent with 4 gas moles becoming 2.

Method — Sign check

The calculated sign should match the qualitative prediction (fewer gas moles $\rightarrow$ negative). If not, recheck the coefficients.

Practice 2.1 ▪ 1 mark

Write the formula for ΔS° of a reaction.

Solution 2.1

Method: The entropy-change formula

Worked steps

$\Delta S^\circ = \Sigma S^\circ(\text{products}) - \Sigma S^\circ(\text{reactants})$ **B1**.

Practice 2.2 ▪ 1 mark

Is S° of an element zero?

Solution 2.2

Method: Standard molar entropy

Worked steps

No — it is a positive value **B1**.

Practice 2.3 ▪ 2 marks

For products summing to 400 and reactants to 550 J/K, find ΔS°.

Solution 2.3

Method: The entropy-change formula

Worked steps

$400 - 550 = -150$ J/K **M1** **A1**.

Exam-style 3.1 ▪ 1 mark

Unlike ΔH_f°, the standard entropy S° of an element is

A zero

B a positive value

C negative

D undefined

Solution 3.1

Method: Standard molar entropy

A zero

B a positive value ✓

C negative

D undefined

Worked steps

B — a positive value.

Exam-style 3.2 ▪ 3 marks

For $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$, with S°: $SO_2 = 248$, $O_2 = 205$, $SO_3 = 257$ J $mol^{-1}K^{-1}$.

(a) Calculate ΔS°.

(b) Is the sign consistent with the change in gas moles?

Solution 3.2

Method: A worked calculation

Worked steps

(a) $\Delta S^\circ = 2(257) - [2(248) + 205] = 514 - 701 = -187$ J K^{-1} M1 M1 A1. (b) Yes — 3 gas moles become 2, so a decrease is expected B1.

Exam-style 3.3 ▪ 2 marks

Explain why ΔS° is negative for a reaction that goes from 3 moles of gas to 2 moles of gas.

Solution 3.3

Method: A worked calculation

Worked steps

Fewer gas molecules means fewer ways to arrange the particles, so the disorder (entropy) decreases, giving a negative ΔS° **M1** **A1**.