

Exercise walk-through

Entropy change, ΔS ■ 23.3

eXercise

You must be able to

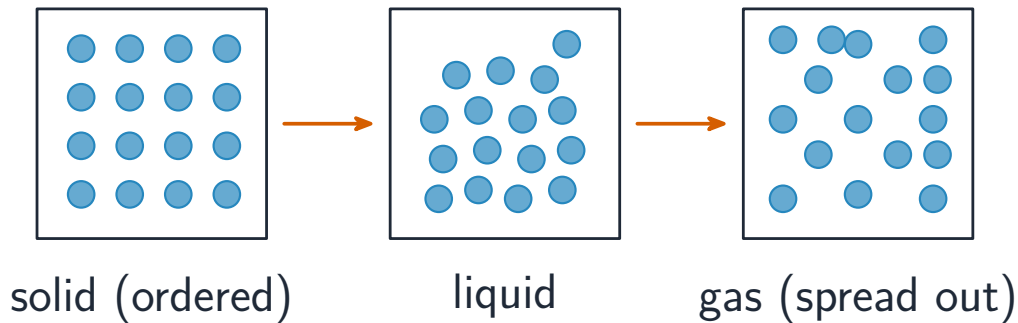
- define entropy as the number of ways the particles and energy can be arranged
- predict and explain the sign of ΔS for state changes and gas-number changes
- calculate ΔS from standard entropies

Method — Entropy and its sign

Entropy S = the number of possible arrangements of the particles and their energy.
More disorder = higher entropy.

- $+\Delta S$: solid $\rightarrow$ liquid $\rightarrow$ gas; dissolving; more gas molecules formed; higher temperature.
- $-\Delta S$: the reverse (fewer gas molecules, freezing).

entropy increases: $\Delta S > 0$



Method — Entropy and its sign

	ΔS positive	ΔS negative
ΔH neg.	feasible at all temperatures	feasible only at low temperature
ΔH pos.	feasible only at high temperature	never feasible

$$\Delta G = \Delta H - T\Delta S; \quad \text{feasible when } \Delta G \leq 0$$

Entropy feeds the Gibbs feasibility test

Method — Calculating ΔS

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

(units $\text{J K}^{-1}\text{mol}^{-1}$).

Practice 2.1 ■ 1 mark

Define **entropy**.

Solution 2.1

Worked steps

the number of possible arrangements of the particles and their energy in a system
B1.

Practice 2.2 ■ 1 mark

State the sign of ΔS when a gas condenses to a liquid.

Solution 2.2

Method: Entropy and its sign

Worked steps

negative **B1**.

Exam-style 3.1 ■ 1 mark

Which change has the **largest positive** entropy change?

A freezing of water

B $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$

C $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$

D condensing steam

Solution 3.1

A freezing of water

B $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$



C $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$

D condensing steam

Worked steps

B. A solid producing a gas gives the largest increase in entropy.

Exam-style 3.2 ■ 1 mark

The entropy of a substance is **highest** when it is a:

A solid

B liquid

C gas

D crystal

Solution 3.2

A solid

B liquid

C gas



D crystal

Worked steps

C. A gas has the highest entropy.

Exam-style 3.3 ■ 3 marks

For $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$, the standard entropies ($\text{J K}^{-1}\text{mol}^{-1}$) are: N 192, H 131, NH 193.

- (a) Calculate $\Delta S^\ominus$ for the reaction.
- (b) Explain the sign of your answer.

Solution 3.3

Method: Calculating ΔS

Worked steps

$$\begin{aligned} \text{(a) } \Delta S^{\ominus} &= \sum S(\text{products}) - \sum S(\text{reactants}) \quad \text{M1}; = 2(193) - [192 + 3(131)] \quad \text{M1} \\ &= 386 - 585 = -199 \text{ J K}^{-1}\text{mol}^{-1} \quad \text{A1}. \end{aligned}$$

(b) negative — 4 moles of gas become 2 moles, so the disorder decreases B1.

Exam-style 3.4 ■ 2 marks

Explain why dissolving a solid in water usually has a positive entropy change.

Solution 3.4

Method: Entropy and its sign

Worked steps

the solid lattice breaks up and its ions/molecules spread out and mix among the water molecules **M1**, giving many more arrangements, so the entropy increases **A1**.