A-LEVEL CHEMISTRY • EXERCISE SHEET

23.3 Entropy change

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS entropy 熵 • entropy change 熵变 • feasibility 可行性

Objective

Build the skills to answer exam questions on **entropy change** 熵变 — what **entropy** 熵 (S) is, predicting the sign of ΔS, and calculating it.

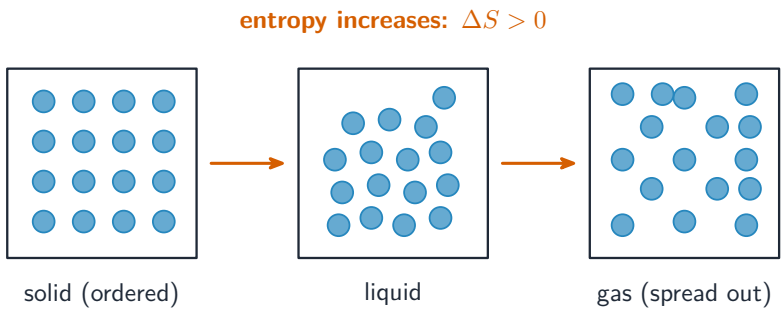
You must be able to:

- 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

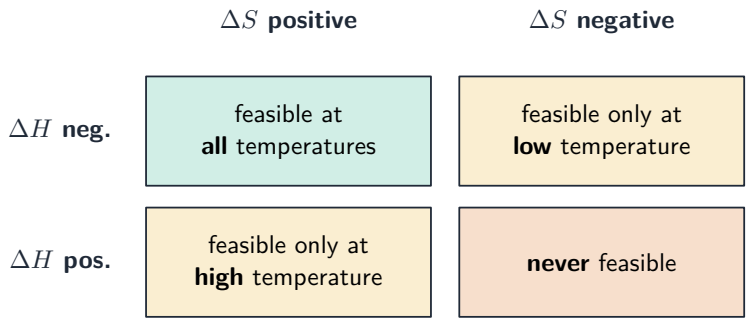
1 Worked examples

Entropy and its sign

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



Entropy rises on melting, boiling and dissolving, and when more gas molecules are made (+ΔS)



$\Delta G = \Delta H - T\Delta S$; **feasible when** $\Delta G \leq 0$

Entropy feeds the Gibbs feasibility test

- **+ΔS:** solid → liquid → gas; dissolving; more gas molecules formed; higher temperature.
- **−ΔS:** the reverse (fewer gas molecules, freezing).

Calculating ΔS

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

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

2 Practice

2.1 Define **entropy**. [1]

2.2 State the sign of ΔS when a gas condenses to a liquid. [1]

3 Exam-style questions

3.1 Which change has the **largest positive** entropy change? [1]

- **A** freezing of water
- **B** $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
- **C** $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
- **D** condensing steam

3.2 The entropy of a substance is **highest** when it is a: [1]

- **A** solid
- **B** liquid
- **C** gas
- **D** crystal

3.3 For $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, the standard entropies (J $K^{-1}mol^{-1}$) are: N_2 192, H_2 131, NH_3 193.

(a) Calculate $\Delta S^{\ominus}$ for the reaction. [3]

(b) Explain the sign of your answer. [1]

3.4 Explain why dissolving a solid in water usually has a positive entropy change. [2]

Solutions

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

2.2 negative.

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

3.2 C. A gas has the highest entropy.

3.3 (a) $\Delta S^{\ominus} = \sum S(\text{products}) - \sum S(\text{reactants})$; $= 2(193) - [192 + 3(131)] = 386 - 585 = -199$ J $K^{-1}mol^{-1}$.
(b) negative — 4 moles of gas become 2 moles, so the disorder decreases.

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