

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.

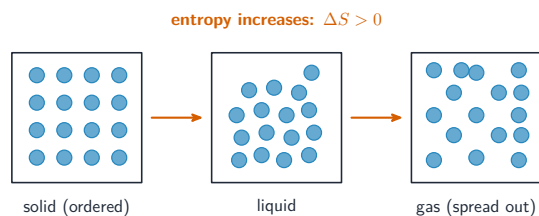
You must be able to:

- 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 ($+\Delta S$)

	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

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

■ Calculating ΔS

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

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

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 $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
- C $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
- D condensing steam

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 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$, the standard entropies ($\text{J K}^{-1}\text{mol}^{-1}$) are: N_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) $\Delta S^\ominus = \sum S(\text{products}) - \sum S(\text{reactants})$; $= 2(193) - [192 + 3(131)] = 386 - 585 = -199 \text{ J K}^{-1}\text{mol}^{-1}$.

(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.