

23.3 Entropy change

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS entropy • entropy change • feasibility

Objective

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

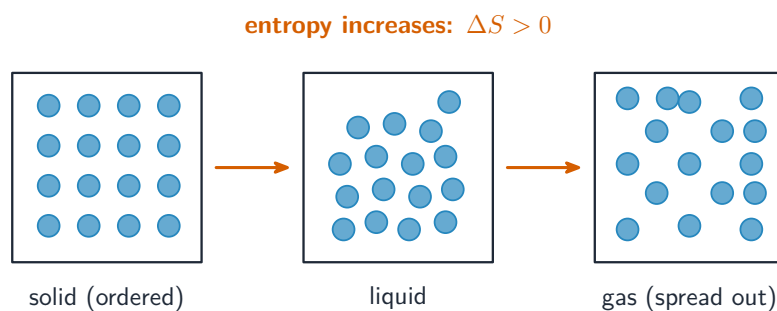
You must be able to:

- 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 Key knowledge and 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

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

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

Each answer shows the steps, then the **result**.

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