

9.1 Introduction to Entropy

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS entropy 熵

Objective

Build the skills to answer exam questions on **entropy** — the measure of disorder.

You must be able to:

- describe **entropy** 熵 as the number of ways to arrange a system
- predict the **sign of ΔS** for a process
- rank states by entropy (gas > liquid > solid)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ What entropy is

Entropy (S) measures disorder — the number of ways energy and particles can be arranged. More spread-out, more random $\Rightarrow$ higher entropy.

■ Entropy by state

For the same substance, $S_{\text{gas}} > S_{\text{liquid}} > S_{\text{solid}}$. Gases have far more ways to arrange their particles.

■ Predicting the sign of ΔS

$\Delta S > 0$ (increase) when:

- a solid or liquid becomes a **gas**;
- the number of **gas molecules increases**;
- a solid **dissolves**.

$\Delta S < 0$ when the reverse happens (gas $\rightarrow$ liquid, fewer gas moles).

■ A worked prediction

$2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l)$: 3 gas moles $\rightarrow$ 0 gas moles (a liquid), so $\Delta S < 0$ (a decrease).

2 Practice

Now apply the methods above.

2.1 Rank solid, liquid, and gas by entropy. [1]

2.2 State the sign of ΔS when a liquid boils. [1]

2.3 State the sign of ΔS for $2\text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$ (2 gas moles $\rightarrow$ 1). [1]

3 Exam-style questions

3.1 Which process has $\Delta S > 0$? [1]

A	B
C	D

A gas condensing to liquid

B water freezing

C a solid subliming to gas

D 2 gas moles forming 1 gas mole

3.2 Predict the sign of ΔS for each:

(a) $\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$ [1]

(b) $\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)$ [1]

(c) dissolving salt in water [1]

3.3 Explain, in terms of arrangements, why a gas has higher entropy than the same substance as a solid. [2]