AP CHEMISTRY • EXERCISE SHEET

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 ⇒ 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 → liquid, fewer gas moles).

■ A worked prediction

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$: 3 gas moles → 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 $2NO_2(g) \rightarrow N_2O_4(g)$ (2 gas moles $\rightarrow$ 1). [1]

3 Exam-style questions

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

- **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) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ [1]

(b) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ [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]

Solutions

2.1 gas > liquid > solid.

2.2 Positive ($\Delta S > 0$).

2.3 Negative (fewer gas moles).

3.1 C — subliming a solid to gas greatly increases disorder.

3.2 (a) positive (a gas is produced); (b) negative (4 gas moles $\rightarrow$ 2); (c) positive.

3.3 A gas has vastly more available positions and energy arrangements than a rigid, ordered solid, so far more microstates — hence higher entropy.