AP CHEMISTRY • EXERCISE SHEET

9.2 Absolute Entropy and Entropy Change

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS entropy 熵

Objective

Build the skills to answer exam questions on **absolute entropy and entropy change**.

You must be able to:

- use $\Delta S^\circ = \Sigma S^\circ(\text{products}) - \Sigma S^\circ(\text{reactants})$
- weight each S° by its coefficient
- interpret the sign of the result

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.

■ Standard molar entropy

Every substance has a positive **standard molar entropy** S° (unlike ΔH_f, elements are **not** zero). Gases have the largest S°.

■ The entropy-change formula

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

each weighted by its coefficient.

■ A worked calculation

For $N_2 + 3H_2 \rightarrow 2NH_3$, with S°: $N_2 = 192$, $H_2 = 131$, $NH_3 = 193$ J mol^{-1}K^{-1}:

$$\Delta S^\circ = 2(193) - [192 + 3(131)] = 386 - 585 = -199 \text{ J K}^{-1}.$$

Negative — consistent with 4 gas moles becoming 2.

■ Sign check

The calculated sign should match the qualitative prediction (fewer gas moles → negative). If not, recheck the coefficients.

2 Practice

Now apply the methods above.

2.1 Write the formula for ΔS° of a reaction. [1]

2.2 Is S° of an element zero? [1]

2.3 For products summing to 400 and reactants to 550 J/K, find ΔS°. [2]

3 Exam-style questions

3.1 Unlike ΔH_f°, the standard entropy S° of an element is [1]

- **A** zero
- **B** a positive value
- **C** negative
- **D** undefined

3.2 For $2SO_2(g)+O_2(g) \rightarrow 2SO_3(g)$, with S°: $SO_2 = 248$, $O_2 = 205$, $SO_3 = 257$ J mol^{-1}K^{-1}.

(a) Calculate ΔS°. [3]

(b) Is the sign consistent with the change in gas moles? [1]

3.3 Explain why ΔS° is negative for a reaction that goes from 3 moles of gas to 2 moles

of gas. [2]

Solutions

2.1 $\Delta S^\circ = \Sigma S^\circ(\text{products}) - \Sigma S^\circ(\text{reactants})$.

2.2 No — it is a positive value.

2.3 $400 - 550 = -150$ J/K.

3.1 B — a positive value.

3.2 (a) $\Delta S^\circ = 2(257) - [2(248) + 205] = 514 - 701 = -187$ J K^{-1}. (b) Yes — 3 gas moles become 2, so a decrease is expected.

3.3 Fewer gas molecules means fewer ways to arrange the particles, so the disorder (entropy) decreases, giving a negative ΔS°.