

4.2.1 Total entropy and feasibility

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS entropy

Objective

Calculate system, surroundings and total entropy with consistent units. Questions and marking guidance are original.

1 Key knowledge and worked examples

Entropy measures dispersal of energy among accessible arrangements. More gas particles often mean greater system entropy, but calculate from given standard values when available. $\Delta S_{system} = \sum \nu S(products) - \sum \nu S(reactants)$.

■ Worked method

At 298 K, a reaction has $\Delta H = -40.0 \text{ kJ mol}^{-1}$ and $\Delta S_{system} = -100 \text{ J mol}^{-1} \text{ K}^{-1}$.

$$\Delta S_{surroundings} = -\Delta H/T = 40000/298 = +134 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$\Delta S_{total} = -100 + 134 = +34 \text{ J mol}^{-1} \text{ K}^{-1}$$

Positive total entropy favours the forward direction thermodynamically. It does not promise a fast reaction: a large activation barrier may still prevent an observable change. Temperature boundaries assume the supplied enthalpy/entropy values remain approximately constant over the range.

2 Practice

2.1 Predict the likely sign of system entropy for $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$, with a reason. [2]

2.2 For $\text{A}(\text{g}) \rightarrow 2\text{B}(\text{g})$, $S^\circ(\text{A}) = 200$ and $S^\circ(\text{B}) = 150 \text{ J mol}^{-1} \text{ K}^{-1}$. Calculate standard system entropy change. [2]

2.3 At 300 K a reaction has $\Delta H = +18.0 \text{ kJ mol}^{-1}$ and $\Delta S(\text{system}) = +90.0 \text{ J mol}^{-1} \text{ K}^{-1}$. Calculate total entropy. [3]

3 Exam-style questions

3.1 A reaction has $\Delta H = +36.0 \text{ kJ mol}^{-1}$ and $\Delta S(\text{system}) = +120 \text{ J mol}^{-1} \text{ K}^{-1}$. Find the temperature boundary and predict the favourable side. State an assumption. [4]

3.2 A reaction is exothermic and has negative system entropy. Explain why it may be favoured only at lower temperatures, and why thermodynamic favourability does not imply fast reaction. [3]

3.3 (a) State the entropy of a perfect crystal at 0 K, then describe how its entropy changes as it warms within a phase and passes through melting and boiling. (b) Explain why dissolving an ionic crystal does not always give a positive system entropy change. (c) Explain spontaneous spreading of a gas through a sealed room in terms of arrangements and total entropy. [7]
