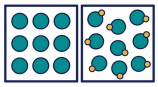
Entropy and Gibbs Free Energy Map

Cambridge International AS & A Level Chemistry · Topic 23 Entropy and Gibbs free energy

1 Entropy, S

23.3.1

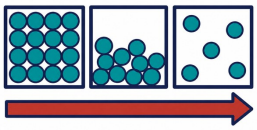
- Endothermic changes can happen: **ΔH alone does not decide**
- **Entropy**: disorder of a system
- Ways of arranging **molecules** and sharing **energy quanta**
- Units **J K^{-1} mol^{-1}** (joules)



2 State and temperature

23.3.2

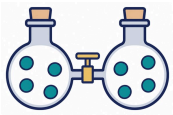
- **Solid < liquid < gas**
- Biggest jump at **boiling**
- S rises with **temperature**
- Perfect crystal at 0 K: **S = 0**

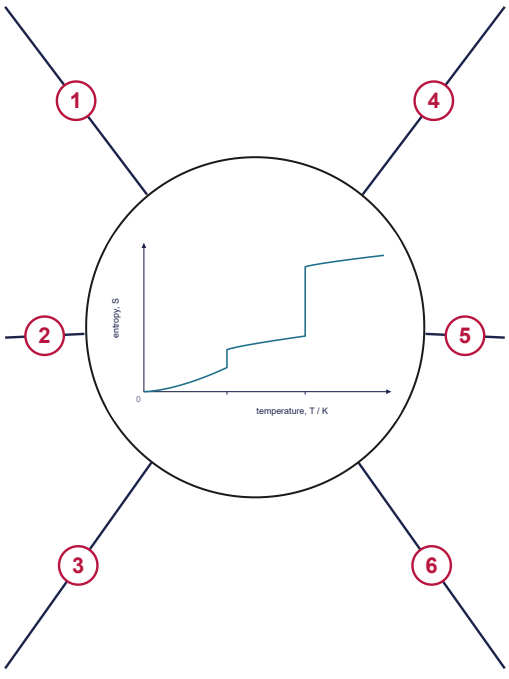


3 The sign of ΔS

23.3.2

- Left alone, change goes the way **disorder increases**
- Gases spread; never gather back
- More moles of gas: **ΔS positive**
- Dissolving: ions freed (+), water ordered (−)





4 ΔS and ΔG

23.3.3, 23.4.1–23.4.3

- ΔS = **ΣS(products) − ΣS(reactants)**
- Multiply by the **balancing numbers**
- **ΔG = ΔH − TΔS**: ΔS ÷ 1000 to kJ
- **ΔG ≤ 0**: feasible



5 Temperature and ΔG

23.4.4

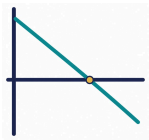
- Mixed signs: **temperature decides**
- Turning point: **T = ΔH ÷ ΔS** (ΔG = 0)
- Feasible above T if both +; below T if both −
- Assume ΔH and ΔS **constant**



6 ΔG against T

23.4.4

- A **straight line**: ΔG = ΔH − TΔS
- Intercept **ΔH**; gradient **−ΔS**
- Crosses zero at **T = ΔH ÷ ΔS**
- Below the axis: **feasible**



Which way does temperature push feasibility?

ΔG = ΔH − TΔS: the −TΔS term grows as T rises

ΔH	ΔS	−TΔS	Feasible
negative	positive	negative	at all temperatures
positive	negative	positive	never
negative	negative	positive	below T = ΔH ÷ ΔS
positive	positive	negative	above T = ΔH ÷ ΔS

Worked examples

ΔS of a reaction

- $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
- 2(69.9) − (2(130.6) + 205.0)
- **−326.4 J K^{-1} mol^{-1}**

Feasibility temperature

- ΔH = +50 kJ mol^{-1}
- ΔS = +125 J K^{-1} mol^{-1}
- T = 50 000 ÷ 125 = **400 K**: feasible above

ΔG at a temperature

- $CaCO_3$: ΔH +178, ΔS +161
- ΔG(1200 K) = 178 − 1200 × 0.161
- = **−15.2 kJ mol^{-1}**: feasible

ΔG returns in Topic 24 (electrochemistry).

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