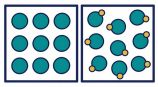
Entropy and Free Energy Map

Edexcel A Level Chemistry · Topic 13B Entropy and Free Energy

1 Entropy, S

13B.12, 13B.13

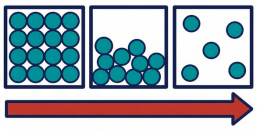
- Endothermic changes can happen: **ΔH alone does not decide**
- **Entropy**: disorder of a system
- Ways of arranging **molecules** and sharing **energy quanta**
- Units **J K^{-1} mol^{-1}** (joules)



2 State and temperature

13B.13

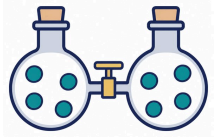
- **Solid < liquid < gas**
- Biggest jump at **boiling**
- S rises with **temperature**
- Perfect crystal at 0 K: **S = 0**

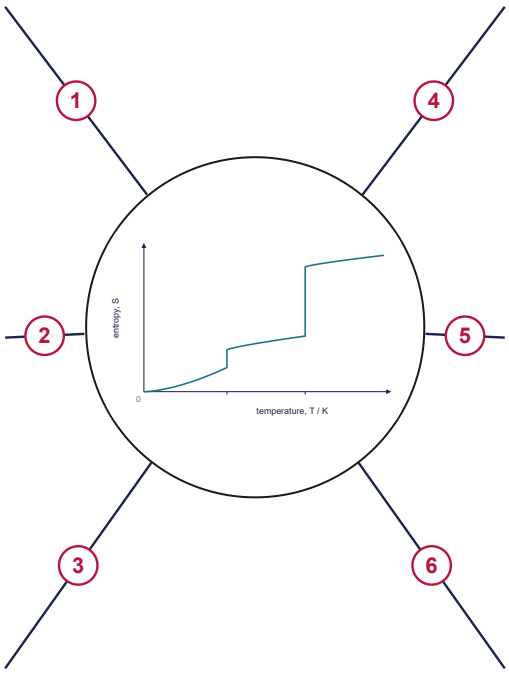


3 The natural direction

13B.13, 13B.14

- Changes go the way **total entropy increases**
- Gases spread; never gather back
- More moles of gas: **ΔS positive**
- Dissolving: ions freed (+), water ordered (−)





4 Calculating ΔS

13B.15–13B.17

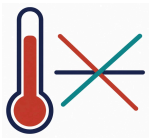
- ΔS_{system} = **ΣS(products) − ΣS(reactants)**
- $\Delta S_{surroundings}$ = **−ΔH ÷ T**, ΔH in J
- $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$
- **ΔS_{total} > 0**: feasible



5 Temperature and ΔG

13B.18–13B.20

- **$\Delta G = \Delta H - T\Delta S_{system}$** (ΔS in kJ)
- **ΔG ≤ 0**: feasible; $\Delta G = -T\Delta S_{total}$
- Turning point: **T = ΔH ÷ ΔS**
- **ΔG = −RT ln K**: negative ΔG, K > 1



6 Stability

13B.21, 13B.22

- **Thermodynamic**: ΔG: can it happen?
- **Kinetic**: E_a: how fast?
- Feasible but slow: **high E_a**
- Catalysts lower E_a; ΔG unchanged



Which way does temperature push feasibility?

$\Delta S_{surroundings} = -\Delta H \div T$: its size shrinks as T rises

ΔH	ΔS_{system}	$\Delta S_{surroundings}$	Feasible
negative	positive	positive	at all temperatures
positive	negative	negative	never
negative	negative	positive	below T = ΔH ÷ ΔS
positive	positive	negative	above T = ΔH ÷ ΔS

Worked examples

ΔS of the system

- $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
- 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

Methane in air

- ΔG = −818 kJ mol^{-1}: feasible
- but E_a is high: no reaction
- **kinetically stable** until a spark

ΔG returns in Topic 14 (electrode potentials and E⊖cell).

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