15.1 Entropy, Gibbs energy and feasibility

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS entropy • Gibbs energy

Objective

Entropy, Gibbs energy and feasibility. Original classroom practice for IB HL; not an official IB paper.

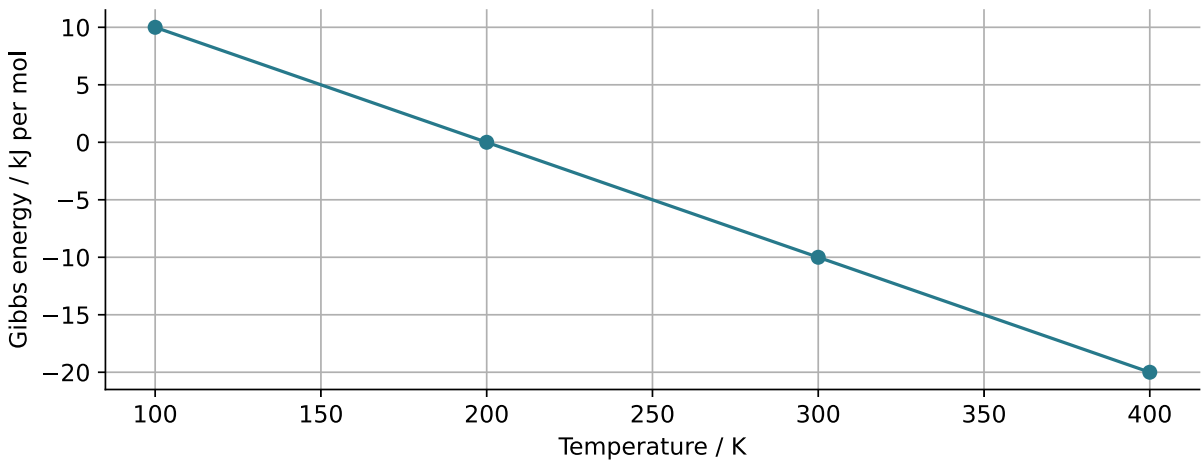
1 Key knowledge and worked examples

What would explain this observation?

- A reaction can be endothermic and still be thermodynamically favourable. Enthalpy alone does not determine the direction favoured at a given temperature.

Build the model

- **Entropy** is associated with energy dispersal and the number of accessible microscopic arrangements.
- **Gibbs energy** combines enthalpy, entropy and absolute temperature for a process at constant temperature and pressure.
- entropy: A state property related to energy dispersal and accessible arrangements.
- Gibbs energy: A thermodynamic quantity combining enthalpy and entropy contributions.



Choose evidence that can test it

- Use $\Delta G = \Delta H - T\Delta S$ with consistent energy units.
- A negative Gibbs energy change indicates thermodynamic favourability for the stated conditions, not a fast rate.
- An activation barrier can make a favourable process slow.

In the lab: State whether values are standard-state quantities and record temperature in kelvin. Convert entropy from joules per kelvin per mole into kilojoules per kelvin per mole when enthalpy is in kilojoules per mole.

Work from known quantities

- Known: $\Delta H = +20$ kJ per mole, $\Delta S = +100$ J per kelvin per mole and $T = 300$ K.
- Convert $\Delta S = 0.100$ kJ per kelvin per mole. $\Delta G = \Delta H - T\Delta S = 20 - 300\times0.100 = -10$ kJ per mole.
- The process is favourable under the stated approximation.

Your turn: ΔH=30 kJ per mole, ΔS=0.10 kJ per kelvin per mole and T=400 K. Find ΔG.

Check the conclusion and its limits

- Thermodynamic favourability does not establish reaction rate.
- Celsius cannot replace kelvin in $T\Delta S$, and a unit conversion error can change the result by a factor of 1,000.

Not true: A thermodynamically favourable reaction must be fast. Feasibility and speed are different questions. Thermodynamics (delta G) says a reaction can proceed; kinetics (activation energy, rate) says how fast. Diamond to graphite is favourable yet imperceptibly slow.

Key:

- Entropy is associated with energy dispersal and the number of accessible microscopic arrangements.
- Use $\Delta G = \Delta H - T\Delta S$ with consistent energy units.
- Watch for: thermodynamic favourability does not establish reaction rate.

Write from a Gibbs energy change of plus 8 kJ per mole

- Delta H is plus 40 kJ per mole. Delta S is plus 80 J per kelvin per mole. The temperature is 400 K.
- Find delta G. A favourable reaction is not necessarily fast.

2 Practice

2.1 What can remain small even when ΔG is negative? Choose one answer.

- **A** Reaction rate
- **B** Every activation barrier
- **C** The fact that kelvin is used [1]

2.2 ΔH=30 kJ per mole, ΔS=0.10 kJ per kelvin per mole and T=400 K. Find ΔG. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Feasibility and speed are different questions. [2]

2.4 A state property related to energy dispersal and accessible arrangements: write the technical term. [1]

3 Exam-style questions

3.1 AssumeΔH=+24 kJ/mol andΔS=+80 J/(K mol) are temperature independent. Find the crossover temperature and predict favourability at250 K and400 K. [4]