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.

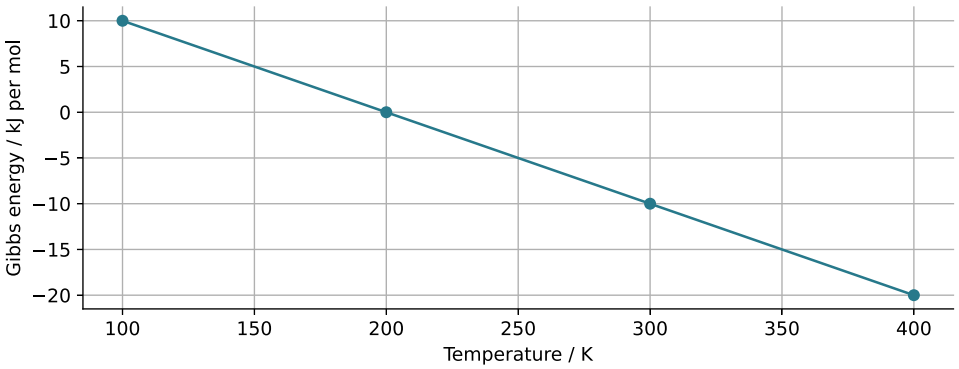
1 Key knowledge and worked examples

■ 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 ΔG = ΔH - TΔS 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: ΔH = +20 kJ per mole, ΔS = +100 J per kelvin per mole and T = 300 K.
- Convert ΔS = 0.100 kJ per kelvin per mole. ΔG = ΔH - TΔS = 20 - 300×0.100 = -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 TΔS, 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 ΔG = ΔH - TΔS 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]

Solutions

2.1 A Delta G says whether a reaction is thermodynamically favourable; it says nothing about kinetics. A high activation barrier can keep a favourable reaction immeasurably slow, as diamond shows.

2.2 $\Delta G = \Delta H - T\Delta S = 30 - 400 \times 0.10 = -10$ kJ/mol.

2.3 True. True. 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.

2.4 entropy. entropy means A state property related to energy dispersal and accessible arrangements.

3.1 Convert$\Delta S = 0.080$ kJ/(K mol);$T = 24/0.080 = 300$ K.$\Delta G = +4$ kJ/mol at250K and-8 at400K. Thermodynamic favourability does not imply a fast reaction.