

Exercise walk-through

15.1

Entropy, Gibbs energy and feasibility

International Baccalaureate · IB Diploma · Chemistry · HL

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

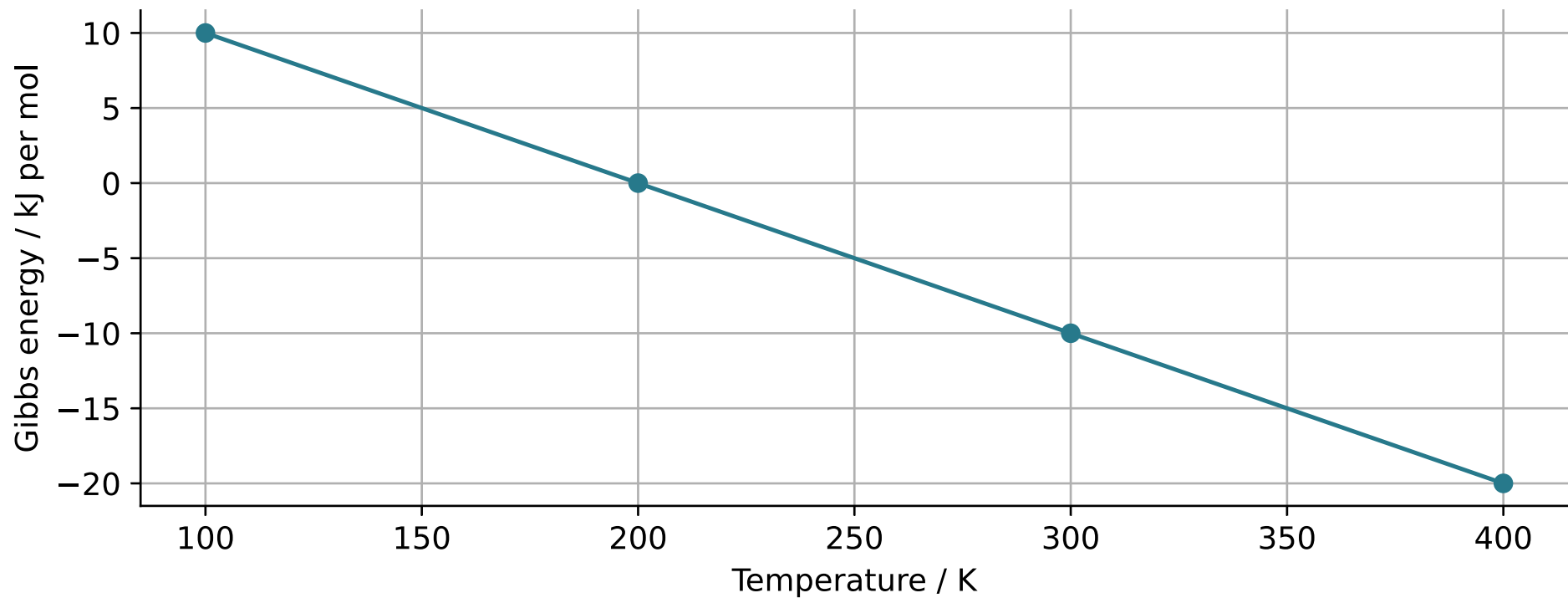
■ What would explain this observation?

- 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. $\Delta G = \Delta H - T\Delta S = 20 - 300 \times 0.100 = -10$ kJ per mole.
- The process is favourable under the stated approximation.

Your turn: $\Delta H = 30$ kJ per mole, $\Delta S = 0.10$ 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 (ΔG) 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.
-

Exercises 2.1·2.3

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 $\Delta H=30$ kJ per mole, $\Delta S=0.10$ 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]

Exercises 2.1-2.3

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]

2.1 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 $\Delta H = 30$ kJ per mole, $\Delta S = 0.10$ kJ per kelvin per mole and $T = 400$ K. Find ΔG . Show the relation, substitution and units.

[2]

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

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

[2]

2.3 True. True. Feasibility and speed are different questions. Thermodynamics (ΔG) says a reaction can proceed; kinetics (activation energy, rate) says how fast. Diamond to graphite is favourable yet imperceptibly slow.

Exercises 2.4·3.1

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

3.1 Assume $\Delta H = +24 \text{ kJ/mol}$ and $\Delta S = +80 \text{ J/(K mol)}$ are temperature independent. Find the crossover temperature and predict favourability at 250 K and 400 K. [4]

Exercises 2.4·3.1

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

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

3.1 Assume $\Delta H = +24 \text{ kJ/mol}$ and $\Delta S = +80 \text{ J/(K mol)}$ are temperature independent. Find the crossover temperature and predict favourability at 250 K and 400 K. [4]

3.1 Convert $\Delta S = 0.080 \text{ kJ/(K mol)}$; $T = 24/0.080 = 300 \text{ K}$. $\Delta G = +4 \text{ kJ/mol}$ at 250 K and -8 at 400 K. Thermodynamic favourability does not imply a fast reaction.