

15.1 Entropy, Gibbs energy and feasibility

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS entropy • Gibbs energy

Objective

Entropy, Gibbs energy and feasibility. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

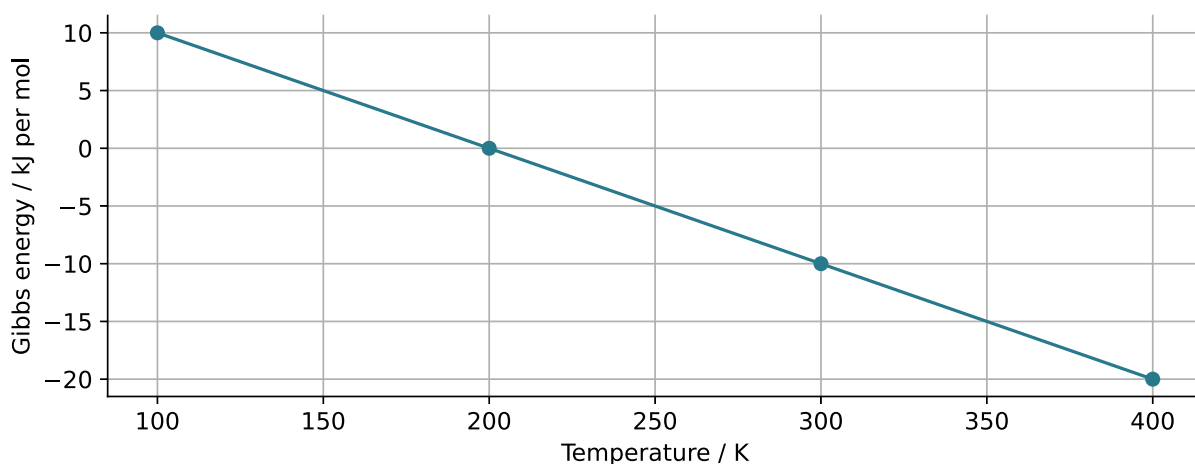
1 Key knowledge and worked examples

■ 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.
 - Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.
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■ 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.
- 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

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- 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.

Example:

$\Delta H = 30$ kJ per mole, $\Delta S = 0.10$ kJ per kelvin per mole and $T = 400$ K. Find ΔG . Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ 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.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A thermodynamically favourable reaction must be fast. This claim is false: 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.

Key:

Entropy, Gibbs energy and feasibility: 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.

2 Practice

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

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

[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: A thermodynamically favourable reaction must be fast.

[2]

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

[1]

3 Exam-style questions

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]

Solutions

2.1 A 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.

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

2.3 False. 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.

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

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 250K and -8 at 400K. Thermodynamic favourability does not imply a fast reaction.