

23.4 Gibbs free energy change

Name: _____ Class: _____ Date: _____

Total: 11 marks

Objective

Build the skills to answer exam questions on **Gibbs free energy change** 吉布斯自由能变—using $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$ to judge **feasibility** 可行性.

You must be able to:

- state and use the Gibbs equation
- use the sign of ΔG to decide whether a reaction is feasible
- predict the effect of temperature on feasibility

1 Worked examples

■ The Gibbs equation

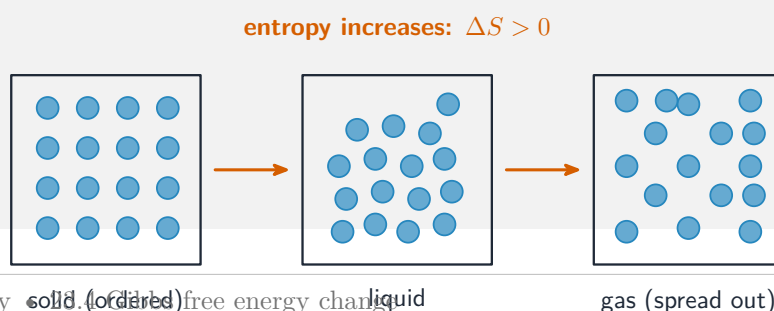
$$\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$$

A reaction is **feasible** when $\Delta G \leq 0$.

	ΔS positive	ΔS negative
ΔH neg.	feasible at all temperatures	feasible only at low temperature
ΔH pos.	feasible only at high temperature	never feasible

$$\Delta G = \Delta H - T\Delta S; \text{ feasible when } \Delta G \leq 0$$

Feasibility depends on temperature: a $+\Delta S$ reaction becomes feasible above a certain T (where $T\Delta S$ outweighs ΔH)



Watch the units: ΔH is in kJ mol^{-1} but ΔS is in $\text{J K}^{-1} \text{mol}^{-1}$ —divide ΔS by 1000 (or multiply ΔH by 1000) before subtracting.

Example. $\Delta H = +178 \text{ kJ mol}^{-1}$, $\Delta S = +160 \text{ J K}^{-1} \text{mol}^{-1}$. At 298 K: $\Delta G = 178 - 298(0.160) = 178 - 47.7 = +130 \text{ kJ mol}^{-1}$ (not feasible). It becomes feasible above $T = \Delta H / \Delta S = 178 / 0.160 = 1113 \text{ K}$.

2 Practice

2.1 State the Gibbs equation. [1]

2.2 State the condition on ΔG for a reaction to be feasible. [1]

3 Exam-style questions

3.1 A reaction has ΔH negative and ΔS positive. It is: [1]

- A feasible at all temperatures
 - B feasible only at high temperature
 - C feasible only at low temperature
 - D never feasible
-

3.2 In the Gibbs equation, the temperature T must be in: [1]

- A $^{\circ}\text{C}$
 - B kelvin
 - C joules
 - D kJ
-

3.3 A reaction has $\Delta H = +120 \text{ kJ mol}^{-1}$ and $\Delta S = +200 \text{ J K}^{-1} \text{mol}^{-1}$.

(a) Calculate ΔG at 298 K and state whether the reaction is feasible. [3]

(b) Calculate the minimum temperature at which the reaction becomes feasible. [2]

3.4 Explain why an endothermic reaction with a positive entropy change becomes feasible only above a certain temperature. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **23.4 Gibbs free energy change** past-paper sheet in the Library, or try this in **Practice mode**:

- 9701/44 N25 —Q3 (gibbs free energy change)

Solutions

2.1 $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$.

2.2 $\Delta G \leq 0$ (negative or zero).

3.1 A. With $-\Delta H$ and $+\Delta S$, ΔG is negative at all temperatures.

3.2 B. Temperature must be in kelvin.

3.3 (a) $\Delta G = 120 - 298(0.200) = 120 - 59.6 = +60.4 \text{ kJ mol}^{-1}$; not feasible (positive ΔG).

(b) feasible when $\Delta G = 0$: $T = \Delta H / \Delta S = 120 / 0.200 = 600 \text{ K}$.

3.4 at low T the $T\Delta S$ term is small, so $\Delta G = \Delta H - T\Delta S$ stays positive; raising T increases $T\Delta S$ until it exceeds ΔH , making ΔG negative and the reaction feasible.