

Entropy, Gibbs energy and reaction feasibility

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Test

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test covers entropy, entropy changes of reactions, the Gibbs equation, a ΔG -T graph and the link to K. You have 45 minutes and may use a calculator. Show your working, convert ΔS to kJ before using it, and use kelvin.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R1.4

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Meaning of entropy (2 marks)

Explain, in terms of particles, why the entropy of water increases when it boils.

Question 2 Predicting the sign of ΔS (3 marks)

State whether ΔS is positive or negative for each change, with a reason.

- a. $2\text{KClO}_3(\text{s}) \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$ (1 mark)
- b. $2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$ (1 mark)
- c. $\text{Ca}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$ (1 mark)

Question 3 Steam reforming: entropy (3 marks)

In steam reforming, $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{CO}(\text{g}) + 3\text{H}_2(\text{g})$. S° values in $\text{J K}^{-1} \text{mol}^{-1}$: CH_4 186.3, $\text{H}_2\text{O}(\text{g})$ 188.8, CO 197.7, H_2 130.7. Calculate ΔS° .

Question 4 Steam reforming: feasibility (2 marks)

For the reaction in the previous question $\Delta H = +206 \text{ kJ/mol}$. Calculate ΔG at 298 K and state whether the reaction is spontaneous.

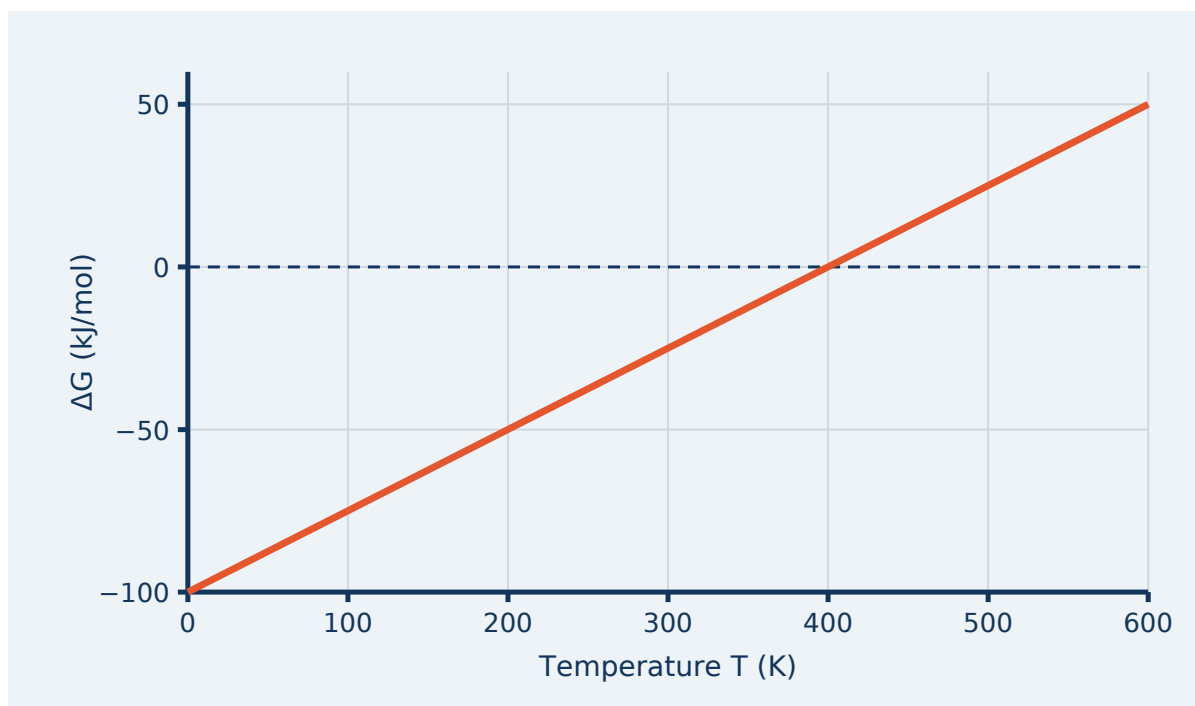
Question 5 Steam reforming: temperature (3 marks)

Calculate the minimum temperature at which the reaction becomes spontaneous. Give your answer in kelvin.

Question 6 Reading a ΔG -T graph (3 marks)

The graph shows ΔG against T for a reaction.

- State the signs of ΔH and ΔS , with a reason. (1 mark)
- Read the temperature at which $\Delta G = 0$. (1 mark)
- State the temperatures at which the reaction is spontaneous. (1 mark)



ΔG against T for a reaction.

Question 7 From ΔG to K (2 marks)

A reaction has $\Delta G^\circ = -17.0$ kJ/mol at 298 K. Calculate the equilibrium constant ($R = 8.31$ J K⁻¹ mol⁻¹).

Question 8 Entropy of the surroundings (2 marks)

Explain why an exothermic reaction increases the entropy of the surroundings.