Two changes are described below.

For each change,
- write an equation, including state symbols,
- state and explain how the entropy changes.

(i) The reaction of aqueous barium nitrate with aqueous sodium sulfate.

Full equation with state symbols

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Explanation of entropy change .....

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..... **[2]**

(ii) The change that accompanies the standard enthalpy change of atomisation of iodine.

Equation with state symbols

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Explanation of entropy change .....

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..... **[2]**

Methanol is formed when carbon dioxide and hydrogen react.

$$CO_2(g) + 3\,H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

Table 5 contains enthalpy of formation and entropy data for these substances.

Table 5

	$CO_2(g)$	$H_2(g)$	$CH_3OH(g)$	$H_2O(g)$
$\Delta_f H$ / kJ mol^{-1}	–394	0	–201	–242
S / J K^{-1} mol^{-1}	214	131	238	189

. **1** Use the equation and the data in **Table 5** to calculate the Gibbs free-energy change (ΔG), in kJ mol^{-1}, for this reaction at 890 K

[6 marks]

ΔG _____ kJ mol^{-1}

Ammonia is produced industrially by reacting nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92.0 \text{ kJ mol}^{-1}$$

A temperature in the range of 673 to 773 K is used.

The standard entropies, $S^{\ominus}$, of $N_2(g)$, $H_2(g)$ and $NH_3(g)$ at 298 K are given in the table.

substance	$N_2(g)$	$H_2(g)$	$NH_3(g)$
$S^{\ominus}$ **/ J K^{-1} mol^{-1}**	192	131	193

(a) Show that this reaction is feasible at 298 K by calculating $\Delta G^{\ominus}$ in kJ mol^{-1}. Give your answer to an appropriate number of significant figures.

(5)

(b) Explain, in terms of entropy, why this reaction is not feasible at very high temperatures.

(2)

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