3 Ammonia can be manufactured by the Haber Process.

The equation for the reaction that occurs is shown below.

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

3 (a) The table below contains some bond enthalpy data.

	N≡N	H—H	N—H
Mean bond enthalpy / kJ mol^{-1}	944	436	388

3 (a) (i) Use data from the table to calculate a value for the enthalpy of formation for one mole of ammonia.

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(3 marks)

3 (a) (ii) A more accurate value for the enthalpy of formation of ammonia is –46 kJ mol^{-1}. Suggest why your answer to part **3 (a) (i)** is different from this value.

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(1 mark)

3 (b) The table below contains some entropy data.

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

Use these data to calculate a value for the entropy change, with units, for the formation of one mole of ammonia from its elements.

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(3 marks)

3 (c) The synthesis of ammonia is usually carried out at about 800 K.

3 (c) (i) Use the ΔH value of -46 kJ mol^{-1} and your answer from part **3 (b)** to calculate a value for ΔG, with units, for the synthesis at this temperature.
(If you have been unable to obtain an answer to part **3 (b)**, you may assume that the entropy change is –112 J K^{-1} mol $^{-1}$. This is not the correct answer.)

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(3 marks)

3 (c) (ii) Use the value of ΔG that you have obtained to comment on the feasibility of the reaction at 800 K.

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(1 mark)

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Turn over ▶