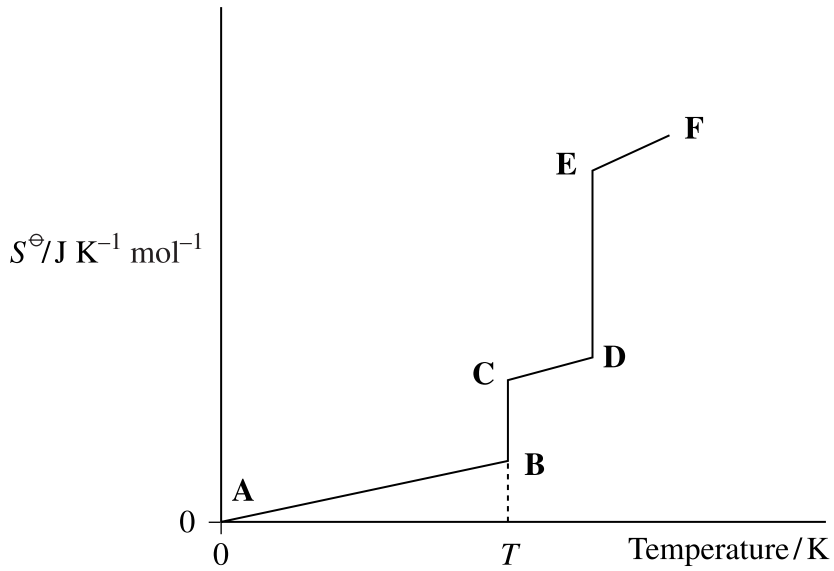
5 The simplified diagram below shows how the entropy of ammonia varies with temperature at a pressure of 100 kPa. In this diagram, ammonia is a solid at point **A** and a gas at point **F**.



5 (a) State why the entropy value for ammonia is equal to zero at 0 K.

....

(1 mark)

5 (b) Explain, in terms of the movement of particles, why the entropy value increases between points **A** and **B** on the diagram.

....

....

(1 mark)

5 (c) Temperature T is marked on the diagram. What does the value of this temperature represent?

....

(1 mark)

5 (d) Explain why there is a large entropy change between points **D** and **E** on the diagram.

....

....

(2 marks)

Areas outside the box will not be scanned for marking

5 (e) An equation for the reaction in the Haber Process is shown below, together with some entropy data.

$$\tfrac{1}{2}N_2(g) + \tfrac{3}{2}H_2(g) \rightleftharpoons NH_3(g) \qquad \Delta H^\ominus = -46.2\,\text{kJ mol}^{-1}$$

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

5 (e) (i) Calculate a value for the entropy change, $\Delta S^\ominus$, for the formation of one mole of ammonia.

....

....

....

....

(2 marks)

5 (e) (ii) Give the equation that relates free-energy change, $\Delta G^\ominus$, to enthalpy change, $\Delta H^\ominus$, and entropy change, $\Delta S^\ominus$.

Use this equation to calculate the temperature at which the value of $\Delta G^\ominus = 0$ for the formation of ammonia in the Haber Process.
(If you have been unable to calculate an answer to part (e) (i), you may assume that $\Delta S^\ominus = -81.4$ J K mol^{-1} but this is not the correct value.)

Equation ....

Calculation ....

....

....

....

(4 marks)

(Extra space) ....

5 (e) (iii) What can you deduce about the formation of ammonia if the reaction mixture is heated to a temperature above the value that you have calculated in part (e) (ii)?

....

(1 mark)

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Turn over ▶