0 1 Ammonia is manufactured from nitrogen and hydrogen by the Haber process:

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

The forward reaction is exothermic.

Nitrogen and hydrogen are needed to make ammonia.

0 1 . 1 What are the sources of these two materials?

[2 marks]

Nitrogen Air [1]

Hydrogen Methane/Natural gas [1]

Not all the hydrogen and nitrogen reacts.

0 1 . 2 Explain what happens to the unreacted nitrogen and hydrogen, and why?

[2 marks]

Recycled [1]
So that it is not wasted or to save raw materials or less cost on raw materials / nitrogen and hydrogen. [1]

0 2 In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

The conditions used in the Haber process are:

200 atmospheres pressure 450°C iron

0 2 . 1 Use the equation and your knowledge of reversible reactions to explain why these conditions are used in the Haber process.

To get full marks you must consider both yield and rate of reaction in your answer.

[6 marks]

Level 3: Detailed and coherent conclusions based on the evidence together with an evaluation are given in a response that is coherent and well-structured. A range of relevant points is made demonstrating a broad understanding of the key scientific ideas.	5-6
Level 2: An attempt to relate relevant points and draw conclusions or to make an evaluation. The logic may be inconsistent at times but builds towards a coherent argument.	3-4
Level 1: Simple descriptive statements are made. The logic may be unclear and any conclusions, if present, may not be consistent with the reasoning.	1-2

Examples of chemistry points made in the response:

TOP TIP :
One of the most common mistakes with a question like this is that students try to talk about all the conditions in one go. Much easier to separate out the factors an talk about them individually for this question.

200 atmospheres pressure
- High pressure gives a high yield of ammonia
- Too high a pressure causes risk of explosion
- High pressure costly to maintain
- A high pressure will cause the rate to be higher
- 4 moles of gas become 2 (or fewer moles of gas in products)

450°C
- High temperature increases the rate of reaction
- Optimum temperature
- (Forward reaction is exothermic so) a high yield of ammonia requires a low temperature but too low a temperature causes the rate of reaction to be too slow

Iron catalyst
- A catalyst speeds up the reaction
- An iron catalyst allows a lower temperature to be used (saving energy and causing a higher yield)
- Iron catalyst increases the rate of reaction equally in both reactions

Others
- Compromise conditions
- Unreacted nitrogen and hydrogen is recycled

0 3 Ammonia is a very useful chemical. It is produced from nitrogen and hydrogen. The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g)$$

A company wants to make 13.6 tonnes of ammonia.

0 3 . 1 Calculate the mass of nitrogen needed.

[3 marks]

Relative atomic masses (Ar): H = 1; N = 14

RFM $N_2 = 28$ $2NH_3 = 34$ [1]
28/34 x 13.6 = 11.2 [1]

Mass of nitrogen = 11.2 tonnes [2]

0 3 . 2 The company expected to make 13.6 tonnes of ammonia. The yield of ammonia was only 8.4 tonnes.

Calculate the percentage yield of ammonia.

[2 marks]

8.4 / 13.6 x 100 [1]
Percentage yield of ammonia = 61.8 % [1]

0 3 . 3 Use the equation above to explain why the percentage yield of ammonia was less than expected.

[1 mark]

Reaction is reversible [1]

(Total 16 marks)

End of Question