

A Level Chemistry B (Salters)
H433/01 Fundamentals of chemistry

Question Set 21

- 1 (a) Plants need nitrogen to synthesise proteins, but most plants cannot use atmospheric nitrogen. Ammonium nitrate is often used as a fertiliser as it contains nitrogen in a form that plants can absorb.

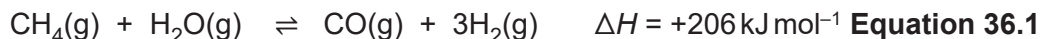
The first step in the process of making ammonium nitrate is the synthesis of ammonia from atmospheric nitrogen.

This synthesis reaction has a very high activation enthalpy.

Explain this in terms of the bonding in nitrogen.

[1]

- (b) (i) The hydrogen needed to manufacture ammonia can be produced from steam and methane as shown in **equation 36.1** below.



Use the entropy values in the table below to calculate $\Delta_{\text{sys}}S$ for the forward reaction in **equation 36.1**

Substance	Entropy $S / \text{JK}^{-1} \text{mol}^{-1}$
$\text{CH}_4(\text{g})$	186.2
$\text{H}_2\text{O}(\text{g})$	189.0
$\text{CO}(\text{g})$	197.6
$\text{H}_2(\text{g})$	130.6

$$\Delta_{\text{sys}}S = \quad \text{JK}^{-1} \text{mol}^{-1}$$

[1]

- (b) (ii) Explain how the sign of your answer to (i) is predicted by **equation 36.1**.

[1]

- (c) Calculate the minimum temperature required for the forward reaction in **equation 36.1** to be feasible.

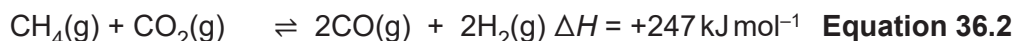
Give your answer to an **appropriate** number of significant figures.

$$\text{Temperature} = \quad \text{K}$$

[2]

- (d) $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g}) \quad \Delta H = +206 \text{ kJ mol}^{-1}$ **Equation 36.1**

Another source of hydrogen is from the reaction shown in **equation 36.2**.



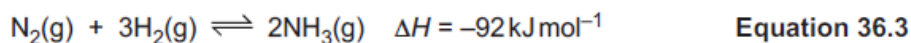
This is claimed to be a much greener process than that in **equation 36.1**.

Comment on the validity of this statement, considering:

- the raw materials used
- the operating conditions
- the mole ratios.

[3]

- (e) The Haber process for the manufacture of ammonia is shown in **equation 36.3**.



At a certain temperature, a mixture of nitrogen and hydrogen was allowed to reach equilibrium in a container of fixed volume. Chemists found the concentrations shown in the table.

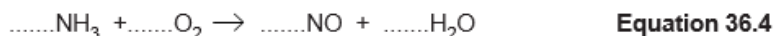
Substance	Concentration at the start / mol dm ⁻³	Concentration at equilibrium / mol dm ⁻³
N ₂	1.00	0.90
H ₂	1.00	
NH ₃	0.00	

Calculate the equilibrium concentrations of H₂ and NH₃.

Use these values to calculate a value for K_c at the temperature of the experiment and give the units.

$$K_c = \dots\dots\dots \text{ units } \dots\dots\dots \quad [3]$$

- (f) (i) In order to make the ammonium nitrate fertiliser, some of the ammonia is oxidised to nitric acid in several stages shown by **equations 36.4–36.6**.



The nitric acid formed is reacted with more ammonia.



Use oxidation states or some other method to balance **equation 36.4**. [1]

- (f) (ii) The overall yield of the reactions **in equations 36.4 – 36.6** is 77%.
The yield of ammonium nitrate in **equation 36.7** can be taken as 100%.

What mass (in tonnes) of ammonia is needed to make 25 tonnes of ammonium nitrate?

mass of ammonia needed = tonnes [4]

- (f) (iii) Describe a test that would identify nitrate ions. [2]

Total Marks for Question Set 21: 18

OCR

Oxford Cambridge and RSA

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact The OCR Copyright Team, The Triangle Building, Shaftesbury Road, Cambridge CB2 8EA.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge