Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7798977742

CHEMISTRY **9701/23**

Paper 2 AS Level Structured Questions **October/November 2017**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **9** printed pages and **3** blank pages.

IB17 11_9701_23/6RP

CAMBRIDGE International Examinations

Answer **all** the questions in the spaces provided.

1 Ammonia, NH_3, is manufactured from nitrogen and hydrogen by the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

(a) Some bond energies are given.

N≡N = 944 kJ mol^{-1}
H–H = 436 kJ mol^{-1}

(i) Explain the meaning of the term *bond energy*.

....

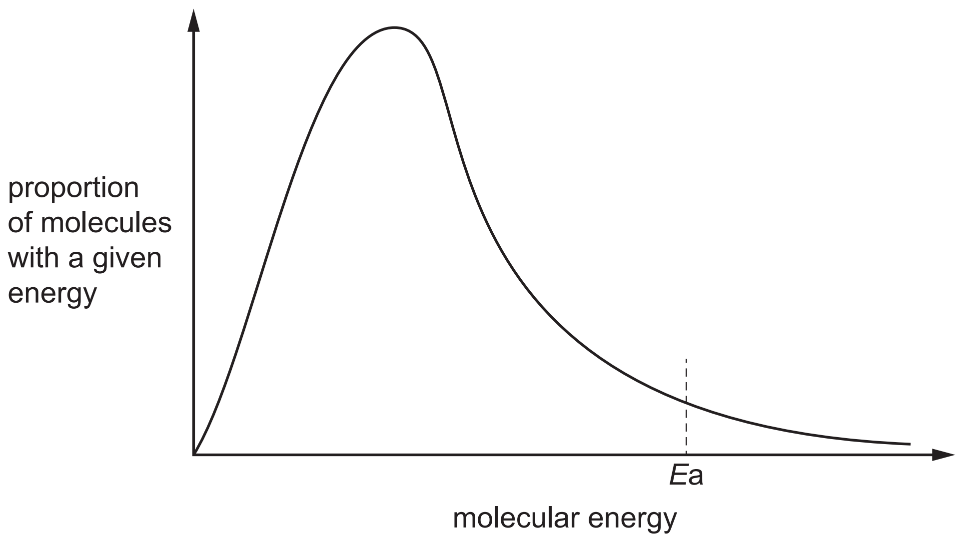
.... [2]

(ii) Use the data to calculate a value for the N–H bond energy.
You must show your working.

N–H bond energy = ... kJ mol^{-1} [2]

(b) The Haber process is usually carried out at a temperature of approximately 400 °C in the presence of a catalyst. Changing the temperature affects both the rate of production of ammonia and the yield of ammonia.

The Boltzmann distribution for a mixture of nitrogen and hydrogen at 400 °C is shown.
Ea represents the activation energy for the reaction.



(i) Using the same axes, sketch a second curve to indicate the Boltzmann distribution at a higher temperature. [2]

(ii) **With reference to the Boltzmann distribution**, state and explain the effect of increasing temperature on the rate of production of ammonia.

....

....

....

.... [3]

(iii) State and explain the effect of increasing temperature on the yield of ammonia.
Use Le Chatelier's principle to explain your answer.

....

....

....

.... [3]

(c) At a pressure of 2.00×10^7 Pa, 1.00 mol of nitrogen, $N_2(g)$, was mixed with 3.00 mol of hydrogen, $H_2(g)$. The final equilibrium mixture formed contained 0.300 mol of ammonia, $NH_3(g)$.

(i) Calculate the amounts, in mol, of $N_2(g)$ and $H_2(g)$ in the equilibrium mixture.

$N_2(g)$ = ... mol

$H_2(g)$ = ... mol
[2]

(ii) Calculate the partial pressure of ammonia, pNH_3, in the equilibrium mixture.

Give your answer to **three** significant figures.

pNH_3 = ... Pa [3]

(d) In another equilibrium mixture the partial pressures are as shown.

substance	partial pressure / Pa
$N_2(g)$	2.20×10^6
$H_2(g)$	9.62×10^5
$NH_3(g)$	1.40×10^4

(i) Write the expression for the equilibrium constant, K_p, for the production of ammonia from nitrogen and hydrogen.

K_p =

[1]

(ii) Calculate the value of K_p for this reaction.

State the units.

K_p = ...

units = ...
[2]

(iii) This reaction is repeated with the same starting amounts of nitrogen and hydrogen. The same temperature is used but the container has a smaller volume.

State the effects, if any, of this change on the yield of ammonia and on the value of K_p.

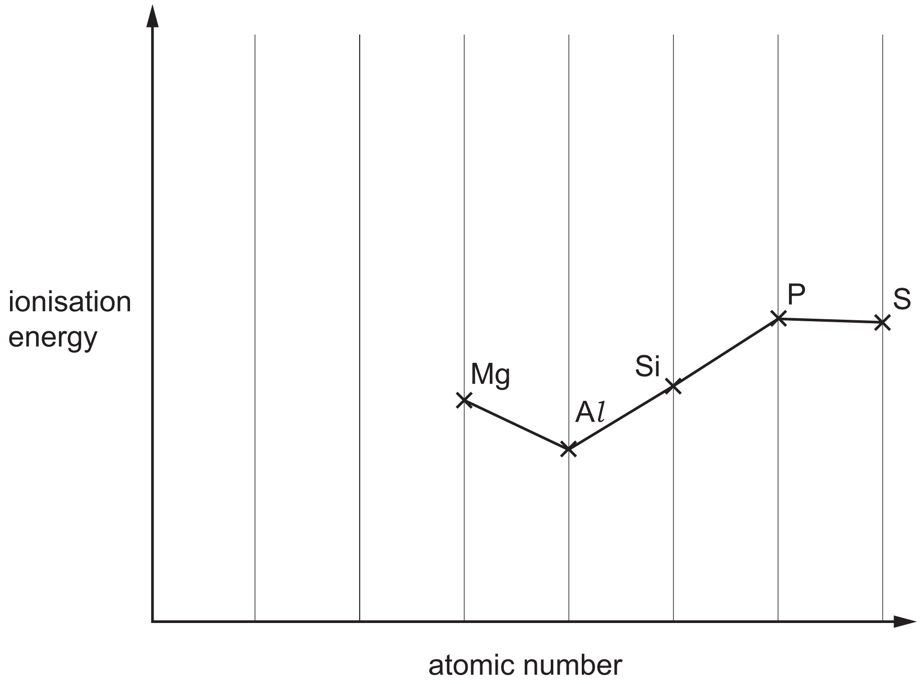
effect on yield of ammonia ....

effect on value of K_p ....
[2]

[Total: 22]

2 The elements in the third period, and their compounds, show trends in their physical and chemical properties.

(a) A sketch graph of the first ionisation energies of five successive elements in the third period is shown.



(i) Explain why there is a general increase in the first ionisation energy across the third period.

....

....

.... [2]

(ii) Sketch, on the graph, the position of the ionisation energies of the two elements that come before Mg in this sequence. [2]

(iii) Explain, with reference to electron arrangements, the decreases in first ionisation energy between Mg and Al and between P and S.

Mg and Al ....

....

....

P and S ....

....

....

[4]

(b) The chlorides of the elements in the third period behave in different ways when added to water, depending on their structure and bonding.

L and **M** are each a chloride of an element in Period 3. A student investigated **L** and **M** and their results are given.

L is a white crystalline solid with a melting point of 987 K. **L** dissolves in water to form an approximately neutral solution. Addition of NaOH(aq) to an aqueous solution of **L** produces a white precipitate.

M is a liquid with a boiling point of 331 K. **M** is hydrolysed rapidly by cold water to form a strongly acidic solution, a white solid and white fumes.

Identify **L** and **M**.
Explain any properties and observations described.
Give equations where appropriate.

(i) **L** is ....

....

....

....

.... [3]

(ii) **M** is ....

....

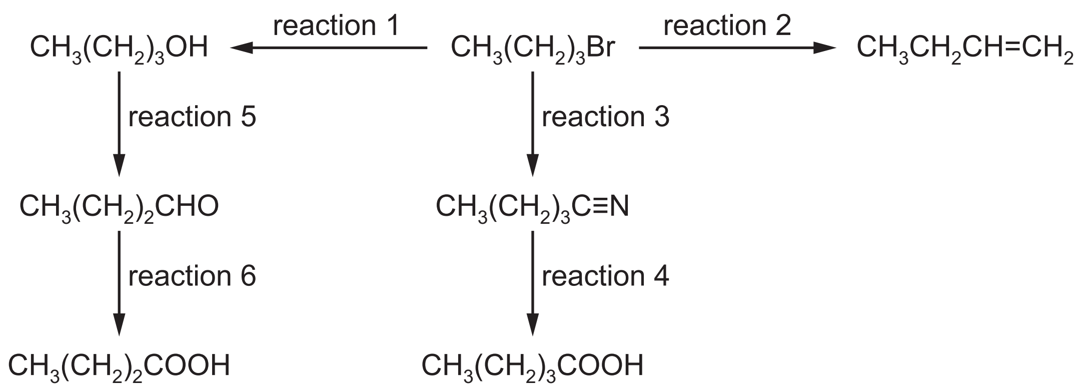
....

....

.... [3]

[Total: 14]

3 Some reactions based on 1-bromobutane, $CH_3(CH_2)_3Br$, are shown.



(a) For each of the reactions state the reagent(s), the particular conditions required, if any, and the type of reaction.

For the type of reaction choose from the list.
Each type may be used once, more than once or not at all.
Each reaction may be described by more than one type.

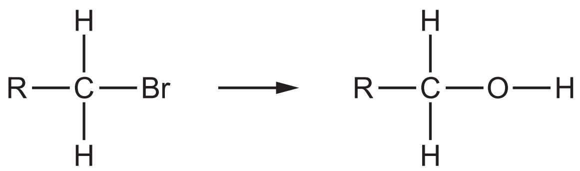
elimination hydrolysis substitution

oxidation addition condensation

reaction	reagent(s) and conditions	type(s) of reaction
1		
2		
3		
4		
5		
6		

[6]

(b) Complete the diagram to show the S_N2 mechanism of reaction 1. R represents the $CH_3(CH_2)_2$ group.
Include all necessary charges, dipoles, lone pairs and curly arrows.



[2]

(c) 2-bromo-2-methylpropane is a tertiary halogenoalkane that is a structural isomer of 1-bromobutane.

(i) Define the term *structural isomer* and name the three different types of structural isomerism.

definition ....

....

....

....

types of structural isomerism

1 ....

2 ....

3 ....

[4]

(ii) 2-bromo-2-methylpropane is treated with the same reagents as in reaction 1.
Methylpropan-2-ol is formed.

Identify the mechanism for this reaction.
Explain why this reaction proceeds via a different mechanism from that of reaction 1.

mechanism ....

explanation ....

....

....

....

....

[3]

(d) The product of reaction 2, but-1-ene, does **not** show stereoisomerism. However, but-1-ene reacts with HC*l* to form a mixture of structural isomers **X** and **Y**.

but-1-ene + HC*l* → **X** (exists as a pair of stereoisomers and is produced in higher yield than **Y**)

but-1-ene + HC*l* → **Y** (does not show stereoisomerism)

(i) Explain the meaning of the term *stereoisomers*.

....

....

.... [2]

(ii) Give **two** reasons why but-1-ene does **not** show stereoisomerism.

....

....

.... [2]

(iii) Name **X** and **Y**.

X ....

Y ....

[2]

(iv) Name the type of stereoisomerism shown by **X**.

.... [1]

(v) Use the conventional representation to draw the two stereoisomers of **X**.

[2]

[Total: 24]

BLANK PAGE

BLANK PAGE

BLANK PAGE