Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0123456789

CHEMISTRY **9701/02**

Paper 2 AS Level Structured Questions **For Examination from 2016**

SPECIMEN PAPER

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 **10** printed pages.

CAMBRIDGE International Examinations

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

1 Elements and compounds which have small molecules usually exist as gases or liquids.

(a) Chlorine, Cl_2, is a gas at room temperature whereas bromine, Br_2, is a liquid under the same conditions.

Explain these observations.

....

....

.... [2]

(b) The gases nitrogen, N_2, and carbon monoxide, CO, are isoelectronic, that is they have the same number of electrons in their molecules.

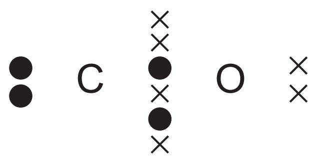
Suggest why N_2 has a lower boiling point than CO.

....

....

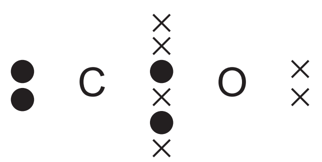
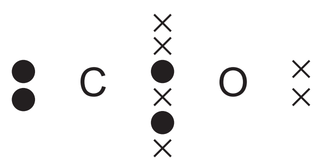
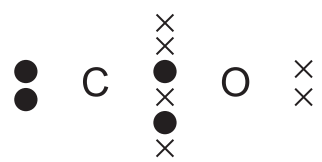
.... [2]

(c) A 'dot-and-cross' diagram of a CO molecule is shown below. Only electrons from outer shells are represented.



In the table below, there are three copies of this structure.

On the structures, draw a circle around a pair of electrons that is associated with **each** of the following.

a co-ordinate bond	a covalent bond	a lone pair
		

[3]

(d) Hydrogen cyanide, HCN, is a gas which is also isoelectronic with N_2 and with CO. Each molecule contains a strong triple bond with the following bond energies.

bond	bond energy / $kJ\,mol^{-1}$
C≡N in HCN	890
N≡N	994
C≡O	1077

Although each compound contains the same number of electrons and a strong triple bond in its molecule, CO and HCN are both very reactive whereas N_2 is not.

Suggest a reason for this.

....

.... [1]

(e) HCN reacts with ethanal, CH_3CHO.

(i) Give the **displayed formula** of the organic product formed.

[1]

(ii) What type of reaction is this?

.... [1]

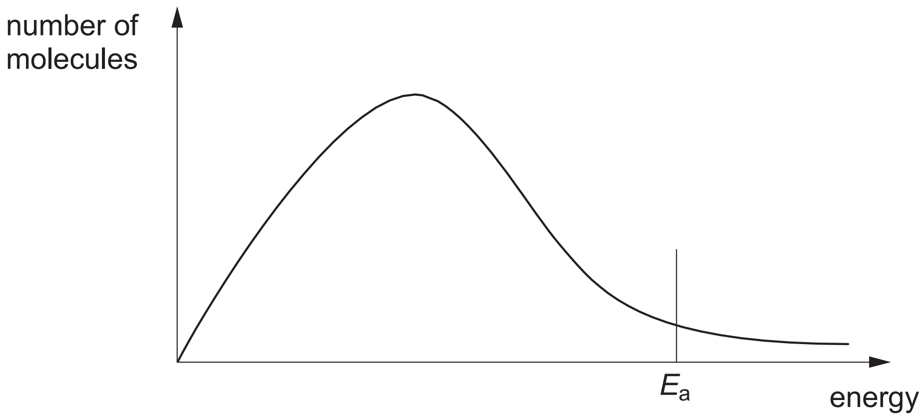
(iii) Draw the mechanism of this reaction. You should show all full and partial charges and represent the movement of electron pairs by curly arrows.

[3]

[Total: 13]

2 The diagram below shows, for a given temperature T, a Boltzmann distribution of the kinetic energy of the molecules of a mixture of two gases that will react together, such as nitrogen and hydrogen.

The activation energy for the reaction, E_a, is marked.



(a) **On the graph above,**

(i) draw a new distribution curve, **clearly labelled T′**, for the same mixture of gases at a higher temperature, **T′**, [1]

(ii) **mark clearly, as H**, the position of the activation energy of the reaction at the higher temperature, **T′**. [1]

(b) Explain the meaning of the term *activation energy*.

....

....

.... [2]

The reaction between nitrogen and hydrogen to produce ammonia in the Haber process is an example of a large-scale gaseous reaction that is catalysed.

(c) **(i)** State the catalyst used and give the operating temperature and pressure of the Haber process.

catalyst .... temperature .... pressure .... [1]

(ii) **On the energy axis of the graph above**, mark the position, **clearly labelled C**, of the activation energy of the reaction when a catalyst is used. [1]

(iii) Use your answer to **(ii)** to explain how the use of a catalyst results in reactions occurring at a faster rate.

....

.... [1]

(d) Two reactions involving aqueous NaOH are given below.

$CH_3CHBrCH_3$ + NaOH → $CH_3CH(OH)CH_3$ + NaBr   reaction 1

HCl + NaOH → $NaCl$ + H_2O reaction 2

(i) In order for **reaction 1** to occur, the reagents must be heated together for some time. **Reaction 2** however is almost instantaneous at room temperature.

Suggest brief explanations why the rates of these two reactions are very different.

reaction 1 ....

....

....

reaction 2 ....

....

.... [4]

(ii) State the reagent needed to confirm the presence of the –$CH(OH)CH_3$ group in the products of **reaction 1** and the observations that would be made.

....

....

.... [2]

[Total: 13]

3 This question refers to the elements shown in the portion of the Periodic Table given below.

							H										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

(a) From this table, identify in **each** case **one** element that has the property described. Give the **symbol** of the element in each case.

(i) The element that forms the largest cation.

.... [1]

(ii) An element that floats on water and reacts with it.

.... [1]

(iii) An element that reacts with water to give a solution that can behave as an oxidising agent.

.... [1]

(iv) An element in the s-block whose nitrate gives a brown gas on thermal decomposition.

.... [1]

(b) **(i)** Give the formula of the oxide of the most electronegative element.

.... [1]

(ii) Several of these elements form more than one acidic oxide.

Give the formulae of **two** such oxides formed by the **same** element.

.... and .... [2]

(iii) Give the formula of an oxide with a very high melting point used as a ceramic insulator.

.... [1]

(iv) Explain these properties of the oxide chosen in **(iii)**.

....

....

.... [2]

The formulae and melting points of the fluorides of the elements in Period 3, Na to C*l*, are given in the table.

formula of fluoride	NaF	MgF_2	AlF_3	SiF_4	PF_5	SF_6	ClF_5
m.p./K	1268	990	1017	183	189	223	170

(c) **(i)** What is the shape of the SF6 molecule?

.... [1]

(ii) In the sequence of fluorides above, the oxidation number of the elements increases from NaF to SF_6 and then falls at ClF_5.

Attempts to make ClF_7 have failed but IF_7 has been prepared.

Suggest an explanation for the existence of IF_7 and for the non-existence of ClF_7.

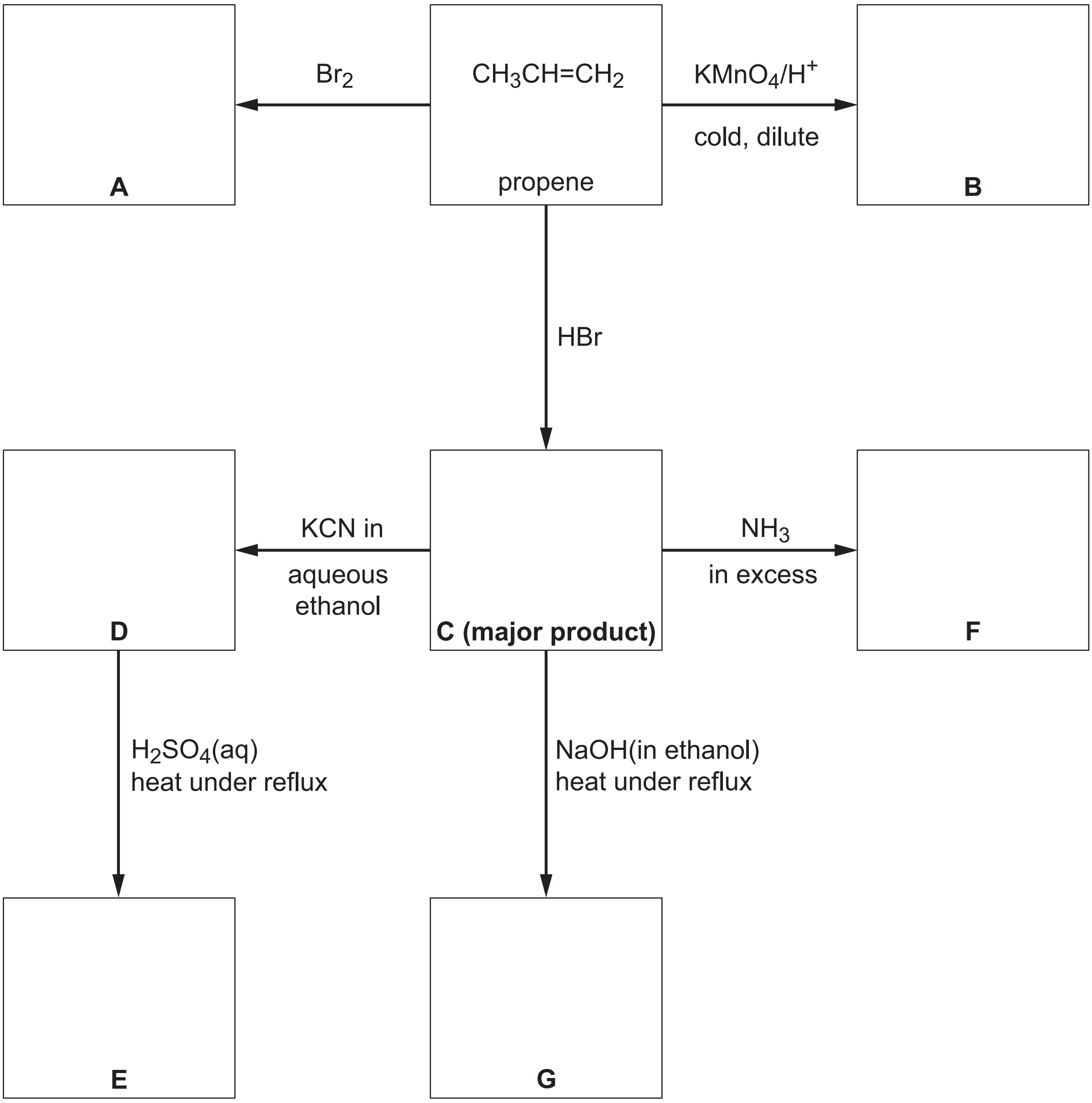
....

....

.... [2]

[Total: 13]

4 **(a)** Complete the following reaction scheme which starts with propene.
In **each empty** box, write the **structural formula** of the organic compound that would be formed.



[7]

(b) A minor product, **H**, is also produced by reaction of HBr with propene.

(i) Identify **H**.

.... [1]

(ii) Explain why **C** is a much more likely product of this reaction than **H**.

....

.... [2]

[Total: 10]

5 Isomerism occurs in many organic compounds. The two main forms of isomerism are structural isomerism and stereoisomerism. Many organic compounds that occur naturally have molecules that can show stereoisomerism, that is *cis-trans* or optical isomerism.

(a) (i) Explain what is meant by *structural isomerism*.

....

.... [1]

(ii) State **two** different features of molecules that can give rise to **stereoisomerism**.

....

.... [2]

Unripe fruit often contains polycarboxylic acids, that is acids with more than one carboxylic acid group in their molecule. One such acid is citric acid shown below.

$$\begin{array}{c} OH \\ | \\ HO_2CCH_2CCH_2CO_2H \\ | \\ CO_2H \end{array}$$

(b) (i) Does citric acid show optical isomerism? Explain your answer.

....

.... [1]

(ii) Dehydration of citric acid produces $HO_2CCH{=}C(CO_2H)CH_2CO_2H$. Draw the structure of the repeat unit formed by addition polymerisation of this molecule.

[2]

A second polycarboxylic acid present in unripe fruit is a colourless crystalline solid, **W**, which has the following composition by mass: C, 35.8%; H, 4.5%; O, 59.7%.

(c) Show by calculation that the empirical formula of **W** is $C_4H_6O_5$.

[2]

A sample of **W** (M_r = 134) of mass 1.97 g was dissolved in water and the resulting solution titrated with 1.00 mol dm^{-3} NaOH.
29.4 cm^3 of 1.00 mol dm^{-3} NaOH were required for complete neutralisation.

(d) Use these data to deduce the number of carboxylic acid groups present in one molecule of **W**.

[3]

[Total: 11]