Cambridge Pre-U Specimen Papers
and Mark Schemes

Cambridge
Pre-U

Cambridge International Level 3
Pre-U Certificate in
CHEMISTRY

For use from 2008 onwards

UNIVERSITY of CAMBRIDGE
International Examinations

Cambridge Pre-U

Specimen Materials

Chemistry (9791)

Cambridge International Level 3
Pre-U Certificate in Chemistry (Principal)

For use from 2008 onwards

QAN 500/3683/X

Support

CIE provides comprehensive support for all its qualifications, including the Cambridge Pre-U. There are resources for teachers and candidates written by experts. CIE also endorses a range of materials from other publishers to give a choice of approach. More information on what is available for this particular syllabus can be found at www.cie.org.uk

Syllabus Updates

This booklet of specimen materials is for use from 2008. It is intended for use with the version of the syllabus that will be examined in 2010, 2011 and 2012. The purpose of these materials is to provide Centres with a reasonable idea of the general shape and character of the planned question papers in advance of the first operational examination.

If there are any changes to the syllabus CIE will write to centres to inform them. The syllabus and these specimen materials will also be published annually on the CIE website (www.cie.org.uk/cambridgepreu). The version of the syllabus on the website should always be considered as the definitive version.

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CHEMISTRY **9791/01**

Paper 1 Part A Multiple Choice

SPECIMEN PAPER

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will **not** be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **13** printed pages and **1** blank page.

1 The first seven successive ionization energies of an element are 1010, 1900, 2900, 5000, 6300, 21300 and 25400 kJ mol^{-1} respectively. In which group of the Periodic Table is this element found?

A 1 **B** 13 **C** 15 **D** 17

2 How does a catalyst function?

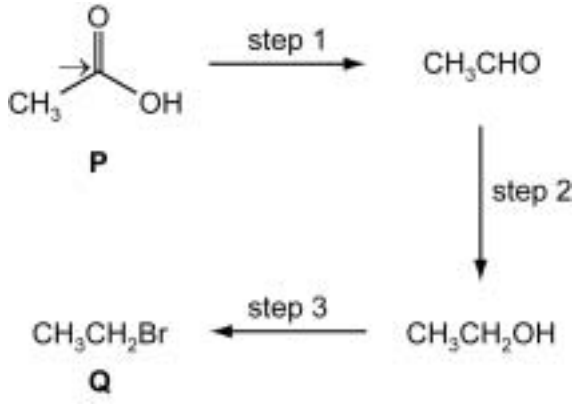
A by providing the same reaction pathway and increasing the average energy of the molecules

B by providing an alternative reaction pathway and increasing the average energy of the molecules

C by providing the same reaction pathway with a lower activation energy

D by providing an alternative reaction pathway with a lower activation energy

3 Compound **P** is converted to compound **Q** in three steps.



What is the overall change in functional group level of the carbon marked with an arrow (→) in this reaction scheme?

A no change

B 1 level

C 2 levels

D 3 levels

4 Which simple molecule has the correct shape and bond angle?

A BF_3 trigonal pyramidal, 120°

B CBr_4 tetrahedral, 109.5°

C NCl_3 trigonal pyramidal, 109.5°

D SF_6 octahedral, 120°

5 Group I elements form diatomic molecules in the gas phase.
Which molecule has the **smallest** dipole moment?

A Na—Li

B Na—Na

C Na—Rb

D Na—Cs

6 Cyclohexane, C_6H_{12}, is prepared industrially by the hydrogenation of benzene as shown in the equation.

$$C_6H_6(l) + 3H_2(g) \rightarrow C_6H_{12}(l)$$

Using the data in the table, what is the standard enthalpy change, $\Delta_r H^\ominus$, of this reaction?

enthalpy change	value
$\Delta_c H^\ominus$ ($C_6H_6(l)$)	–3268 kJ mol^{-1}
$\Delta_c H^\ominus$ ($H_2(g)$)	–286 kJ mol^{-1}
$\Delta_c H^\ominus$ ($C_6H_{12}(l)$)	–3754 kJ mol^{-1}

A –372 kJ mol^{-1}

B +372 kJ mol^{-1}

C +200 kJ mol^{-1}

D –200 kJ mol^{-1}

7 How many different orbitals are there in the 3s, 3p and 3d sub-shells respectively?

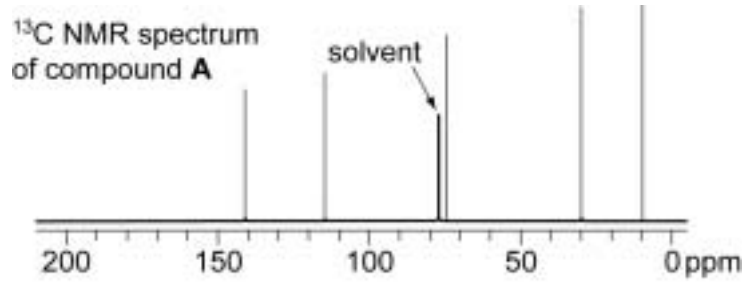
A 1, 3, 5

B 1, 4, 9

C 2, 6, 10

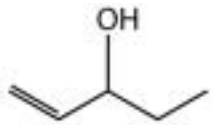
D 2, 8, 18

8 Compound **A** has the formula $C_5H_{10}O$. Its ^{13}C NMR spectrum is shown below.

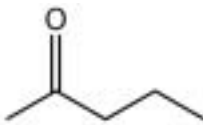


Which of the following structures is consistent with the NMR spectrum?

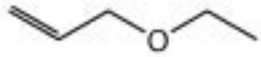
A



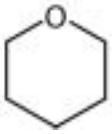
B



C



D



9 Predict the correct order for the stretching frequencies of IR absorptions of the following bonds involving nitrogen, highest frequency first.

A C≡N > C=N > C–N > N–H

B N–H > C≡N > C=N > C–N

C C≡N > C=N > N–H > C–N

D C–N > C≡N > C=N > N–H

10 Which period 3 element has the highest melting point?

A aluminium

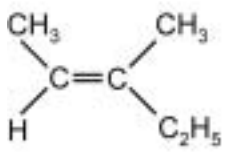
B magnesium

C phosphorus

D silicon

11 The structures below show isomers of C_6H_{12}.

1



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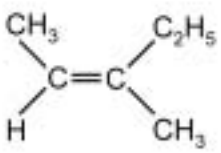

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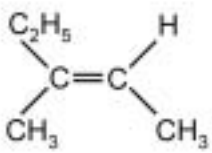

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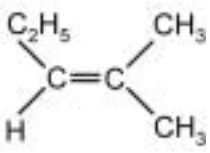


In which pair are the members *cis-trans* isomers of each other?

A 1 and 2 **B** 1 and 3 **C** 1 and 4 **D** 2 and 4

12 What is the correct order for the processes involved in mass spectrometry?

A acceleration, separation, vaporisation, ionisation, detection

B ionisation, vaporisation, acceleration, separation, detection

C ionisation, vaporisation, separation, acceleration, detection

D vaporisation, ionisation, acceleration, separation, detection

13 What is the atom economy of the following synthesis of C_4H_9CN?

$$C_4H_9Cl + NaCN \rightarrow C_4H_9CN + NaCl$$

A 59% **B** 88% **C** 90% **D** 100%

14 Which of the compounds below will **not** decompose upon heating with a hot Bunsen burner flame?

A lithium carbonate

B magnesium carbonate

C calcium carbonate

D sodium carbonate

15 What is the equation for the second ionisation energy of sulfur?

A $S(s) \rightarrow S^{2+}(s) + 2e^-$

B $S(g) \rightarrow S^{2+}(g) + 2e^-$

C $S^+(g) \rightarrow S^{2+}(g) + e^-$

D $S^+(s) \rightarrow S^{2+}(g) + e^-$

16 What type of reaction is the following?

$$3NaClO(aq) \rightarrow NaClO_3(aq) + 2NaCl(aq)$$

A oxidation

B reduction

C disproportionation

D elimination

17 For which halogen is the colour and state at room temperature correct?

	halogen	colour	state
A	bromine	brown	gas
B	chlorine	green	liquid
C	fluorine	green	gas
D	iodine	black	solid

18 The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What is element **X**?

A sodium

B magnesium

C aluminium

D phosphorus

19 The emissions from a power station contain about 14 tonnes of SO_2 per hour from the oxidation of FeS_2 contained in the coal.

What is the most practical way of preventing the SO_2 from being released into the atmosphere?

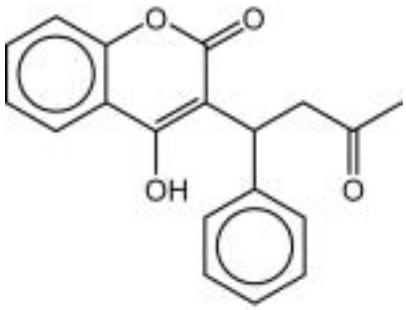
A Cool the gases and the SO_2 will liquefy and can be removed.

B Dissolve the ionic FeS_2 in hexane.

C Pass the emissions through a bed of calcium oxide.

D Pass the gases through concentrated sulphuric acid to dissolve the SO_2.

20 Warfarin is used as a rat poison.



warfarin

How many chiral centres are present in the warfarin molecule?

A 0 **B** 1 **C** 2 **D** 3

21 Aldehydes and ketones are carbonyl compounds.

Which of them react both with $NaBH_4$ and with Tollens' reagent?

A aldehydes only

B ketones only

C both aldehydes and ketones

D neither aldehydes nor ketones

22 For which equation is the enthalpy change correctly described as an enthalpy change of formation?

A $2NO(g) \rightarrow N_2(g) + O_2(g)$

B $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

C $H_2O(l) + NaCl(s) \rightarrow NaCl(aq)$

D $K(s) + Mn(s) + 2O_2(g) \rightarrow KMnO_4(s)$

23 Under the Montreal Protocol, the manufacture of chlorofluorocarbons has been phased out, and they are being replaced by fluorocarbons.

One chlorofluorocarbon which was widely used as a solvent is CCl_2FCClF_2. Large stocks of it remain. One process to use up these stocks is to convert it into the fluorocarbon CH_2FCF_3 by the following route.

$$CCl_2FCClF_2 \xrightarrow{\text{step 1}} CCl_3CF_3 \xrightarrow{\text{step 2}} CCl_2FCF_3 \xrightarrow{\text{step 3}} CH_2FCF_3$$

What type of reaction is step 2?

A disproportionation

B elimination

C isomerisation

D substitution

24 What is the total number of different chloroethanes, formula $C_2H_{6-n}Cl_n$, where n can be any integer from 1 to 4?

A 4 **B** 6 **C** 7 **D** 8

25 The compound 1,2-dichloroethene, $C_2H_2Cl_2$, has been used as an industrial solvent for a number of compounds including fats, camphor and caffeine.

Which statement about this compound is **incorrect**?

A The compound can be hydrogenated.

B The compound is a planar molecule.

C The compound shows *cis-trans* isomerism.

D The compound shows optical isomerism.

26 The nickel-cadmium rechargeable battery is based upon the following overall reaction.

$$Cd + 2NiO(OH) + 4H_2O \rightarrow Cd(OH)_2 + 2Ni(OH)_2.H_2O$$

What is the oxidation number of nickel at the beginning and at the end of the reaction?

	beginning	end
A	+1.5	+2
B	+2	+3
C	+3	+2
D	+3	+4

27 Consider the following half-equations.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$
$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$
$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

What volume of 0.01 mol dm^{-3} $KMnO_4$ is required to oxidise 15 cm^3 of an acidified solution of 0.01 mol dm^{-3} FeC_2O_4?

A 6 cm^3 **B** 9 cm^3 **C** 15 cm^3 **D** 25 cm^3

28 *Use of the Data Booklet is relevant to this question.*

In research on the atomic nucleus, scientists have been comparing the stability of isotopes with the same neutron : proton ratio.

Which isotope has the same neutron : proton ratio as ^{10}B?

A ^{32}P **B** ^{32}S **C** ^{40}Ar **D** ^{40}K

29 The compound phenylethylamine occurs naturally in chocolate and is believed to raise blood pressure producing a feeling of "well being".

Phenylethylamine has the formula $C_6H_5CH_2CH_2NH_2$ and a boiling point of 195 °C.

Which statement is **incorrect**?

A Phenylethylamine contains one carbon atom at the "alcohol level".

B Phenylethylamine could be produced from phenylethylchloride, $C_6H_5CH_2CH_2Cl$.

C The mass spectrum of phenylethylamine will show a major fragmentation peak at m/z = 78.

D The relatively high boiling point of phenylethylamine results from hydrogen bonding.

30 The atoms *X* and *Y* have the following electronic configurations.

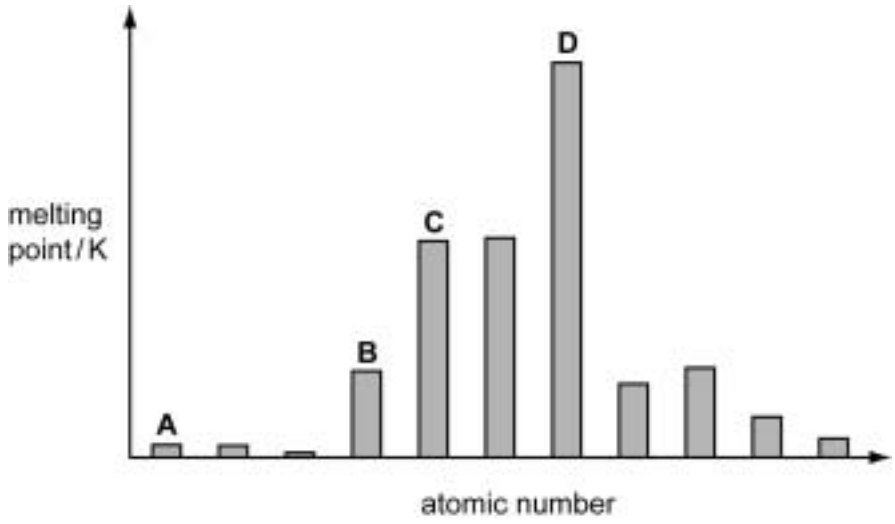
X, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$
Y, $1s^2\ 2s^2\ 2p^4$

What is the formula of the compound they are likely to form?

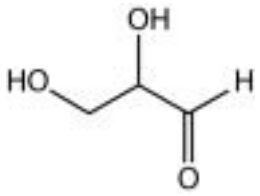
A $X^{2+}(Y^-)_2$ **B** $X^{2+}Y^{2-}$ **C** XY_4 **D** X_2Y_4

31 The bar chart shows the melting points of a series of consecutive elements arranged in order of increasing atomic number. The elements sodium to chlorine form part of this series.

Which bar represents sodium?



32 What is the molecular formula of the following molecule?



A $HOCH_3CH_2(OH)CHO$

B $HOCH_2CH(OH)CHO$

C $C_3H_6O_3$

D $C_3H_8O_3$

33 Which statement does **not** explain why white phosphorus is more reactive than nitrogen gas?

A It is lower down the group so its outer electrons are more shielded from the nucleus.

B The phosphorus-phosphorus bond in white phosphorus is much weaker than the nitrogen-nitrogen bond in N_2.

C There is considerable bond strain in the P_4 molecule.

D Reactions involving nitrogen gas mostly require extremely high activation energies.

34 A sample of chlorine containing isotopes of mass numbers 35 and 37 was analysed in a mass-spectrometer.

How many peaks corresponding to Cl_2^+ were recorded?

A 2 **B** 3 **C** 4 **D** 5

35 N_2O_4 is a poisonous gas. It can be disposed of safely by reaction with sodium hydroxide.

$$N_2O_4(g) + 2NaOH(aq) \rightarrow NaNO_3(aq) + NaNO_2(aq) + H_2O(l)$$

What is the minimum volume of 0.5 mol dm^{-3} NaOH(aq) needed to dispose of 0.02 mol of N_2O_4?

A 8 cm^3 **B** 12.5 cm^3 **C** 40 cm^3 **D** 80 cm^3

36 Gallium nitride, GaN, could revolutionise the design of electric light bulbs because only a small length used as a filament gives excellent light at low cost.

Gallium nitride is an ionic compound containing the Ga^{3+} ion.

What is the electron arrangement of the nitrogen ion in gallium nitride?

A $1s^2\ 2s^2$

B $1s^2\ 2s^2\ 2p^3$

C $1s^2\ 2s^2\ 2p^4$

D $1s^2\ 2s^2\ 2p^6$

37 A radioactive isotope of thallium, $^{201}_{81}Tl$, is used to assess damage in heart muscles after a heart attack.

Which statement about $^{201}_{81}Tl$ is correct?

A This isotope has a nucleon number of 120.

B The number of electrons in one atom of this isotope is 81.

C The number of neutrons in one atom of this isotope is 201.

D $^{201}_{82}X$ is an isotope of $^{201}_{81}Tl$.

38 In which process are hydrogen bonds broken?

A $H_2(l) \rightarrow H_2(g)$

B $NH_3(l) \rightarrow NH_3(g)$

C $2HI(g) \rightarrow H_2(g) + I_2(g)$

D $CH_4(g) \rightarrow C(g) + 4H(g)$

39 An organic liquid **X** with molecular formula $C_4H_{10}O$, shows a broad absorption between 3500 and 3100 cm^{-1} in the infra-red spectrum. When **X** reacts with acidified sodium dichromate(VI) solution under mild conditions, a liquid can be distilled from the reaction mixture which gives a silver mirror on warming with Tollens' reagent.

Liquid **X** could be

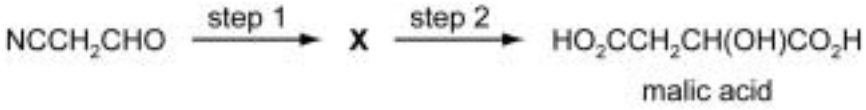
A propan-1-ol.

B 2-methylpropan-2-ol.

C butan-2-ol.

D 2-methylpropan-1-ol.

40 Apples, the fruit of trees of the genus *Malus*, are rich in malic acid. Malic acid may be synthesised in the laboratory in two steps.



Which reagents could be used for this synthesis?

	step 1	step 2
A	HC*l*(aq)	HCN(g)
B	HCN, NaCN(aq/alcoholic)	H_2SO_4(aq)
C	H_2SO_4(aq)	$K_2Cr_2O_7$ / H_2SO_4(aq)
D	CH_3MgBr	H_2SO_4(aq)

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Cambridge International Level 3 Pre-U Certificate
Principal Subject

CHEMISTRY **9791/01**

Paper 1 Part A Multiple Choice

SPECIMEN MARK SCHEME

1 hour

MAXIMUM MARK: 40

Question Number	*Key*	*Question Number*	*Key*
1	**C**	21	**A**
2	**D**	22	**D**
3	**C**	23	**D**
4	**B**	24	**C**
5	**B**	25	**C**
6	**A**	26	**C**
7	**A**	27	**B**
8	**A**	28	**B**
9	**B**	29	**C**
10	**D**	30	**B**
11	**A**	31	**B**
12	**D**	32	**C**
13	**A**	33	**A**
14	**D**	34	**B**
15	**C**	35	**D**
16	**C**	36	**D**
17	**D**	37	**B**
18	**D**	38	**B**
19	**C**	39	**D**
20	**A**	40	**B**

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CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **9791/02**

Paper 2 Part A Written

SPECIMEN PAPER

2 hours 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 in the spaces provided.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You are advised to show all working in calculations.
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.

For Examiner's Use	
1	
2	
3	
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7	
Total	

This document consists of **17** printed pages and **1** blank page.

For Examiner's Use

1 This question is about the mining of copper.

The largest copper mine in the world is in Atacama, Chile, where the mineral chalcopyrite, $CuFeS_2$, is extracted.

(a) Work out the percentage by mass of copper in chalcopyrite.

percentage by mass ..... [2]

The richest ore dug out of the ground in Atacama, however, is only about 1.0% copper by mass.

(b) Work out what percentage of the ore is chalcopyrite, assuming it is the only copper-containing component of the ore.

percentage chalcopyrite ..... [1]

During the extraction process all the sulfur in the ore is converted into SO_2.

(c) Calculate the volume of SO_2 (at room temperature and pressure) generated from 1.00 tonne of pure chalcopyrite.
[1 tonne = 1000 kg]

volume of SO_2 ..... [3]

The SO_2 produced is converted into sulfuric(VI) acid, which is used in the extraction process.

(d) Calculate the maximum possible volume of 2 mol dm^{-3} sulfuric(VI) acid that could be made from the sulfur dioxide obtained from 1 tonne of chalcopyrite.

volume of 2 mol dm^{-3} sulfuric(VI) acid ..... [1]

When sulfur dioxide first reacts with water it forms an acid of formula H_2SO_3.

For Examiner's Use

(e) Work out the oxidation number of sulfur in this acid and hence suggest the modern systematic name of this acid.

oxidation number .....

systematic name ..... [2]

Chalcopyrite is a sulfide mineral. Adding dilute acid to sulfides generates the malodorous and toxic gas, hydrogen sulfide.

(f) **(i)** Draw the structure of hydrogen sulfide, giving an estimate of any bond angles.

[2]

(ii) Hydrogen sulfide is a gas at room temperature and pressure. In fact, all of the hydrogen compounds of Group 16 elements are gases at room temperature and pressure except for that of oxygen. Explain this observation, referring to the intermolecular forces in hydrogen sulfide and in the hydrogen compound of oxygen.

.....

..... [2]

When oxides of sulfur escape into the atmosphere they form sulfuric(VI) acid. The resulting acid rain can dissolve compounds of aluminium, for example aluminium oxide in rocks. In solution, aluminium causes environmental damage and health problems in humans.

(g) Write a balanced equation including state symbols to show how sulfuric(VI) acid takes aluminium oxide into solution.

..... [3]

(h) Discuss the measures that can be taken to reduce the oxides of sulfur in industrial emissions. Include any relevant equations in your answers.

For Examiner's Use

.....

.....

.....

.....

.....

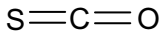
..... [5]

[Total: 21]

For Examiner's Use

2 This question is about the origin of life.

Carbon oxysulfide, COS, has been detected in emissions from volcanoes. It has recently been suggested that it played an important role in the formation of the first peptides from prebiotic amino acids. The structure of COS is shown below.

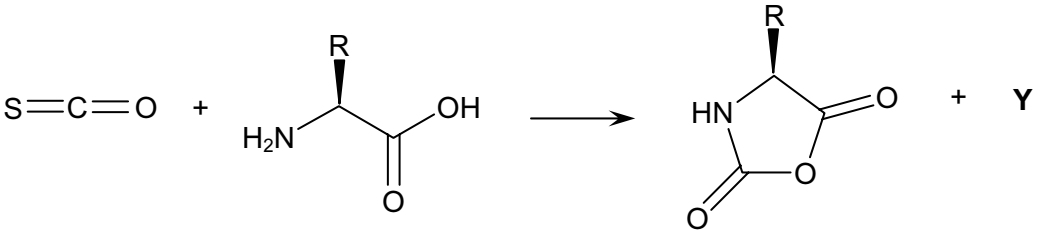


(a) State the functional group level of the carbon in COS.

.....

[1]

COS helps the formation of the peptide linkages through the initial formation of a cyclic compound **X**, shown below. COS and the amino acid react in a 1:1 ratio.



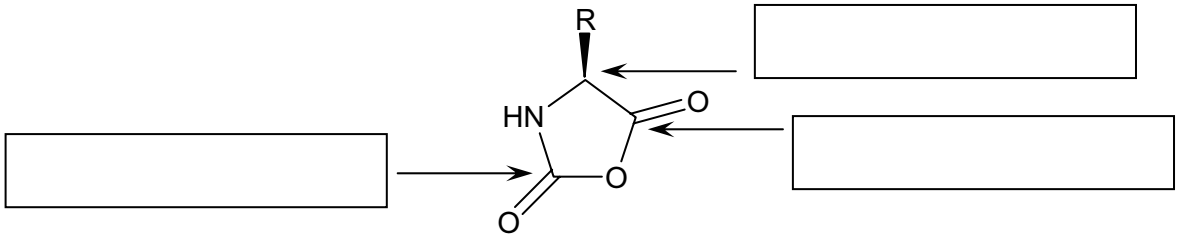
compound **X**

(b) By ensuring the reaction balances, identify the by-product **Y**.

.....

[1]

(c) On the structure of **X** below identify the functional group level of each of the carbons indicated by an arrow. [Assume R is alkyl.]

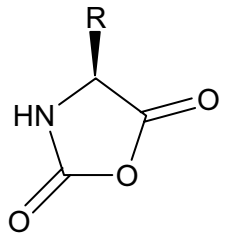


X

[3]

For Examiner's Use

(d) In the light of your answer to **(c)**, circle the carbon atom in **X** in the structure below that originated from the carbon oxysulphide.

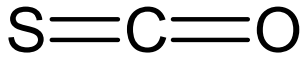


X

[1]

The chemistry of carbon oxysulfide is greatly influenced by the dipoles on its two bonds.

(e) Using δ- and δ+ symbols, add dipoles to the bonds in the structure of COS below.



[1]

(f) Predict the stable carbon-containing product resulting from the hydrolysis of COS.

.....

[1]

(g) Suggest an equation for the reaction of COS with water.

.....

[1]

[Total: 9]

For Examiner's Use

3 This question is about element 118.

On 9th October 2006 a team of scientists from America and Russia reported the discovery of element 118, the heaviest element yet discovered. Just three atoms were made, which existed for less than a millisecond before decaying. The atoms had a relative atomic mass of 294. The element has provisionally been named ununoctium and given the symbol Uuo.

(a) (i) In which group of the Periodic Table does the element Uuo belong?

.....

[1]

(ii) Suggest the shape that would be adopted by the tetroxide $UuoO_4$.

.....

[1]

(b) Would the first ionisation energy of element 118 be expected to be higher or lower than the element above it in the Periodic Table? Explain your answer.

.....

.....

.....

[2]

(c) Write down the number of protons, the number of neutrons, and the number of electrons in a neutral atom of element 118.

number of protons .....

number of neutrons .....

number of electrons .....

[2]

The three atoms of element 118 were produced after 4.1×10^{19} atoms of ^{48}Ca bombarded a target of ^{249}Cf.

(d) Calculate the mass, in g, of 4.1×10^{19} atoms of ^{48}Ca.

.....

.....

[2]

[Total: 8]

For Examiner's Use

4 This question is about the van Arkel triangle.

The type of bonding between two elements can be rationalised and even predicted using a van Arkel triangle. The triangle is based on electronegativity values. Difference in electronegativity is plotted along the *y*-axis and average electronegativity is plotted along the *x*-axis.

(a) What is meant by the term *electronegativity*?

.....

.....

[2]

(b) State and explain the trend in electronegativity

(i) across a period from left to right,

.....

.....

.....

[2]

(ii) down a group.

.....

.....

.....

[2]

(c) Considering only elements in period 2 (Li to Ne), write down

(i) the formula of the compound that has the greatest ionic character,

.....

[1]

(ii) the formula of a simple molecule that has pure covalent bonding,

.....

[1]

(iii) the element that has the greatest metallic character.

.....

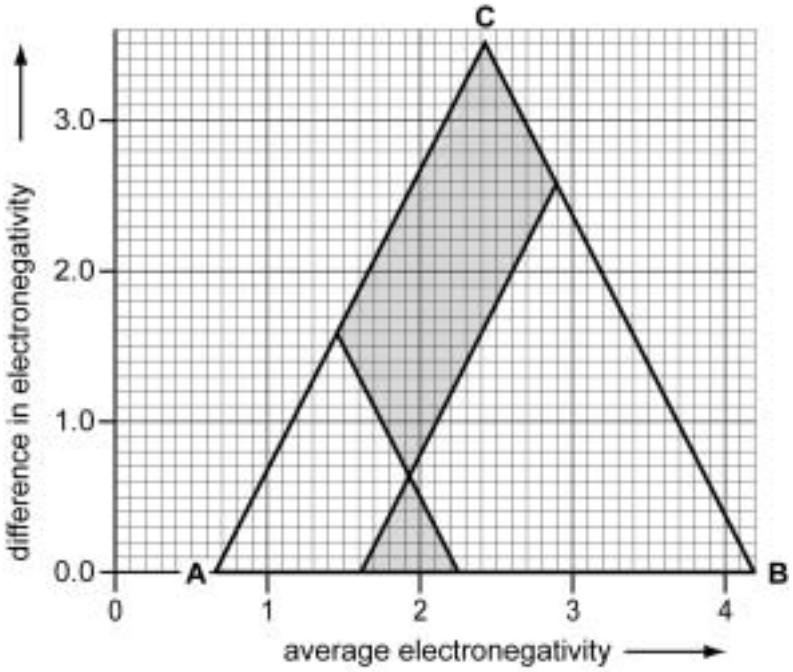
[1]

(d) Use the electronegativity values quoted below to plot on the template van Arkel triangle below each of the following compounds. Label your points with the formulae.

(i) titanium boride, TiB_2

(ii) silicon carbide, SiC

(iii) gallium antimonide, GaSb [2]



element	electronegativity
B	2.05
C	2.54
Si	1.92
Ti	1.38
Sb	1.98
Ga	1.76

(e) What is the type of bonding present at each of these bonding extremes, labelled **A**, **B** and **C** on the triangle?

A .....

B .....

C ..... [1]

(f) The electrical properties of the materials in part **(f)** are all very different. Suggest which of the compounds in part **(f)** would be expected to be

(i) a good conductor, ... [1]

(ii) a semiconductor, ... [1]

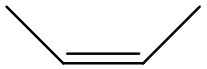
(iii) an insulator. ..... [1]

[Total: 15]

5 This question is about alkenes.

For Examiner's Use

The four isomeric alkenes **A**, **B**, **C** and **D** have the formula C_4H_8. Each alkene is a gas at room temperature and pressure. Some information about these alkenes is given in the table below.

	A	**B**	**C**	**D**
structure		?	?	?
number of signals in ^{13}C NMR spectrum	?	2	3	4
standard enthalpy of combustion at 298 K, $\Delta_c H^\ominus$ / kJ mol^{-1}	–2710	–2707	–2700	–2717
standard enthalpy of formation at 298 K, $\Delta_f H^\ominus$ / kJ mol^{-1}	–8	–11	?	–1

(a) (i) How many signals would there be in the ^{13}C NMR spectrum of **A**?

.....[1]

(ii) By considering the number of peaks in their ^{13}C NMR spectra, suggest structures for alkenes **B**, **C**, and **D**. Label each structure with the appropriate letter.

[3]

(b) (i) Write a balanced equation for the complete combustion of C_4H_8.

.....[1]

(ii) Draw reaction pathway energy diagram for the combustion of **A**, clearly labelling the reactants and products and the enthalpy change of combustion.

[3]

(c) (i) Using the data for the standard enthalpies of combustion, draw an enthalpy cycle to calculate the standard enthalpy change for the following reaction of alkene **A** to alkene **B**.

$$\mathbf{A}(g) \longrightarrow \mathbf{B}(g)$$

[2]

(ii) By considering the standard enthalpies of combustion, predict which of the four alkenes is the most stable. Explain your answer.

.....

..... [1]

(d) (i) Define the term *standard enthalpy change of formation*.

.....

..... [1]

(ii) Calculate the standard enthalpy of formation of alkene **C** at 298 K.

[1]

(e) Construct an enthalpy cycle that relates the standard enthalpies of combustion and formation of **A** with the standard enthalpies of formation of water and carbon dioxide. Hence, or otherwise, calculate the standard enthalpy change for the following reaction.

$$C(s) + H_2(g) + {}^3/_2O_2(g) \longrightarrow CO_2(g) + H_2O(l)$$

[2]

The four isomeric alkenes **A**, **B**, **C** and **D**, can be made by elimination of HCl from chloroalkanes.

For Examiner's Use

In cases where it is possible to form the C=C double bond in more than one position in this process, the double bonds preferentially form between non-terminal carbon atoms, i.e. those not at the end of a chain.

(f) Write an unambiguous structural formula for the best chloroalkane to prepare each of the four alkenes **A**, **B**, **C** and **D**. Indicate next to each chloroalkane the letter of the alkene produced.

[3]

(g) Using your answer to **(c) (i)**, suggest why a chloroalkane is not in fact suitable for the preparation of alkene **A**.

.....

..... [1]

[Total: 19]

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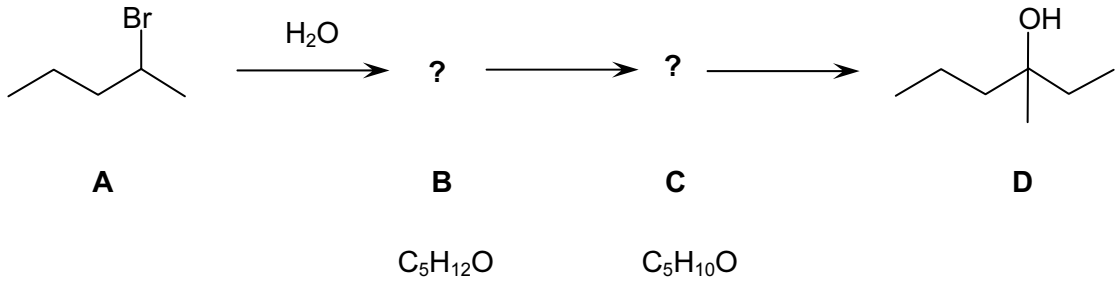
For Examiner's Use

6 This question is about organic synthesis.

In the reaction scheme below, the five-carbon bromoalkane, **A**, is converted into the seven-carbon alcohol, **D**.



(a) Name compound **A** and write its **molecular** formula.

name .....

molecular formula .....

[2]

(b) Give the approximate frequencies of any absorptions present above 1500 cm^{-1} in the IR spectrum of **A**. Identify the bond or bonds responsible.

.....

[1]

The infrared spectrum of **B** shows a broad absorption based around 3300 cm^{-1} that is not present in **A** or **C**. In **C** there is sharp intense absorption close to 1700 cm^{-1} that is not found in the infrared spectra of **A**, **B** or **D**.

(c) The reaction to give **B** from **A** can be carried out with water alone, but is slow even on warming. Name the reagent that is typically employed in this reaction to prepare **B** more quickly.

.....

[1]

(d) By comparing the molecular formulae of **B** and **C** suggest what type of reaction transforms **B** into **C**. Explain your answer.

.....

[1]

(e) Draw the skeletal formula for compound **C**.

[1]

(f) Write down the formula of the reagent that will react with **C** to produce **D**.

.....

[1]

For Examiner's Use

(g) What reagent could be used to transform **D** in a single step to form 3-chloro-3-methylhexane?

.....

[1]

[Total: 8]

For Examiner's Use

7 This question is about a practical investigation.

Pure copper(II) carbonate does not exist but basic copper(II) carbonates of the form $Cu(OH)_2.\boldsymbol{x}CuCO_3$ have been characterised, where ***x*** is the amount, in moles, of $CuCO_3$ per mole of $Cu(OH)_2$. Basic copper(II) carbonates decompose to copper(II) oxide when heated by a Bunsen flame. The value of ***x*** can be determined in the laboratory using a gravimetric technique, i.e. measuring mass changes.

(a) Write separate chemical equations for the thermal decomposition of $CuCO_3$ and $Cu(OH)_2$, the components of the basic copper(II) carbonate.

.....

..... [1]

(b) Write a detailed method, using appropriate quantities, to produce data that could be used to determine gravimetrically the value of ***x*** **as accurately as possible** from a sample of basic copper(II) carbonate of unknown composition. Assume that standard school laboratory apparatus is available.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) What is the main safety hazard in this experiment?

..... [1]

(d) Explain how you would process your data to determine the value of ***x***.

For Examiner's Use

.....

.....

.....

.....

.....

..... [4]

An alternative method to determine ***x*** involves a back titration of a known mass of the sample. Basic copper(II) carbonate dissolves in and is neutralised by acid. If the sample is dissolved in an excess of acid, the acid remaining in the solution after neutralisation can be titrated with dilute alkali. A given mass of $CuCO_3$ requires a different amount of acid to neutralise it compared with the same mass of $Cu(OH)_2$.

(e) Write separate chemical equations for the reactions of $CuCO_3$ and $Cu(OH)_2$ with dilute hydrochloric acid.

.....

..... [1]

(f) Write a detailed method for a back titration, including quantities, to produce data that could be used to find the value of ***x*** **as accurately as possible**. Assume that you have 1.00 g of basic copper(II) carbonate, 1.00 mol dm^{-3} dilute hydrochloric acid and 0.100 mol dm^{-3} sodium hydroxide solution. Assume that standard school laboratory apparatus is available, including a 100 cm^3 volumetric flask.

[6]

(g) Calculate the volume of sodium hydroxide required in your experiment if ***x*** were equal to 2.

[3]

[Total: 20]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CHEMISTRY **9791/02**

Paper 2 Part A Written

SPECIMEN MARK SCHEME

2 hours 15 minutes

MAXIMUM MARK: 100

This document consists of **8** printed pages.

UNIVERSITY of CAMBRIDGE
International Examinations

[Turn over

1 Copper

(a) M_r = 183.5 (1)
34.6% (1) [2]

(b) 1.0 / 0.346 = 2.9% [1]

(c) amount of ore = 5.45×10^3 mol (1)
amount of SO_2 = 1.09×10^4 mol (1)
1.09×10^4 x 24 = 2.62×10^5 dm^3 to 3 significant figures (1)
(3 marks for correct answer to 3 sig. figs.)
(if answer is given as 262 dm^3 deduct 1 mark for conversion error (kg to g)) [3]

(d) vol = amount of SO_2 from **(c)** / 2 mol dm^{-3} = 5.45×10^3 dm^3 [1]

(e) oxidation no = +4 or 4+ (1)
systematic name = sulfuric(IV) acid (1) [2]

(f) **(i)** H_2S bent (allow v-shaped, non-linear) (1) 104.5° angle (allow 104–105° or 92°) (1) [2]

(ii) hydrogen bonding in water (accept diagram) (1), only van der Waals forces in hydrogen sulfide (1) [2]

(g) $Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2O(l)$
1 mark for all formulae correct. 1 mark for state symbols.
1 mark for balancing (only if first mark obtained) [3]

(h) removal after combustion (1)
flue gas desulfurisation (1)
use of calcium carbonate or alkali (1)
appropriate equation
e.g. $CaCO_3(s) + SO_2(g) \rightarrow CaSO_3(s) + CO_2(g)$
or $Ca(OH)_2(s) + SO_2(g) \rightarrow CaSO_3(s) + H_2O(l)$ (1)
solid sulphur product (or given by state symbol) (1)

removal before combustion (1)
hydrodesulfurisation of fuel oil (1)
suitable equation e.g. $C_2H_5SH + H_2 \rightarrow C_2H_6 + H_2S$ (1)
requires catalyst (1)

at least one equation plus any 4 other marks [5]

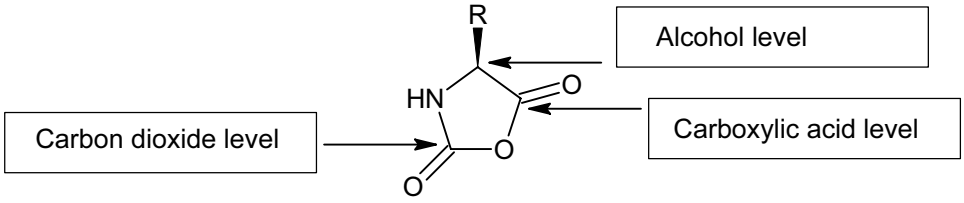
[Total: 21]

2 Origin of life

(a) carbon dioxide level (allow level 4, CO_2 level) [1]

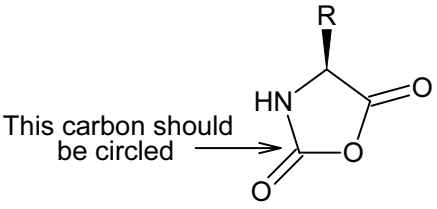
(b) H_2S (allow hydrogen sulfide, SH_2) [1]

(c) one mark for each correct label



(allow level 1 etc. as appropriate) [3]

(d)



(e.c.f. from **(c)**) [1]

(e) δ- on both the oxygen **and** the sulfur. δ+ on the carbon (accept 2δ+ on the carbon) [1]

(f) CO_2 (**not** CO) [1]

(g) $COS + H_2O \rightarrow CO_2 + H_2S$
(allow $COS + 2H_2O \rightarrow H_2CO_3 + H_2S$ as e.c.f. on **(f)**) [1]

[Total: 9]

3 Element 118

(a) (i) Group 18 (allow noble gases, inert gases, Group 8, Group 0) (1) [1]

(ii) tetrahedral (allow tetrahedron) (1) [1]

(b) lower + 1 reason (1) + second reason (1)
reasons: outer electrons further from nucleus
another layer of shielding [2]

(c) 118 protons, 176 neutrons, 118 electrons
1 mark for any two correct, 2 marks for three correct [2]

(d) $48 \times 4.1 \times 10^{19} / 6.02 \times 10^{23}$ (1)
$= 3.27$ mg or 3.27×10^{-3} g (1) [2]

[Total: 8]

4 van Arkel

(a) must include reference to valence or bonding electrons (1) and
either their attraction to the nucleus or their energy (1)
e.g. the ability to attract (1) bonding / valence electrons (1) [2]

(b) (i) increases / gets bigger (1) with increasing nuclear charge / same shielding but more protons (1) [2]

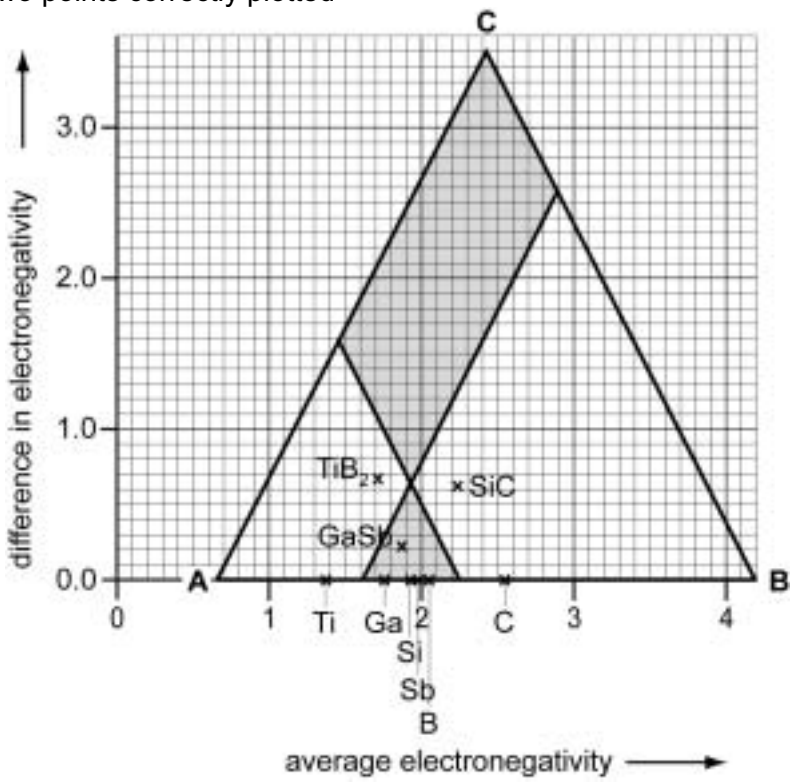
(ii) decreases / gets smaller (1) as electrons further from the nucleus / more shielding (1) [2]

(c) (i) LiF [1]

(ii) F_2, O_2 or N_2 [1]

(iii) Li [1]

(d) 2 marks for all points correctly plotted
1 mark for two points correctly plotted [2]



(e) **A** metallic
B covalent
C ionic [1]

(f) (i) TiB_2 **not** TiB [1]

(ii) GaSb [1]

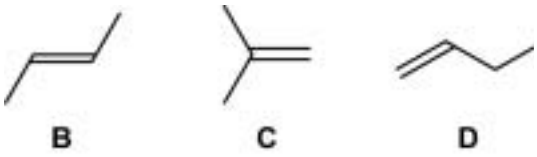
(iii) SiC [1]

[Total: 15]

5 Stability of alkenes

(a) (i) 2 [1]

(ii)

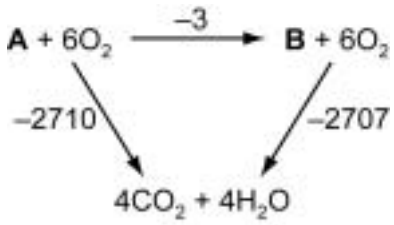


(allow displayed formulae) [3]

(b) (i) $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$ [1]

(ii) products lower than reactants (1)
arrow pointing down, level with product and reactant lines (1)
labelled $\Delta_c H$ or with correct value **and** units (1) [3]

(c) (i)



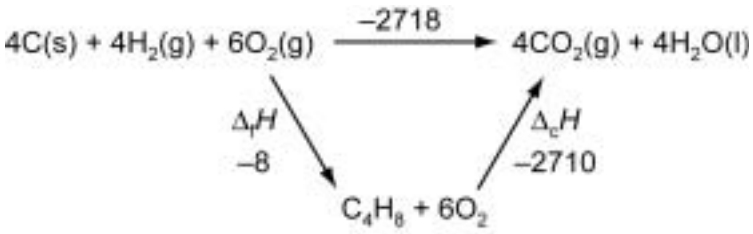
correct and balanced i.e. $6O_2$ included (1)
–3 (1) [2]

(ii) **C** (allow structure or 1,1dimethylethylene) lowest / least positive (**not** smallest) enthalpy of combustion (1) [1]

(d) (i) enthalpy change when 1 mole of a compound is formed from its elements in their standard states (1) [1]

(ii) –18 kJ mol^{-1} [1]

(e)



cycle correct and balanced (1)
2718/4 = 679.5 kJ mol^{-1} (1) [2]

(f) 2-chlorobutane gives **A** (1)
2-chlorobutane gives **B** (trans but-2-ene) (1)
2-chloro-2-methylpropane gives **C** (methylpropene) (1)
1-chlorobutane gives D (but-1-ene) (1)
e.c.f. from **(a)(ii)** [3]

(g) same chloroalkane as **B** – **B** is the thermodynamic product (1) [1]

[Total: 19]

6 Organic synthesis

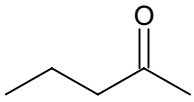
(a) 2-bromopentane (1)
$C_5H_{11}Br$ (1) [2]

(b) C-H stretch at 2900 to 3000 cm^{-1} (accept anything in this range) [1]

(c) sodium hydroxide / NaOH / potassium hydroxide / KOH [1]

(d) oxidation because loss of hydrogen [1]

(e)



[1]

(f) EtMgBr or C_2H_5MgBr or CH_3CH_2MgBr **not** C_2H_5BrMg [1]

(g) $SOCl_2$ or PCl_5 or PCl_3 [1]

[Total: 8]

7 Practical

(a) $CuCO_3 \rightarrow CuO + CO_2$
$Cu(OH)_2 \rightarrow CuO + H_2O$
1 mark for both equations correct (ignore state symbols) [1]

(b) appropriate quantity (gram or so) (1)
heat in crucible (1)
with a lid, lifted periodically to allow escape of gas (1)
weigh after heating (1)
repeat and re-weigh until constant mass (1) [5 max 4]

(c) hot apparatus – risk of burns [1]

(d) formula masses of $CuCO_3$ (123.5), $Cu(OH)_2$ (97.5) and CuO (79.5) calculated (1)
relative mass loss for $CuCO_3$ (35.6%) and $Cu(OH)_2$ (18.5%) calculated (1)
(% mass loss – % mass loss for $Cu(OH)_2$):(% mass loss – % mass loss for $CuCO_3$) gives ratio $CuCO_3$:$Cu(OH)_2$ (1)
divide by value of $Cu(OH)_2$ to obtain ***x*** (1)
[alternative single-step method involving formula masses in terms of ***x*** (4)] [4]

(e) $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$
$Cu(OH)_2 + 2HCl \rightarrow Cl_2 + 2H_2O$
1 mark for both equations correct (ignore state symbols) [1]

(f) determination of maximum possible of amount of Cu in 1 g of sample
(0.0103 mol $Cu(OH)_2$) (1)
determination of amount of hydrochloric acid to neutralise it
(2:1 ratio, 0.0205 mol, 20.5 cm^3) (1)
volume of hydrocholoric acid corresponding to an excess (over 20.5 cm^3) (1)
[alternative method producing suitable volume (3)]
making the mixture up in a 100 cm^3 volumetric flask so the excess acid
(ideally about 10 cm^3 worth) leads to about a 0.1 mol dm^{-3} solution (1)
titration of <u>aliquots</u> of excess acid solution with sodium hydroxide (1)
mention of suitable indicator and correct solutions in pipette and burette (1) [6]

(g) calculation of moles of acid required to neutralise (0.0174) (1)
calculation of excess acid (1)
calculation of volume of sodium hydroxide solution (1)
[correct answer from alternative method (3)] [3]

[Total: 20]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **9791/03**

Paper 3 Part B Written

SPECIMEN PAPER

2 hours 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 in the spaces provided.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You are advised to show all working in calculations.
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.

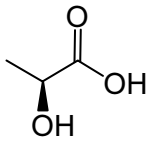
For Examiner's Use	
1	
2	
3	
4	
5	
6	
Total	

This document consists of **16** printed pages.

For Examiner's Use

1 This question is about lactic acid.

Lactic acid (2-hydroxypropanoic acid) is a by-product of metabolizing glucose for energy. The skeletal formula of lactic acid is shown below.



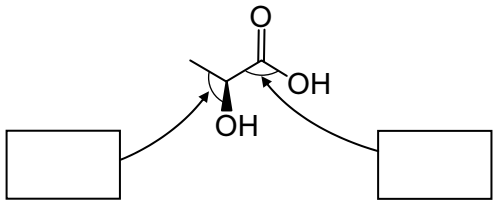
lactic acid

(a) What is the molecular formula of lactic acid?

.....

[1]

(b) In the boxes on the diagram below fill in the approximate bond angles.



[2]

In the laboratory lactic acid can be synthesised from ethanal in two steps.

$$CH_3CHO + HCN \xrightarrow{\text{step 1}} CH_3CH(OH)CN$$
ethanal — 2-hydroxypropanenitrile

$$CH_3CH(OH)CN + 2H_2O + H^+ \xrightarrow{\text{step 2}} CH_3CH(OH)COOH + NH_4^+$$
lactic acid

(c) In step 1 the nucleophilic cyanide attacks the carbonyl carbon of the ethanal.

(i) Define the term *nucleophile*.

.....

.....

[2]

(ii) Draw the mechanism for the reaction between the cyanide ion (CN^-) and ethanal. Include any relevant lone-pairs and dipoles.

[3]

(d) (i) Describe the changes in functional group level in steps 1 and 2.

.....

.....

..... [2]

(ii) What type of reaction is step 2?

..... [1]

(e) (i) In step 1, equal amounts of two optical isomers of 2-hydroxypropanenitrile are formed. Draw the 3-D representations of these two optical isomers, assign priorities to each of the four groups around the central carbon, labelling the highest priority group as **1** and the lowest **4**. Hence assign R and S configurations.

configuration …… configuration ……

[3]

(ii) Explain why equal amounts of these two optical isomers are formed.

.....

.....

..... [2]

[Total: 16]

For Examiner's Use

2 This question is about lead(IV) oxide.

Lead(IV) oxide, PbO_2, may be prepared by the oxidation of metallic lead using concentrated nitric acid and sodium chlorate(I).

The +4 oxidation state of lead is strongly oxidising and hence the purity of a sample of the oxide may be estimated by reacting with excess acidified potassium iodide and titrating the iodine liberated against standard sodium thiosulphate solution.

(a) Lead(IV) oxide was prepared from metallic lead as described above. A 0.496 g sample of this lead(IV) oxide was dissolved in excess acid and potassium iodide and made up to 100 ml in a volumetric flask. 10 ml portions of this solution were titrated against 0.02 M sodium thiosulphate solution.

(i) Write a half-equation for the reduction of lead(IV) oxide to lead(II) in acid solution.

..... [1]

(ii) Suggest why sulphuric acid is used and not hydrochloric acid in this step.

.....

..... [1]

(iii) Write a half-equation for the oxidation of iodide to iodine.

..... [1]

(iv) Hence write an equation for the oxidation of iodide to iodine by lead(IV) oxide in acid solution.

..... [1]

(v) Write the equation for the reaction of sodium thiosulphate with iodine.

..... [1]

(b) From the results of the titration, the amount of lead(IV) oxide in the 0.496 g sample was 0.00198 moles.

Calculate the percentage purity of the sample of lead(IV) oxide.

purity = ... % [2]

(c) Compare the chemistry of lead and carbon and their oxides. You should refer to structure and oxidation states in your answer.

For Examiner's Use

[8]

(d) Suggest why

(i) PbI_4 is unstable,

[1]

(ii) $PbCl_4$ is a liquid but $PbCl_2$ is a solid at room temperature and pressure.

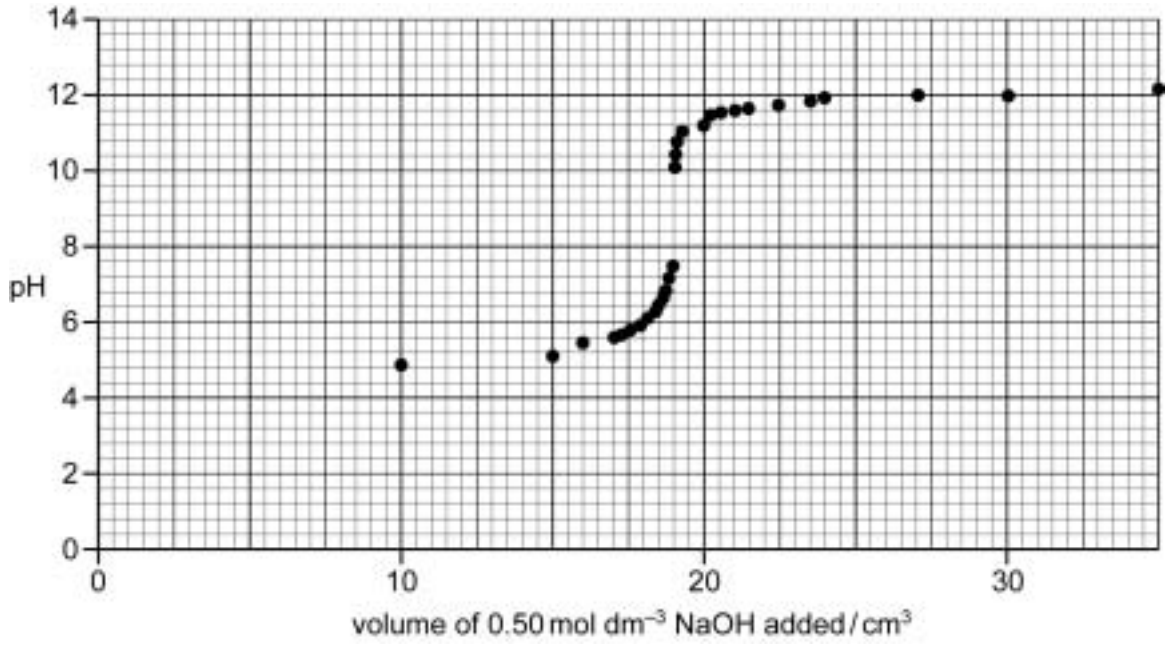
[2]

[Total: 18]

For Examiner's Use

3 This question is about acid–base reactions.

The following results were obtained when a 0.50 mol dm^{-3} solution of NaOH was gradually added to 20.0 cm^3 of a solution of a weak monoprotic acid HA to which a few drops of indicator had been added. The first pH reading was not recorded until after 10 cm^3 of NaOH had been added.



(a) What name is given to the practical procedure described above?

.....

[1]

(b) (i) Draw a line of best fit on the graph above. [1]

(ii) From the graph, what is the volume of NaOH needed to exactly neutralise the acid?

.....

[1]

(iii) Hence calculate the initial concentration of the acid HA.

concentration = ... [2]

(c) (i) Write an expression for the dissociation constant, K_a, of the weak acid HA.

.....

[1]

(ii) Given that K_a for the acid HA is 1.41 x 10^{-5} mol dm^{-3} at the temperature of the experiment, calculate the pH of the original acid solution.

pH = ... [3]

(d) Use your answer from **(c) (ii)** to complete the titration curve from 0.0 to 10.0 cm^3 of NaOH added. [2]

(e) Given the following information about three indicators, choose the indicator most suitable for determining the end-point of this reaction. Give a reason for your choice.

indicator	pH range of colour change
methyl yellow	2.9 – 4.0
bromocresol purple	5.2 – 6.8
cresol red	7.2 – 8.8

indicator chosen .....

reason for choice .....

.....

..... [1]

(f) A buffer solution is formed when half of the original amount of the acid HA(aq) has been neutralised by the base NaOH(aq). Explain how this buffer solution is able to resist change in pH when

(i) a small amount of NaOH(aq) is added,

.....

.....

..... [2]

(ii) a small amount of HC*l*(aq) is added.

.....

.....

..... [2]

(g) Calculate the pH of the buffer solution described in **(f)**.

For Examiner's Use

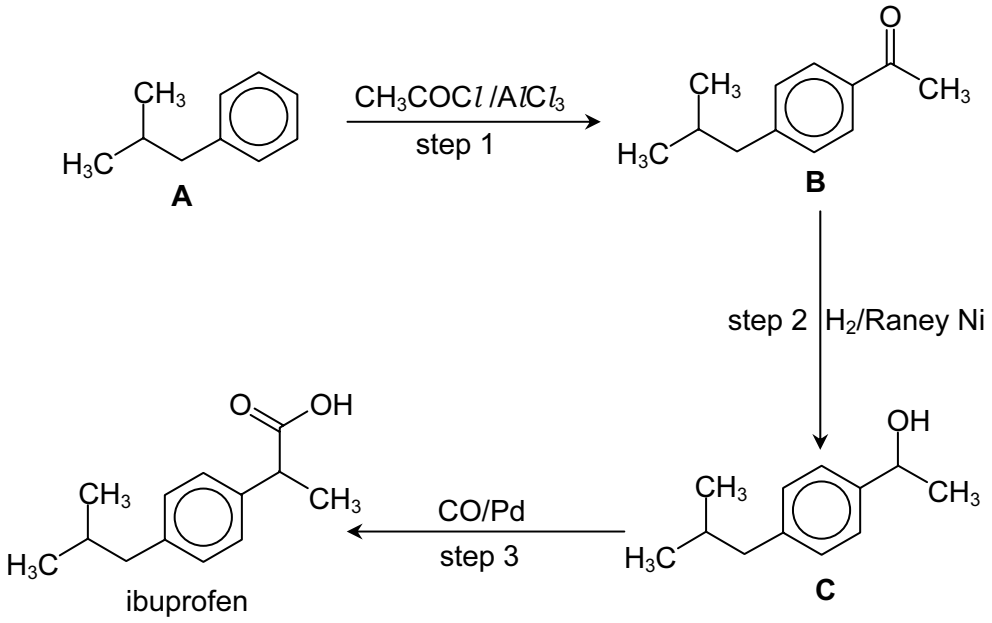
pH = ... [2]

[Total: 18]

4 This question is about the synthesis of ibuprofen.

For Examiner's Use

The reaction sequence below shows the Hoechst process for the manufacture of the painkiller ibuprofen. This process replaced the original Boot process, which required 6 separate steps, as it has much better atom economy.



(a) What name is given to the reaction in step 1?

.....

[2]

(b) What mechanism is involved in step 1?

.....

[2]

(c) (i) Write a balanced equation for step 1, using molecular formulae for compounds **A** and **B**.

.....

[1]

(ii) Use the equation from part **(i)** to calculate the percentage atom economy for the synthesis of **B**.

.....

[3]

(d) Explain the nature of the reaction occurring in step 2, with reference to the concept of functional group level.

For Examiner's Use

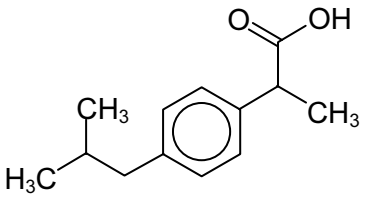
.....

.....

.....

..... [3]

(e) On the structure of ibuprofen shown below, mark the chiral centre with an asterisk (*).



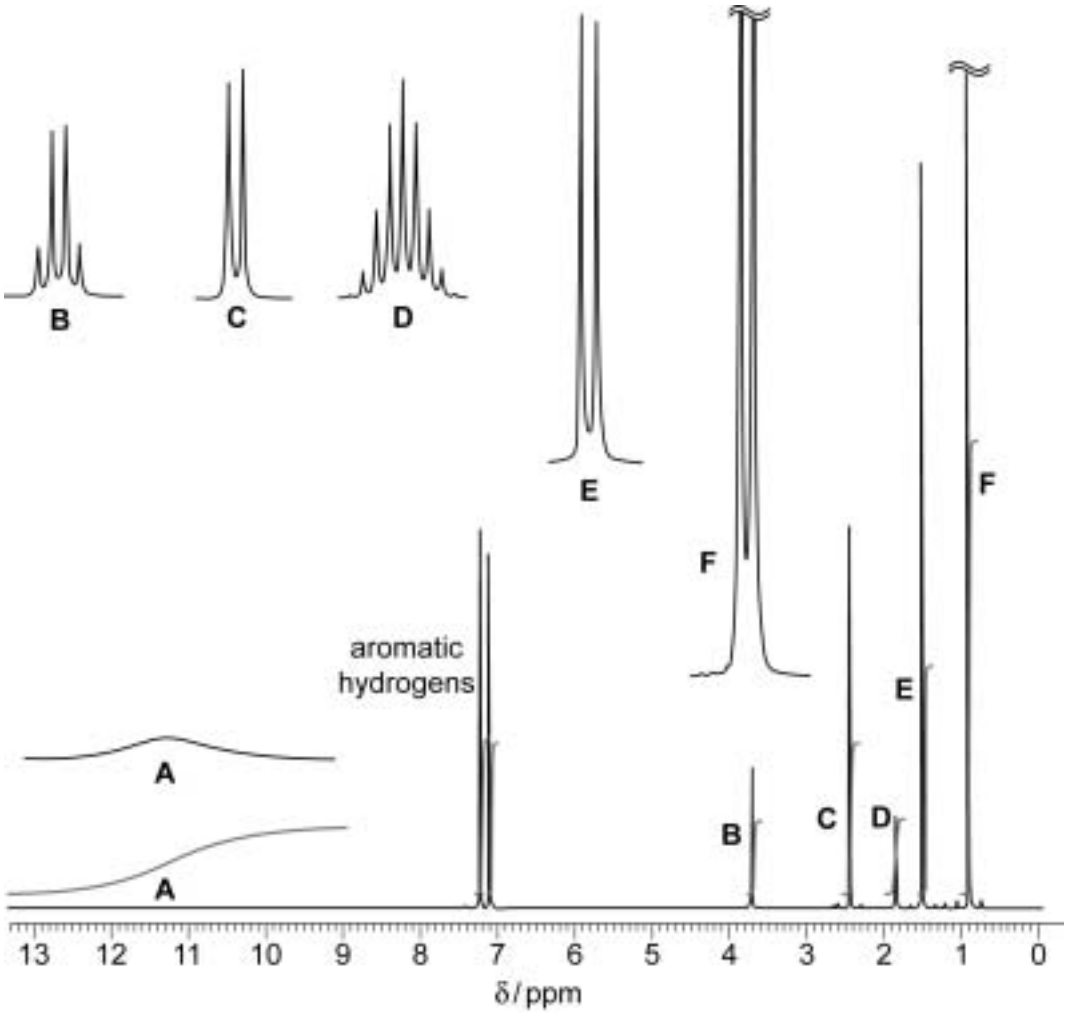
[1]

(f) How many peaks will there be in the ^{13}C NMR spectrum of ibuprofen?

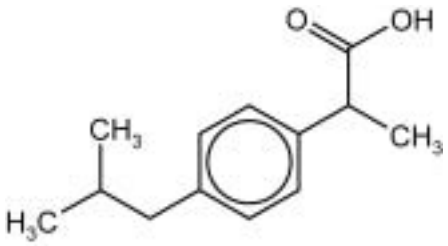
..... [1]

(g) The ^{1}H NMR spectrum for ibuprofen is shown below.

For Examiner's Use



On the structure of ibuprofen below, mark the protons responsible for the peaks **A**, **B**, **C**, **D**, **E** and **F** on the spectrum. The integrals and expansions for each peak are shown on the spectrum.



[6]

[Total: 19]

For Examiner's Use

5 This question is about fluorite.

Fluorite is a commonly occurring mineral with the chemical formula CaF_2.

(a) State the type of chemical bonding in fluorite.

.....

[1]

(b) Draw a dot-cross diagram, using only outer electrons, of calcium fluoride.

[2]

Now that known natural deposits of cryolite are virtually exhausted, fluorite is increasingly being used as the flux in the electrolytic process that extracts aluminium from bauxite.

(c) If molten CaF_2 were electrolysed on its own, state which products would be formed at

(i) the anode, ... [1]

(ii) the cathode. ..... [1]

(d) Suggest briefly why these products are not formed in the electrolytic extraction of aluminium from bauxite (aluminium oxide), despite a large quantity of fluorite being present.

.....

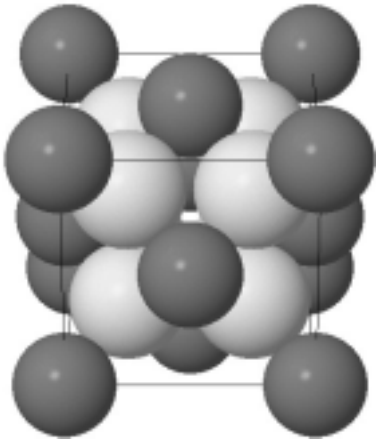
.....

.....

..... [2]

Consider the structure of fluorite shown in the diagram below.

For Examiner's Use



(e) Write down the types of positions in the unit cell occupied by the dark-grey ions.

.....

..... [2]

(f) Work out how many dark-grey ions are within a unit cell. Remember that an ion may be shared between more than one cell.

..... [1]

(g) Using your answer to **(f)** and the atom occupancy of the light-grey ions, deduce the identity of the dark- and light-grey ions.

light-grey ions .....

dark-grey ions .....

[1]

(h) State the coordination number of the light-grey ions and the geometric arrangement of its nearest dark-grey ion neighbours.

coordination number .....

geometry .....

[2]

(i) Suggest the coordination number of the dark-grey ions and the geometric arrangement of its nearest light-grey ion neighbours.

coordination number .....

geometry .....

[2]

[Total: 15]

For Examiner's Use

6 This question is about the hydrolysis of an ester.

Ethyl ethanoate may be hydrolysed by treatment with aqueous sodium hydroxide.

(a) Write an equation for this reaction, using structural formulae.

.....

[1]

The rate equation for the reaction is found to be first order with respect to both the concentration of hydroxide ion and the concentration of the ester.

rate of reaction = k_2 [OH^-] [ester] where k_2 is the second order rate constant

(b) (i) What are the units for concentration?

.....

[1]

(ii) What are the units of the rate of reaction?

.....

[1]

(iii) What are the units of the rate constant k_2?

.....

[1]

During the reaction, the concentrations of both the hydroxide ion and the ester change.

However, if the initial concentration of the ester, $[ester]_0$, is much larger than that of the hydroxide ion, the concentration of the ester remains essentially constant as the hydroxide ion is used up during the reaction. The reaction is then said to follow *pseudo-first order* kinetics.

rate of reaction = k_1 [OH^-]

where k_1 is the pseudo-first order rate constant and $k_1 = k_2$ [ester]

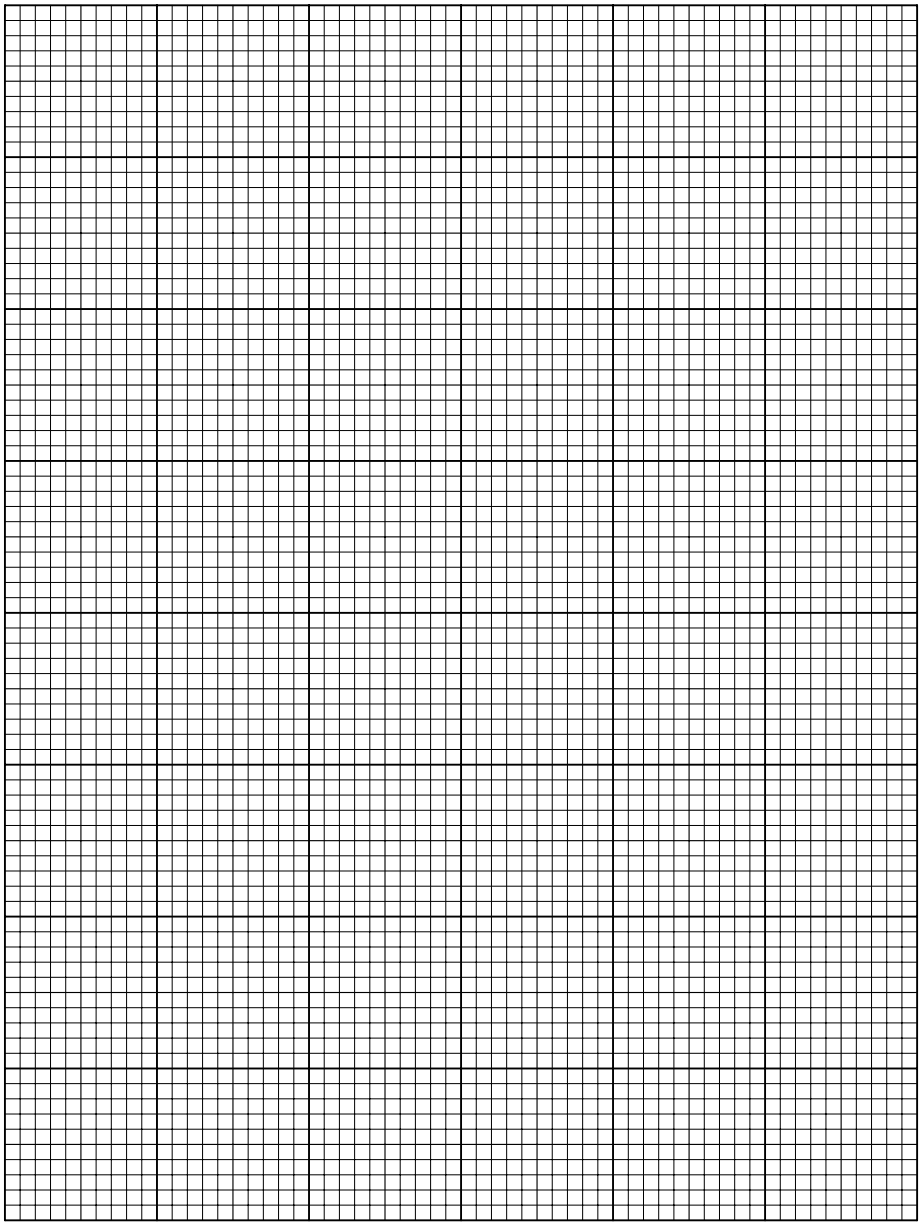
In a typical experiment, 10.0 cm^3 of 0.5 mol dm^{-3} aqueous ethyl ethanoate was added to 10 cm^3 of 0.005 mol dm^{-3} NaOH, all solutions being maintained at 0 °C. The change in concentration of the hydroxide ion over the course of the reaction was followed by monitoring the change in conductivity of the solution. The data obtained is shown in the table.

time, t /s	$[OH^-]_0$ / $[OH^-]_t$	
0	1.00	
100	1.77	
200	3.13	
300	5.53	
400	9.78	
500	17.30	

(c) (i) From the data given in the table, calculate suitable values to enable you to plot a graph to obtain the pseudo-first order rate constant, k_1. Enter your values in the blank column of the table. (A useful equation is provided in the Data Booklet.) [1]

For Examiner's Use

(ii) By plotting a suitable graph on the grid below, determine the pseudo-first order rate constant, k_1.



k_1 = ... [2]

(iii) What is the concentration of ester at time t = 0?

..... [1]

(iv) Hence, calculate the value of the second order rate constant, k_2.

k_2 = ... [1]

For Examiner's Use

(v) How would you expect the gradient of your graph to change if the initial concentration of the ester was doubled?

.....

..... [1]

The first step in the reaction between the hydroxide and ethyl ethanoate forms a single intermediate which then breaks down to form the products.

$$\text{ethyl ethanoate + hydroxide} \xrightarrow{\text{step 1}} \text{intermediate} \xrightarrow{\text{step 2}} \text{products}$$

(d) (i) Suggest a mechanism for the formation of the intermediate.

[1]

(ii) Propose the structure of the intermediate.

[1]

(e) State the molecularity of

(i) step 1, ... [1]

(ii) step 2. ..... [1]

[Total: 14]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CHEMISTRY **9791/03**

Paper 3 Part B Written

SPECIMEN MARK SCHEME

2 hours 15 minutes

MAXIMUM MARK: 100

This document consists of **7** printed pages and **1** blank page.

UNIVERSITY of CAMBRIDGE International Examinations

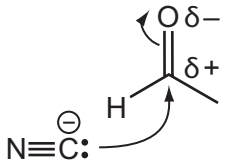
1 Lactic acid

(a) $C_3H_6O_3$ [1]

(b) 109.5° (1) 120° (1) [2]

(c) (i) lone pair/non-bonding pair (1) donor (1) [2]

(ii) curly arrows correct (1) dipoles on carbon and oxygen of carbonyl (1) lone pair on the carbon of the cyanide/nitrile ion (1) [3]



(d) (i) in step 1 the carbonyl carbon changes from aldehyde to alcohol level/level 2 to level 1 (1)
in step 2 the nitrile carbon stays at the carboxylic acid level/level 3/does not change level (1) [2]

(ii) hydrolysis [1]

(e) (i) 3d (wedge/hash) diagrams (1)
showing object and non-superimposable mirror image (1)
R and S consistent with diagrams (1) [3]

(ii) the ethanal molecule is planar about the aldehyde group (1)
the nucleophile has no bias from which side of plane to attack/nucleophile can attack from above or below the plane of the C=O (1) [2]

[Total: 16]

2 Lead(IV) oxide

(a) (i) $PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + 2H_2O$ (ignore state symbols) (1) [1]

(ii) Pb(IV) will oxidise chloride to chlorine / H_2SO_4 is a better reducing agent (1) [1]

(iii) $2I^- \rightarrow I_2 + 2e^-$ / $2I^- - 2e^- \rightarrow I_2$(1) [1]

(iv) $PbO_2 + 4H^+ + 2I^- \rightarrow Pb^{2+} + 2H_2O + I_2$ (ignore state symbols) (1) [1]

(v) $2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$
or $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$ (ignore state symbols) (1) [1]

(b) mass PbO_2 = 0.00198*239 = 0.473 g (1)
purity PbO_2 = 0.473/0.496 = 95.4% (1)
or if 100% PbO_2, 0.496/239 = 0.00208 moles PbO_2 (1)
purity = (0.00198/0.00208) x 100 = 95.4% (1) [2]

(c) lead – metallic (1)
carbon – giant covalent (1)
carbon has allotropes (1)
graphite, diamond, buckminsterfullerenes (1)
both have +4 and +2 oxidation states (1)
+2 oxidation state is more stable in lead (1)
+4 oxidation state is more stable in carbon (1)
carbon has covalent molecular oxides (1)
CO and CO_2 (1)
PbO is ionic (1)
PbO_2 has greater degree of covalency (1)
any 8 to score [8]

(d) (i) Pb^{4+} oxidises I^- (1) [1]

(ii) $PbCl_4$ is simple covalent so intermolecular forces are weak (1)
$PbCl_2$ is giant ionic (1) [2]

[Total: 18]

3 Titration curve/pK_a

(a) titration (**not** neutralisation) [1]

(b) (i) smooth line of best fit drawn [1]

(ii) 18.8 – 19.0 cm^3 [1]

(iii) 0.5 x 18.9 (use value from **(ii)**) = concentration x 20 (or equivalent) (1)
$\therefore$ concentration = (0.5 x 18.9)/20 = 0.47 mol dm^{-3}
value with units (1) [2]

(c) (i) $K_a = \frac{[H^+][A^-]}{[HA]}$ (allow H_3O^+ in place of H^+) [1]

(ii) $[H^+] = \sqrt{(K_a \text{ x acid concentration})} = \sqrt{(1.41 \text{ x } 10^{-5} \text{ x } 0.4725)}$ (1)
(e.c.f. from **(i)** and **(b)(iii)**)

$= 2.58 \text{ x } 10^{-3}$ mol dm^{-3} (1)

$pH = -\log_{10} [H^+] = -\log_{10} 2.58 \text{ x } 10^{-3} = 2.59$ (1) [3]

(d) meets *y*-axis between 2.5 and 2.7 (1)
steeper at start (1) [2]

(e) cresol red because pH range corresponds to rapid pH change of titration/near-vertical part of curve [1]

(f) $HA \rightleftharpoons H^+ + A^-$ ①; $H_2O \rightleftharpoons H^+ + OH^-$ ②

(i) adding OH^- moves eqm ② left so reducing $[H^+]$ (1) so eqm ① moves right in response; replacing H^+ and so maintaining approx constant pH (1)
or ^-OH reacts with H^+ producing H_2O (1) so more acid dissociates to replace H^+ (1) [2]

(ii) adding H^+ moves eqm ① to the left (1) so eqm ② moves right in response, removing H^+ and so maintaining approx constant $[H^+]$ and hence approx constant pH (1)
or H^+ reacts with A^- producing HA (1) so H_2O dissociates to replace H^+ (1) [2]

(g) if half HA neutralised then $[HA] = [A^-]$ so $K_a = [H^+]$ (1)
$\therefore pK_a = pH$ so $pH = -\log_{10} 1.41 \text{ x } 10^{-5} = 4.85$ (1)
(or from half-equivalence point on graph) [2]

[Total: 18]

4 Ibuprofen

(a) Friedel-Crafts (1) acylation (accept ethanoylation) (1) [2]

(b) electrophilic (1) substitution (1) [2]

(c) (i) $C_{10}H_{14} + CH_3COCl \rightarrow C_{12}H_{16}O + HCl$ (allow C_2H_3ClO from ethanoyl chloride) [1]

(ii) atom economy $= \dfrac{M_r \text{ Product}}{\sum M_r \text{ Reactants}}$ (1) (e.c.f. from **(i)**)

$= \dfrac{176}{(134 + 78.5)} \times 100$ (1)

= 82.8% (1)

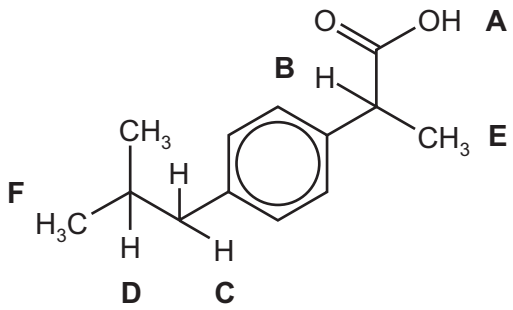
(Correct answer = 3) [3]

(d) reduction (1) **not** hydrolysis
the carbon atom moves down a level (1)
from the aldehyde/ketone level/level 2 to the alcohol level/level 1 (1) [3]

(e) correct chiral centre [1]

(f) 10 [1]

(g)



[6]

[Total: 19]

5 Fluorite

(a) ionic [1]

(b) empty outer shell of calcium and full outer shell of fluoride showing a different type of electron (1)
2^+ charge on Ca, 1^- charge on each F and 2:1 ratio indicated (1) [2]

(c) (i) anode = F_2/fluorine (**not** fluoride, **not** F) [1]

(ii) cathode = Ca/calcium [1]

(d) oxygen less reactive than fluorine **so** formed in preference at the anode (1)
aluminium less reactive than calcium **so** formed in preference at the cathode (1)
or aluminium is more easily discharged than calcium **so** formed at the cathode (1) [2]

(e) corners (1)
centre of faces (1) [2]

(f) 4 [1]

(g) light grey = fluoride/F^-; dark grey = calcium/Ca^+ [1]

(h) CN = 4 (1)
geometry = tetrahedral (accept tetrahedron) (1) [2]

(i) CN = 8 (1)
geometry = cubic (1) [2]

[Total: 15]

6 Ester hydrolysis

(a) $CH_3CH_2COOCH_2CH_3 + NaOH \rightarrow CH_3CH_2COONa + CH_3CH_2OH$ [1]
allow $CH_3CH_2CO_2^-Na^+$

(b) (i) mol dm^{-3} (allow mol/dm^3) [1]

(ii) mol dm^{-3} s^{-1}(allow mol/dm^3/s) [1]

(iii) s^{-1} mol^{-1} dm^3 (any order) (allow dm^3/s/mol) [1]

(c) (i) ln ($[OH^-]_0/[OH^-]_t$) calculated (**not** $\log_{10}$) [1]

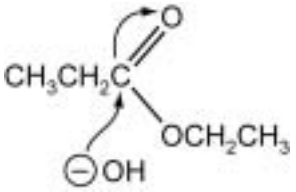
(ii) graph of $\ln[OH]_0/[OH^-]_t$ on *y*-axis against time on *x*-axis, all points correctly plotted with straight line through origin (e.c.f. on **(i)**) (1)
$k_1 = 5.7 \times 10^{-3}$ s^{-1} (1) [2]

(iii) 0.5/2 = 0.25 mol dm^{-3} [1]

(iv) $k_2 = 5.7 \times 10^{-3}$ (answer to **(ii)**)/0.25 (answer to **(iii)**) = 0.0228 s^{-1} mol^{-1} dm^3 [1]

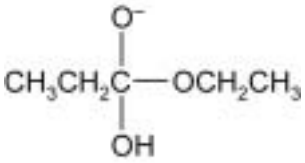
(v) no change/stays the same/same gradient [1]

(d) (i)



[1]

(ii)



[1]

(e) (i) biomolecular (accept 2 or dimolecular) [1]

(ii) unimolecular (accept 1 or monomolecular) [1]

[Total: 14]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **9791/04**

Paper 4 Practical

SPECIMEN PAPER

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen in the spaces provided.
You may use a soft pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You are advised to show all working in calculations.
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.

Session
Laboratory

For Examiner's Use	
1	
2	
Total	

This document consists of **8** printed pages.

1 **FA 1** is 2.00 mol dm^{-3} sodium hydroxide, NaOH.
FA 2 is **approximately** 0.75 mol dm^{-3} sulfuric acid, H_2SO_4.

A student suggests that the concentration of the sulfuric acid can be determined by measuring the temperature of the solution as the acid is added in small amounts to a known volume of **FA 1** in a plastic cup.

The student proposes the following hypothesis.

As the acid is added to the alkali the temperature rise will be directly proportional to the volume of acid added until the end-point of the reaction is reached. Upon further addition of acid there will be a reduction in the temperature of the solution in the cup as the acid added is not reacting and is at a lower temperature than the solution in the plastic cup.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(a) Use the equation for the reaction to estimate the volume of approximately 0.75 mol dm^{-3} H_2SO_4 that will neutralise 25.0 cm^3 of 2.00 mol dm^{-3} NaOH.

[1]

(b) In the experiment you will add **FA 2** from the burette to 25.0 cm^3 of **FA 1** in a plastic cup. You will measure the temperature of the solution after each addition of acid. You will be required to plot a graph of the temperature before and after the end-point in order to determine the end-point accurately and consequently calculate the precise concentration of H_2SO_4 in **FA 2**.

In order to obtain precise information about the end-point of the reaction, you will need to decide

how many additions of H_2SO_4 are to be made,
the volume of acid to be added each time.

number of additions of H_2SO_4 .....

volume of acid added each time ..... [2]

(c) In the space below you should record the results of your experiment, including
the initial temperature of **FA 1** in the plastic cup when no acid has been added,
the total volume of **FA 2** added at each stage of the experiment,
the temperature of the solution in the plastic cup after each addition of acid,
the temperature rise, ΔT.

[ΔT = temperature of the solution after each addition of acid – initial temperature of **FA 1**]

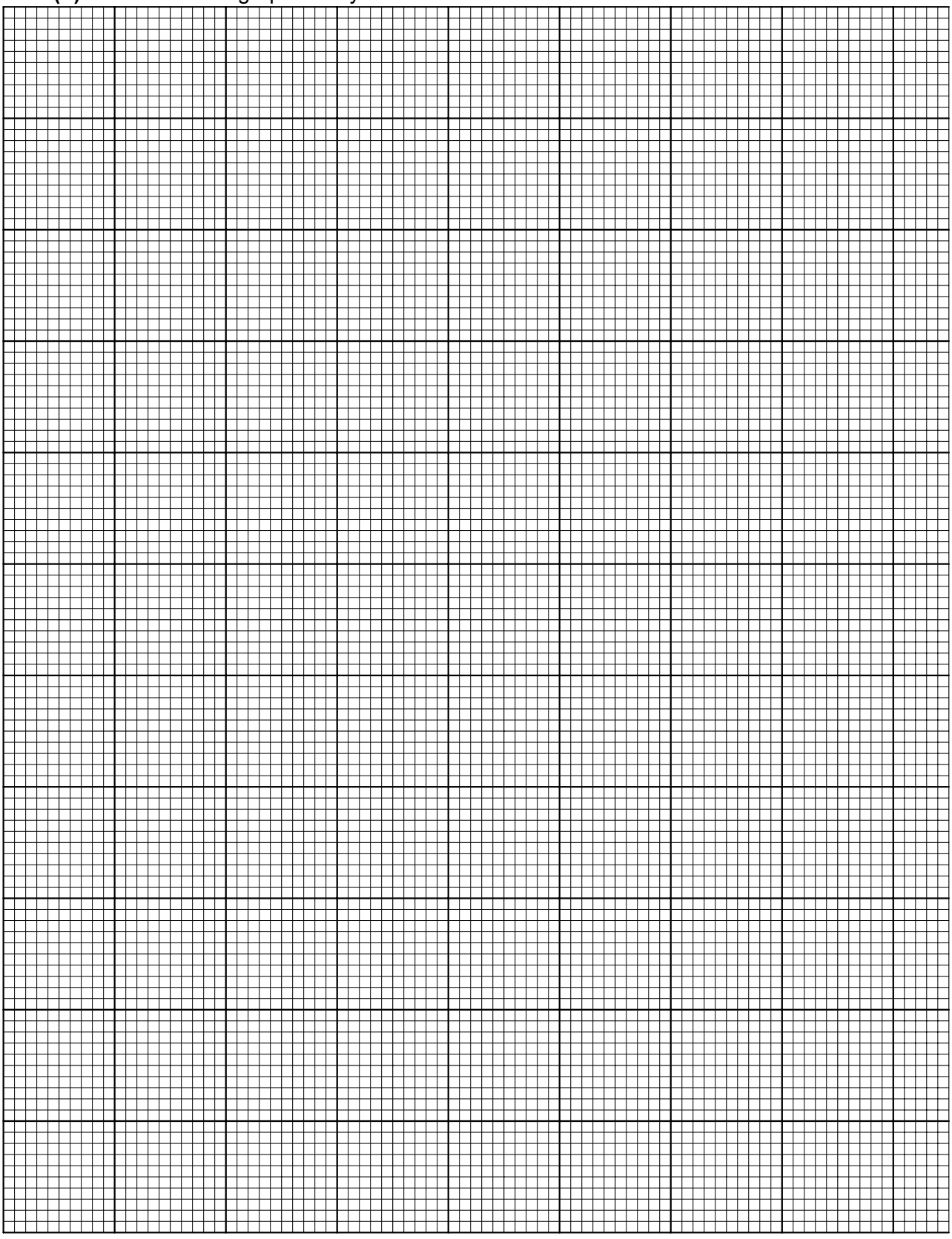
Marks will be awarded for the quality and precision of your practical work and for your recording and presentation of data.

Experimental procedure:
Fill the burette with **FA 2**.
Support the plastic cup in the 250 cm^3 beaker and pipette 25.0 cm^3 of **FA 1** into the plastic cup. Measure and record the steady temperature of **FA 1**.
Run into the cup the first volume of **FA 2** you have selected. Record the highest temperature observed.
Immediately add a second volume of **FA 2** from the burette and repeat the temperature measurement. Continue until you have added all of the planned volume of **FA 2**.

Results

[6]

(d) Plot a suitable graph from your results.



[4]

(e) Use a value obtained from your graph to calculate the exact concentration of H_2SO_4 in **FA 2**. Show all your working and explain the steps in your calculation.

[3]

(f) Explain how the results of your experiment support or do not support each part of the hypothesis proposed by the student.

.....

.....

.....

.....

..... [3]

(g) From the points plotted and the shape of your graph suggest and explain a possible error in the measurements taken in this experiment.

.....

.....

.....

..... [2]

(h) From what you know about the accuracy of your apparatus, calculate the % error in the volume of acid added at the end-point.

[1]

(i) Another student puts forward the hypothesis that the heat energy produced in the reaction, rather than the temperature rise, is proportional to the volume of acid added.

Use one set of data you collected in the experiment to show how the heat energy produced can be calculated.
[The specific heat capacity of the solution is 4.3 J K^{-1} g^{-1}.]

[1]

[Total: 23]

2 Labels have become detached from two bottles of chemicals, each containing a white powder. One of these is believed to be barium iodide and the other a metal nitrate. A solution has been prepared from each of the solids and these solutions are labelled **FA 3** and **FA 4**.

(a) By selecting a suitable reagent from those listed in the reactions of anions in the Data Booklet, you should carry out a test to establish which of the solutions contains the iodide ion.

Record details of the test performed and the observations obtained in the test in the space below.

From this test, solution **FA** ……. contains the iodide ion. [3]

(b) By selecting another suitable reagent, carry out a test on the solution you have chosen, to confirm the presence of the iodide ion.

Record details of the test performed and the observations obtained in the test in the space below. State, with reasons, whether or not this confirms your choice above.

[3]

(c) You are to investigate the reactions of **FA 3** and **FA 4** with the following reagents.

- aqueous sodium hydroxide and aluminium foil
- aqueous ammonia
- dilute sulfuric acid
- aqueous potassium chromate(VI) followed by dilute hydrochloric acid

Record details of the procedures followed, apparatus used, safety precautions taken and your observations, including colour changes seen, the formation of any precipitate and the solubility of any such precipitate in an excess of the reagent added.
Where gases are released they should be identified by an appropriate test which you should describe in your observations.
You should indicate clearly at what stage in a test a change occurs.

Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

Care – use a boiling-tube for any solutions to be heated
Care – solutions containing sodium hydroxide can "bump" when heated and eject the hot alkali from the tube.

Your tests will enable you to

(i) confirm the presence of the nitrate ion in the solution **not** chosen in **(a)**,

(ii) identify and confirm the **cation** in each solution.

test	observations with **FA 3**	observations with **FA 4**

[7]

(d) Explain how your observations identify and confirm the presence of barium ions in the solution that contained the iodide ion.

.....

.....

..... [1]

(e) The observations made with aqueous sodium hydroxide and aqueous ammonia should have indicated either of two possible cations in the other solution.

Identify these cations; explain the observations and explain how other tests carried out eliminate one of these cations, and suggest a further test to eliminate this cation.

.....

.....

.....

.....

..... [2]

(f) Explain how your observations identify the presence of the nitrate ion and confirm that it is the nitrate ion that is present and not the nitrite ion.

.....

.....

..... [1]

[Total: 17]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CHEMISTRY **9791/04**

Paper 4 Practical

SPECIMEN CONFIDENTIAL INSTRUCTIONS

Great care should be taken to ensure that any information given does not reach the candidates either directly or indirectly.

READ THESE INSTRUCTIONS FIRST

1 Access to the examination paper is not permitted before the examination.

Supervisors are asked to carry out any confirmatory tests included in these instructions to ensure the materials supplied are appropriate.

The 'General Apparatus' requirements and the 'Particular Requirements' are printed separately. It is *especially important* that the details on page 4 are kept secure.

2 Supervisors are advised to remind candidates that **all** substances in the examination should be treated with caution. Only those tests described in the question paper should be attempted. Please also see under 'General Apparatus' on the use of pipette fillers and safety goggles.

In accordance with COSHH (Control of Substances Hazardous to Health) Regulations, operative in the UK, a hazard appraisal of the examination has been carried out.

Attention is drawn, in particular, to certain material used in the examination. The following codes are used where relevant.

C = corrosive substance
F = highly flammable substance
H = harmful or irritating substance
O = oxidising substance
T = toxic substance

The Supervisor's attention is drawn to the form on page 7 which must be completed and returned with the scripts.

If you have any problems or queries regarding these instructions, please contact CIE
by e-mail: International@cie.org.uk
by phone: +44 1223 553554
by fax: +44 1223 553558
stating the Centre number, the nature of the query and the syllabus number quoted above.

Safety

The attention of Supervisors is drawn to any local regulations relating to safety and first-aid.
'Hazard Data Sheets', relating to materials used in this examination, should be available from your chemical supplier.

General Apparatus and Materials

1 In addition to the fittings and reagents ordinarily contained in a chemical laboratory, the apparatus and materials specified below will be necessary.

2 Pipette fillers and safety goggles should be used where necessary.

3 It is assumed that common bench reagents and reagents/materials for testing gases listed in the syllabus are available.

[H] 2 mol dm^{-3} hydrochloric acid
[C] 2 mol dm^{-3} nitric acid
[H] 1 mol dm^{-3} sulfuric acid

[C] 2 mol dm^{-3} sodium hydroxide
[H] 2 mol dm^{-3} aqueous ammonia

[T] 0.1 mol dm^{-3} potassium chromate(VI)
wooden splints
red and blue litmus indicator papers
limewater (a saturated solution of calcium hydroxide) and the associated apparatus

For each candidate

1 x plastic cup (expanded polystyrene/foamed plastic)
1 x 250 cm^3 beaker (to support the plastic cup)
1 x 50 cm^3 burette
1 x stand and burette clamp
1 x small funnel for filling burette
1 x 25 cm^3 pipette
1 x pipette filler
1 x thermometer, –10 °C to 110 °C by 1 °C
6 test-tubes
1 boiling-tube
1 x test-tube rack
1 x Bunsen burner
1 x heat proof mat
2 x teat/squeeze pipettes
paper towels
1 x wash bottle of distilled water

Particular Requirements

1 As a possible aid to maintaining security, the descriptions of the particular chemicals required are given under two headings:

(a) overall specifications are given on page 3;

(b) the actual identities are given on page 4.

2 Materials with an **FA** code number should be so labelled for the candidates' benefit, **without** the identities being included on the label – where appropriate, the identity of an **FA** coded chemical is given in the question paper itself.

Chemicals Required

1 The chemicals required per question are described in general terms below.

2 Where quantities are specified for each candidate, they are sufficient for the experiments described in the question paper to be completed.

In preparing materials, the bulk quantity for each substance should be increased by 25% as spare material should be available to cover accidental loss.

More material may be supplied if requested by candidates, without penalty.

3 The additional qualitative analysis reagents needed for Question 2 are identified on page 4.

4 For Question 1

[C]	Solution **FA 1**	50 cm^3
	FA 1 *should be supplied in stoppered bottles or in beakers covered with "cling-film" or "gladwrap".*	
[H]	Solution **FA 2**	70 cm^3

For Question 2

[H]	Solution **FA 3**	30 cm^3
[T]	Solution **FA 4**	30 cm^3

Detailed Identities of Chemicals Required

1 It is *especially important* that great care is taken that the confidential information given below does not reach the candidates either directly or indirectly.

2 The identities of the chemicals with an **FA** code number are as follows.

Question 1

[C] **FA 1** is 2.00 mol dm^{-3} sodium hydroxide, NaOH, containing 80.00 g dm^{-3} of NaOH.
This solution should be kept covered before and after issue to candidates to prevent absorption of carbon dioxide from the atmosphere.

[H] **FA 2** is 0.75 mol dm^{-3} sulfuric acid, H_2SO_4. Prepare this solution by carefully adding 41.0 cm^3 of concentrated (95%) sulfuric acid to distilled water and diluting the resulting solution to 1 dm^3.

The concentration of **FA 1** *should be checked by titrating a 25.0 cm^3 portion of* **FA 2** *against* **FA 1**. *Adjust the concentration of* **FA 2** to give a titre of 18.75 ± 0.20 cm^3.
It is essential that the FA 1 solution is kept securely stoppered until the time of the examination to prevent absorption of carbon dioxide.
It should be issued to candidates just before the start of the examination – see page 3.

Solutions FA 1 and FA 2 should be prepared at least 24 hours before the examination and allowed to stand in the laboratory to equalise their temperature.

[H] **FA 3** is 0.1 mol dm^{-3} aluminium nitrate containing 37.5 g of $Al(NO_3)_3.9H_2O$ in each dm^3 of solution.

[T] **FA 4** contains 0.1 mol dm^{-3} barium chloride **and** 0.1 mol dm^{-3} potassium iodide. Dissolve 24.5 g of $BaCl_2.2H_2O$ **and** 16.6 g of KI in distilled water and make up to 1 dm^3.

3 In addition to those listed on page 2, the qualitative analysis reagents specifically required are set out below. If necessary, they may be made available from a communal supply: however, the attention of the Invigilators should be drawn to the fact that such an arrangement may enhance the opportunity for malpractice between candidates.

aluminium foil

[C] 0.05 mol dm^{-3} silver nitrate, $AgNO_3$, 8.5 g dm^{-3}

[T] 0.10 mol dm^{-3} lead(II) nitrate, $Pb(NO_3)_2$, 33.0 g dm^{-3}

COLOUR-BLINDNESS

With regard to colour-blindness – a minor handicap, relatively common in males – it is permissible to advise candidates who request assistance on colours of, for example, precipitates and solutions (especially titration end-points). Please include with the scripts a note of the index numbers of such candidates.

Experience suggests that candidates who are red/green colour-blind – the most common form – do not generally have significant difficulty. Reporting such cases with the scripts removes the need for a 'Special Consideration' application for this handicap.

Accuracy of Solutions

1 All the solutions are to be labelled as shown and they should be bulked and mixed thoroughly before use to ensure uniformity.

2 Every effort should be made to keep the concentrations accurate to within one part in two hundred of those specified.

3 If the concentrations differ slightly from those specified, the Examiners will make the necessary allowance. They should be informed of the exact concentrations.

4 It should also be noted that descriptions of solutions given in the question paper may not correspond exactly with the specification in these Instructions. **The candidates must assume the descriptions given in the question paper**.

5 In view of the difficulty of the preparation of large quantities of solution of uniform concentration, it is recommended that the maximum number of candidates per group be 30 and that separate supplies of solutions be prepared for each group.

Responsibilities of the Supervisor

(i) The Supervisor, or other competent chemist **must carry out the experiments in question 1** and complete the table of readings on a spare copy of the question paper which should be labelled 'Supervisor's Results'.

This should be done for:
each session held and each laboratory used in that session, and
each set of solutions supplied.

N.B. The question paper cover requests the candidate to fill in details of the examination session and the laboratory used for the examination.

It is essential that each packet of scripts contains a copy of the applicable Supervisor's Results as the candidates' work cannot be assessed accurately without such information.

(ii) The Supervisor must complete the Report Form on page 7 to show which candidates attended each session. If all candidates took the examination in one session, please indicate this on the Report Form. A copy of the Report Form must accompany each copy of the Supervisor's Results in order for the candidates' work to be assessed accurately.

(iii) The Supervisor must give details on page 8 of any particular difficulties experienced by a candidate, especially if the Examiner would be unable to discover this from the written answers.

Each envelope returned to Cambridge must contain the following items.

1 The scripts of those candidates specified on the bar code label provided.

2 A copy of the Supervisor's Report relevant to the candidates in **1**.

3 A copy of the Report Form, including details of any difficulties experienced by candidates (see pages 7 and 8).

4 The Attendance Register.

5 **A Seating Plan for each session/laboratory**.

Failure to provide appropriate documentation in each envelope may cause candidates to be penalised.

9791/04

REPORT FORM

This form must be completed and sent to the Examiner in the envelope with the scripts.

Centre Number …… Name of Centre ……

1 Supervisor's Results

Please submit details of the readings obtained in **Question 1** on a spare copy of the question paper clearly marked 'Supervisor's Results' **and showing the Centre number and appropriate session/laboratory number**.

2 The index numbers of candidates attending each session were:

First Session	*Second Session*

3 The Supervisor is required to give details overleaf of any difficulties experienced by particular candidates, giving names and index numbers. These should include reference to:

(a) any general difficulties encountered in making preparation;

(b) difficulties due to faulty apparatus or materials;

(c) accidents with apparatus or materials;

(d) assistance with respect to colour-blindness.

Other cases of hardship, e.g. illness, temporary disability, should be reported direct to CIE on the normal 'Application for Special Consideration' form.

4 A plan of work benches, giving details by index numbers of the places occupied by the candidates for each experiment for each session, must be enclosed with the scripts.

Report on any difficulties experienced by candidates.

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CHEMISTRY **9791/04**

Paper 4 Practical

SPECIMEN MARK SCHEME

2 hours

MAXIMUM MARK: 40

This document consists of **6** printed pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

Skill	Total marks	Breakdown of marks		Qu. 1	Qu. 2
Manipulation, measurement and observation	17 marks	Successful collection of data and observations	9 marks	2	7
		Quality of measurements or observations	3 marks	3	0
		Decisions relating to measurements or observations	5 marks	2	3
Presentation of data and observations	9 marks	Recording data and observations	2 marks	1	1
		Display of calculation and reasoning	3 marks	3	0
		Data layout	4 marks	4	0
Analysis, conclusions and evaluation	14 marks	Interpretation of data or observations and identifying sources of error	8 marks	5	3
		Drawing conclusions	5 marks	3	2
		Suggesting improvements	1 mark	0	1

MMO = manipulation, measurement and observation
collection = successful collection of data and observations
quality = quality of measurements or observations
decisions = decisions relating to measurements or observations
PDO = presentation of data and observations
recording = recording data and observations
display = display of calculation and reasoning
layout = data layout
ACE = analysis, conclusions and evaluation
interpretation = interpretation of data or observations and identifying sources of error
conclusions = drawing conclusions
improvements = suggesting improvements

Question		Sections	Learning outcomes	Indicative material	mark
1	**(a)**	PDO display	• show their working in calculations, and the key steps in their reasoning	correct working for volume of H_2SO_4	1
	(b)	MMO decisions	• decide how many tests or observations to perform	appropriate volume of acid added each time (between 2 and 4 cm^3) volumes spanning a sufficient range each side of calculated end-point (between 20 and 30 cm^3 below end-point and 10 and 20 cm^3 above end-point)	1 1
	(c)	PDO recording	• use column headings that include both the quantity and the unit and that conform to accepted scientific conventions	volume, temperature and ΔT columns correctly labelled	1
		MMO collection	• making measurements using burettes and thermometers	all volumes recorded to 0.05 cm^3 all temperatures recorded to 0.5 °C	1 1
		MMO quality	• make and record sufficient, accurate measurements	volume at which max temp rise recorded within 5 cm^3 of Supervisor ΔT for highest temp within 1 °C of that obtained by Supervisor (1 of these two marks if in range +1 °C to 3 °C)	1 2
	(d)	PDO layout	• plot appropriate variables on clearly labelled *x*- and *y*- axes	ΔT plotted on *y*-axis and volume of acid on *x*-axis, correctly labelled including units	1
			• choose suitable scales for graph axes	suitable scales selected	1
			• plot all points to an appropriate accuracy	points plotted as fine cross or encircled dot within ½ small square in either direction	1
			• follow the ASE recommendations for putting lines on graphs	two smooth intersecting curves drawn	1

	(e)	ACE interpretation	• find an unknown value by using intercept on a graph	reading the volume of H_2SO_4 at the end-point from the intersect of the graph	1
		PDO display	• show working in calculations, and the key steps in reasoning	shows working and explains the steps in the calculation	1
			• use the correct number of significant figures for calculated quantities	calculates concentration to same sf as titre/volume information recorded	1
	(f)	ACE conclusions	• draw conclusions from an experiment, giving an outline description of the main features of the data, considering whether experimental data supports a given hypothesis.	first part of hypothesis not supported as the graph is not a straight line (hypothesis supported is acceptable if the graph **is** a straight line)	1
				shape of graph described	1
				second part of hypothesis is supported as temperature falls after the end-point	1
	(g)	ACE interpretation	• identify the most significant sources of error in an experiment	comments on the closer spacing of temperatures at higher values or curve with decreasing gradient	1
				explains that heat loss is greater/more rapid at higher temperatures	1
	(h)	ACE interpretation	• estimate, quantitatively, the uncertainty in quantitative measurements; express such uncertainty as an actual or percentage error	calculates 0.05 or 0.10 as a % of the end-point volume	1
	(i)	ACE interpretation	• make other appropriate calculations	calculates (total volume x ΔT x 4.3)	1
					Total: 23

2	**(a)**	MMO decisions	• selecting a suitable reagent	use of $Pb(NO_3)_2$ or $AgNO_3/NH_3(aq)$ as reagent	1
		MMO collection	• use apparatus to collect an appropriate quantity of data or observations, including subtle differences in colour, solubility or quantity of materials	records appropriate observation for selected reagent	1
		ACE conclusions	• draw conclusions from interpretations of observations	draws a conclusion appropriate to the observations in **(a)**	1
	(b)	MMO decisions	• selecting a suitable reagent	use of $Pb(NO_3)_2$ or $AgNO_3/NH_3(aq)$ as reagent;	1
		MMO collection	• use apparatus to collect an appropriate quantity of data or observations, including subtle differences in colour, solubility or quantity of materials	records appropriate observation for selected reagent	1
		ACE conclusions	• draw conclusions from interpretations of observations	draws a conclusion appropriate to the observations in **(b)**	1

	(c)	MMO collection	• follow instructions given in the form of written instructions	all tests attempted and procedures recorded	1
			• takes appropriate safety precautions	uses a boiling-tube for heating	1
			• use apparatus to collect an appropriate quantity of data or observations, including subtle differences in colour, solubility or quantity of materials	initial precipitates correctly recorded and described 2 marks for four precipitates 1 mark for three precipitates	2
				solubility of precipitates in excess $NaOH/NH_3$ correctly described	1
		MMO decisions	• identify where confirmatory tests are appropriate and the nature of such tests	appropriate test for ammonia gas recorded	1
		PDO recording	• record observations to the same level of detail	consistent standard in recording observations i.e. all precipitates and their solubilities in excess recorded	1
	(d)	ACE interpretation	• describes and summarises the key points of a set of observations	explains how the observations identify and confirm the presence of Ba^{2+}	1
	(e)	ACE interpretation	• describes and summarises the key points of a set of observations	explains how the reaction with sodium hydroxide and ammonia identifies Al^{3+} or Pb^{2+} as the unknown cation **and** explains which tests eliminate Pb^{2+}	1
		ACE improvements	• suggest ways in which to extend the investigation	suggests halide test to eliminate Pb^{2+}	1
	(f)	ACE interpretation	• describes and summarises the key points of a set of observations	suggests dilute acid to liberate NO	1
					Total: 17

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