National
Qualifications
SPECIMEN ONLY

S813/77/02

Chemistry
Section 1 — Questions

Date — Not applicable

Duration — 2 hours 30 minutes

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet S813/77/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

You must leave your answer booklet on your desk; if you do not, you could lose all the marks for this paper.

S8137702

Qualifications Scotland
Teisteanasan Alba

SECTION 1 — 25 marks

Attempt ALL questions

1. The energy associated with a photon of electromagnetic radiation is

A independent of the frequency

B proportional to the frequency

C inversely proportional to the frequency

D proportional to the square of the frequency.

2. An element X forms an ion, X^{3+}, which contains 55 electrons.
In which block of the periodic table would element X be found?

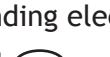
A s

B p

C d

D f

3. The following diagram represents a square-planar structure.

Where  and  represent bonding electron pairs
and  represents a non-bonding electron pair (lone pair).

Which of the following species could have the structure shown above?

A SF_4

B NH_4^+

C XeF_4

D AlH_4^-

4. The reaction

$$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$$

has an equilibrium constant of 3.9 at 950 °C.

The equilibrium concentrations of CO(g), $H_2(g)$ and $H_2O(g)$ at 950 °C are given in the table.

Substance	Equilibrium concentration (mol l^{-1})
CO(g)	5.0×10^{-2}
$H_2(g)$	1.0×10^{-2}
$H_2O(g)$	4.0×10^{-3}

What is the equilibrium concentration of $CH_4(g)$, in mol l^{-1}, at 950 °C?

A 4.9×10^{-1}

B 3.1×10^{-5}

C 4.9×10^{-5}

D 2.0×10^{-7}

5. Which of the following decreases when an aqueous solution of ethanoic acid is diluted?

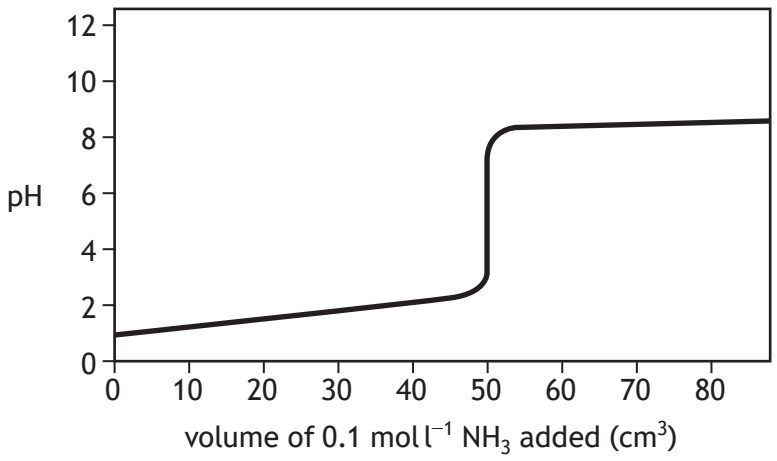
A pH

B $[H^+]$

C pK_a

D K_a

6. The graph below shows the pH changes when 0.1 mol l^{-1} ammonia solution is added to 50 cm^3 of 0.1 mol l^{-1} hydrochloric acid solution.



Which of the following indicators is not suitable for use in determining the equivalence point of the above reaction?

A Phenolphthalein

B Methyl orange

C Bromothymol blue

D Bromocresol purple

7. Which of the following statements is not true?

A 0.1 mol l^{-1} hydrochloric acid has a hydrogen ion concentration of 0.1 mol l^{-1}.

B 20.0 cm^3 of 0.1 mol l^{-1} sodium hydroxide is exactly neutralised by 20.0 cm^3 of 0.1 mol l^{-1} ethanoic acid.

C The pH of 0.1 mol l^{-1} hydrochloric acid is lower than that of 0.1 mol l^{-1} ethanoic acid.

D The K_a value for ethanoic acid is greater than that of hydrochloric acid.

8. The standard enthalpy of formation of strontium chloride is the enthalpy change for

A $Sr(s) + 2Cl(g) \rightarrow SrCl_2(s)$

B $Sr(s) + Cl_2(g) \rightarrow SrCl_2(s)$

C $Sr^{2+}(g) + 2Cl^-(g) \rightarrow SrCl_2(s)$

D $Sr^{2+}(aq) + 2Cl^-(aq) \rightarrow SrCl_2(s)$

9. Which of the following alcohols would have the greatest entropy at 90 °C?

A Propan-1-ol

B Butan-1-ol

C Propan-2-ol

D Butan-2-ol

10. For any liquid, $\Delta S_{\text{vaporisation}} = \dfrac{\Delta H_{\text{vaporisation}}}{T_{\text{b}}}$

where T_{b} is the boiling point of that liquid.

For many liquids, $\Delta S_{\text{vaporisation}} = 88\ \text{J K}^{-1}\ \text{mol}^{-1}$.

Assuming this value is true for water and its $\Delta H_{\text{vaporisation}} = 40.6\ \text{kJ mol}^{-1}$, then the boiling point of water is calculated as

A 461 K

B 373 K

C 2.17 K

D 0.46 K

11. The order of a reactant in a reaction

A can only be obtained by experiment

B determines the speed of the overall reaction

C is determined by the stoichiometry involved

D is the sequence of steps in the reaction mechanism.

[Turn over

12. A suggested mechanism for the reaction

$2X + Y \rightarrow X_2Y$

is a two-step process

$X + Y \rightarrow XY$ (slow)

$XY + X \rightarrow X_2Y$ (fast)

Which of the following rate equations is consistent with this mechanism?

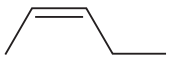
A Rate = $k[XY]$

B Rate = $k[X][Y]$

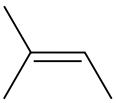
C Rate = $k[X]^2[Y]$

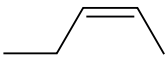
D Rate = $k[X][XY]$

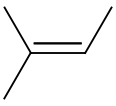
13.

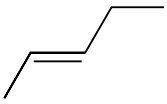


The trans isomer of the molecule represented above is

A 

B 

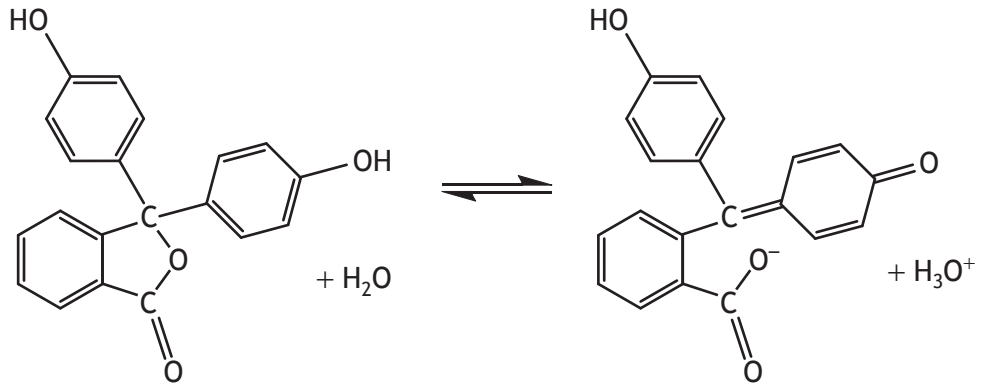
C 

D 

14. Which line in the table is correct for a molecule of ethyne?

	Hybridisation	Number of σ bonds	Number of π bonds
A	sp^2	2	3
B	sp^2	3	2
C	sp	2	3
D	sp	3	2

15.



colourless pink

Which line of the table is correct for the colourless form of the indicator solution above?

	Degree of conjugation	Explanation of colour
A	less than pink form	absorbs UV
B	more than pink form	emits UV
C	more than pink form	absorbs blue-green
D	less than pink form	no light absorbed

16. Which of the following has nucleophilic properties?

A Na

B Br^+

C CH_3^+

D NH_3

17. Which of the following compounds will react with both dilute hydrochloric acid and sodium hydroxide solution?

A C_6H_5OH

B $C_6H_5NH_2$

C HOC_6H_4COOH

D $H_2NC_6H_4COOH$

18. Which of the following is a tertiary haloalkane?

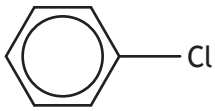
A $CHCl_3$

B $(CH_3)_3CCl$

C $(CH_2Cl)_3CH$

D $(CH_3)_3CCH_2Cl$

19.

Molecule	Structure
P	
Q	$CH_2{=}CHCl$
R	$CH_2{=}CHCH_2Cl$

Which of the above molecules is/are planar?

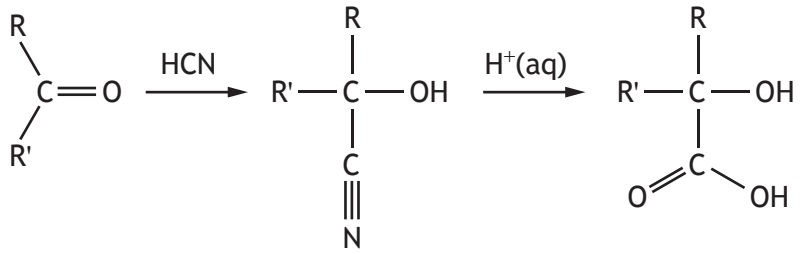
A P only

B Q and R only

C P and Q only

D P, Q and R

20. Carbonyl groups in aldehydes and ketones react with HCN and the product can then be hydrolysed forming a 2-hydroxycarboxylic acid as shown.



When the final product is 2-hydroxy-2-methylbutanoic acid, the starting carbonyl compound is

A butanal

B butanone

C propanol

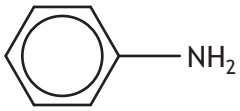
D propanone.

21. Which of the following amines shows no infrared absorption between 3300 cm^{-1} and 3500 cm^{-1}?

A $(CH_3)_3N$

B CH_3NHCH_3

C $H_2NCH_2NH_2$

D 

22. Sirolimus is a drug used in organ transplants. It works by binding to an enzyme and stopping the patient's immune system from rejecting the transplanted organ.

Sirolimus is acting as

A an agonist

B an antagonist

C an inhibitor

D a receptor.

[Turn over

23. What volume of 0.2 mol l^{-1} potassium sulfate is required to make, by dilution with water, one litre of a solution with a potassium ion concentration of 0.1 mol l^{-1}?

A 500 cm^3

B 400 cm^3

C 250 cm^3

D 100 cm^3

24. In which of the following changes would heating to constant mass allow the mass of water produced to be determined?

A $CH_3CH_2OH(\ell) \rightarrow C_2H_4(g) + H_2O(\ell)$

B $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell)$

C $KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(\ell)$

D $Na_2CO_3.10H_2O(s) \rightarrow Na_2CO_3(s) + 10H_2O(\ell)$

25. Which of the following reagents would be most suitable for the gravimetric determination of magnesium ions in water?

A Sodium nitrate

B Silver(I) nitrate

C Sodium carbonate

D Silver(I) carbonate

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET.]

FOR OFFICIAL USE

National Qualifications SPECIMEN ONLY

Mark

S813/77/01

Chemistry
Section 1 — Answer grid and Section 2

Date — Not applicable

Duration — 2 hours 30 minutes

S8137701

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day Month Year

Scottish candidate number

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

Total marks — 100

SECTION 1 — 25 marks

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 — 75 marks

Attempt ALL questions.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Do not remove any exam materials. You must leave this booklet on your desk; if you do not, you could lose all the marks for this paper.

Qualifications Scotland
Teisteanasan Alba

S8137701 01

SECTION 1 — 25 marks

The questions for Section 1 are contained in the question paper S813/77/02.

Read these and record your answers on the answer grid on *page 03*.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample question

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

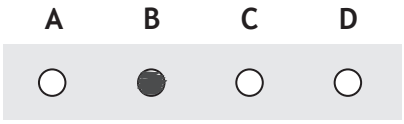
A fractional distillation

B chromatography

C fractional crystallisation

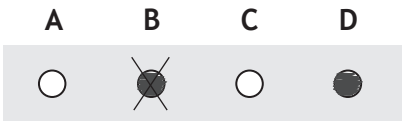
D filtration.

The correct answer is **B** — chromatography. The answer **B** bubble has been clearly filled in (see below).

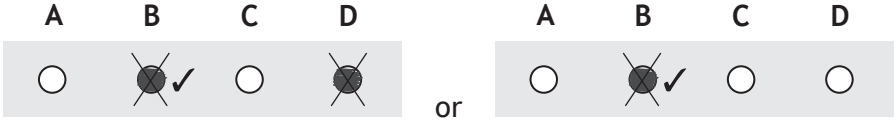


Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



or

SECTION 1 — Answer grid

0BJ25AD1

	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○
16	○	○	○	○
17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○
21	○	○	○	○
22	○	○	○	○
23	○	○	○	○
24	○	○	○	○
25	○	○	○	○

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

SECTION 2 — 75 marks

Attempt ALL questions

MARKS | DO NOT WRITE IN THIS MARGIN

1. In 2002, astronomers observed a flash of light 10 000 times brighter than normal. Its electromagnetic spectrum revealed an intense crimson line with a wavelength of 671 nm.

(a) Identify an element that could be responsible for this intense crimson line in the emission spectrum. **1**

(b) Explain how the line of crimson light is produced. **1**

(c) Calculate the energy, in kJ mol^{-1}, associated with a wavelength of 671 nm. **2**

2. Most commercial bleaches contain hypochlorous acid. This acid dissociates as follows

$$HClO(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + ClO^-(aq)$$

(a) Complete the table to identify one of the acid-conjugate base pairs. **1**

Acid	
Conjugate base	

(b) Write the expression for the dissociation constant, K_a, for hypochlorous acid. **1**

(c) A solution of hypochlorous acid was titrated with sodium hydroxide solution.

The solution at the end point was alkaline.

Explain fully why the solution was alkaline at the end point. **2**

3. Manganese oxide, MnO_2, was used 30 000 years ago as a black pigment in cave paintings.

(a) (i) State the oxidation number of manganese in MnO_2. **1**

(ii) Using orbital box notation, write the electronic configuration for a manganese ion in MnO_2. **1**

(iii) Every electron in a manganese ion can be represented by a unique set of four quantum numbers.

One of these electrons can be represented by the quantum numbers $2,1,0,+\frac{1}{2}$.

(A) Draw the shape of an orbital containing this electron. **1**

(B) Write a set of four quantum numbers for an electron degenerate to the one represented by the quantum numbers $2,1,0,+\frac{1}{2}$. **1**

3. (continued)

(b) Small amounts of manganese are added to the aluminium used for drinks cans to improve their corrosion resistance.

The manganese in aluminium can be converted to an aqueous solution containing purple permanganate ions, $MnO_4^-(aq)$. The concentration of permanganate ions in this solution can be determined by colorimetry.

(i) A calibration graph is prepared using absorbance values from a series of different concentrations of standard solutions of permanganate ions. Prior to recording any absorbance values the colorimeter is switched on for around 5 minutes.

Suggest another two steps that must be carried out to set up the colorimeter before recording the absorbance value of any of the solutions. **1**

(ii) A student measured the absorbance of the sample solution. The absorbance reading gave a concentration of $MnO_4^-(aq)$ higher than any of the standard solutions used to prepare the calibration graph.

Suggest what should be done to determine the most accurate value for the concentration of $MnO_4^-(aq)$ in the sample solution. **1**

3. (b) (continued)

(iii) Manganese can have different oxidation states in different species. The table shows the colours of some of these species.

Species	Colour
Mn^{2+}	colourless
MnO_2	black
MnO_4^-	purple

Using your knowledge of chemistry, discuss the relationship between oxidation state and colour in these species of manganese. **3**

4. A student was investigating the percentage calcium carbonate content of an eggshell.

0.390 g of ground eggshell was placed in a beaker containing 20.0 cm^3 of 1.00 mol l^{-1} hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$$

Once the reaction was complete, the solution was quantitatively transferred to a 100 cm^3 standard flask and made up to the mark with distilled water.

10.0 cm^3 samples of the solution were titrated with 0.100 mol l^{-1} sodium hydroxide solution. The average titre was 11.65 cm^3.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(\ell)$$

(a) Calculate the number of moles of hydrochloric acid left unreacted in the standard flask. **1**

(b) Using the results obtained by the student, calculate the percentage, by mass, of calcium carbonate present in the eggshell. **3**

(c) This procedure gave a mass of calcium carbonate that was greater than expected.

Suggest a reason for this and describe an improvement that should be made to the procedure to give a mass closer to the expected value. **2**

5. The entropy, S, of a system is a measure of the degree of disorder of the system.

The standard entropy values, $S°$, for some substances at 298 K are listed in the table.

Substance	$S°$ (J K^{-1} mol^{-1})
$UO_2(s)$	77
$HF(g)$	174
$UF_4(s)$	152
$H_2O(g)$	189
$H_2O(\ell)$	70
$CCl_4(g)$	310
$CCl_4(\ell)$	216

One of the reactions in the production of nuclear fuel from uranium oxide is

$$UO_2(s) + 4HF(g) \rightarrow UF_4(s) + 2H_2O(g) \quad \Delta H° = -244 \text{ kJ mol}^{-1}$$

(a) Calculate the entropy change, $\Delta S°$, in J K^{-1} mol^{-1}, at 298 K for this reaction. **1**

(b) Determine, by calculation, whether this reaction is feasible at 298 K. **2**

(*Clearly show your working for the calculation.*)

6. At 1000 °C, nitrogen monoxide can combine with hydrogen.

$$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

The initial rate of this reaction was determined at different concentrations of NO(g) and $H_2(g)$. The results are shown in the table.

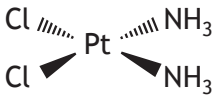
Experiment	[NO(g)] (mol l^{-1})	[H_2(g)] (mol l^{-1})	Initial rate (mol l^{-1} s^{-1})
1	4.00×10^{-3}	1.00×10^{-3}	1.20×10^{-5}
2	8.00×10^{-3}	1.00×10^{-3}	4.80×10^{-5}
3	8.00×10^{-3}	4.00×10^{-3}	1.92×10^{-4}

(a) The reaction was found to be second order with respect to NO(g).
Determine the order of the reaction with respect to $H_2(g)$. **1**

(b) Write the overall rate equation for the reaction. **1**

(c) Calculate the value for the rate constant, *k*, including the appropriate units. **2**

7. Cisplatin was the first member of a class of platinum-containing anti-cancer drugs.



cisplatin

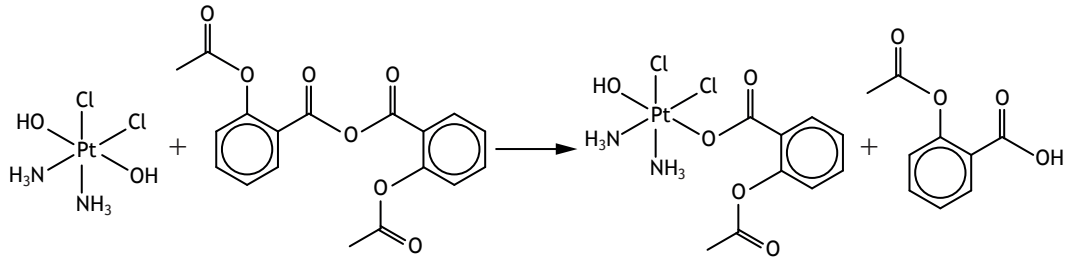
Clinical use of the drug is now limited since cancer cells can develop resistance to it.

(a) Cisplatin is the common name for this complex.

State the IUPAC name for this complex. **1**

(b) A new drug being trialled, asplatin, may be capable of overcoming drug resistance in cancer cells.

Asplatin is synthesised by reacting oxoplatin with acetylsalicylic anhydride.



oxoplatin
$GFM = 334.1$ g

acetylsalicylic anhydride
$GFM = 342$ g

asplatin
$GFM = 496.1$ g

aspirin
$GFM = 180$ g

During a trial synthesis, 5.00 g of oxoplatin was reacted with excess acetylsalicylic anhydride to produce 6.36 g of asplatin.

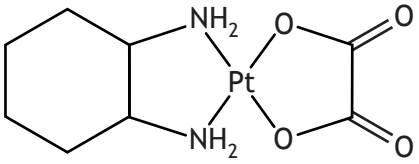
Calculate the percentage yield. **2**

[Turn over

7. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(c) Another platinum based anti-cancer drug, oxaliplatin, is shown.



oxaliplatin

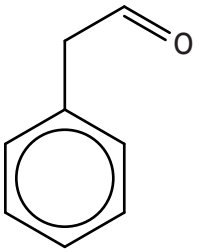
(i) State the coordination number of platinum in oxaliplatin. **1**

(ii) The ligands in oxaliplatin bind to the platinum ion by dative covalent bonds.

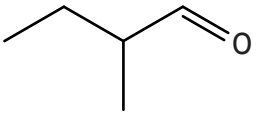
State what feature of ligands allows dative covalent bonds to form. **1**

8. Chocolate contains more than 600 chemical compounds.

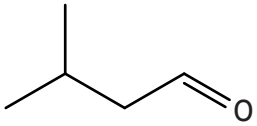
(a) Phenylethanal, 2-methylbutanal and 3-methylbutanal are three of the compounds responsible for the distinctive smell of chocolate.



phenylethanal



2-methylbutanal

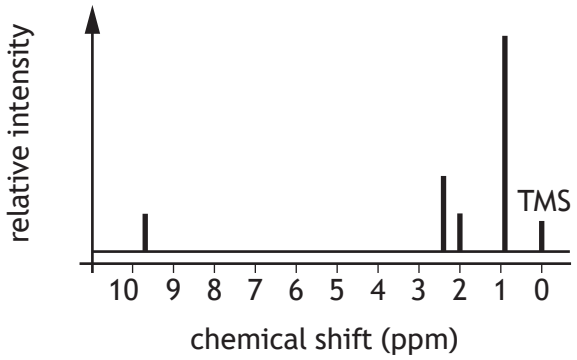


3-methylbutanal

(i) State which one of these compounds has optical isomers. **1**

(ii) Describe how separate samples of two enantiomers could be distinguished using plane polarised light. **1**

(iii) The low resolution ^{1}H NMR spectrum for one of these compounds is shown.

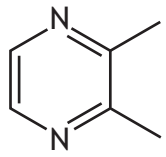


Explain which of the three compounds would give this ^{1}H NMR spectrum. **2**

8. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(b) A compound responsible for the nutty flavour of chocolate is 2,3-dimethylpyrazine.



2,3-dimethylpyrazine

(i) Write the molecular formula for 2,3-dimethylpyrazine. **1**

(ii) The ring structure of 2,3-dimethylpyrazine consists of carbon and nitrogen atoms with sp^2 hybridisation resulting in sigma and pi bonding.

(A) State how sp^2 hybridisation arises in an atom of nitrogen. **1**

(B) State how the sp^2 hybrid orbitals of nitrogen form sigma bonds with carbon atoms in 2,3-dimethylpyrazine. **1**

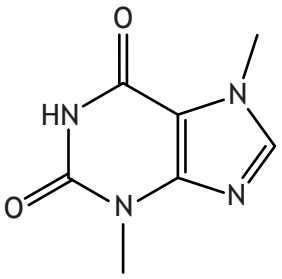
(c) Theobromine is another compound present in chocolate and has been linked to the 'feel-good' factor associated with eating chocolate. If consumed in large enough doses it is toxic.

(i) A bar of dark chocolate of mass 99.6 g contains 802 mg of theobromine. The lethal dose for a dog is 300 mg per kg of body weight.

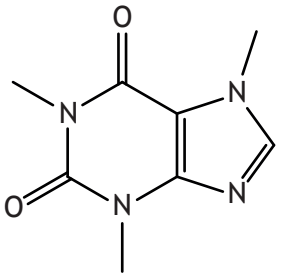
Calculate the mass of dark chocolate that would be lethal for a dog of 30.6 kg body mass to consume. **1**

8. (c) (continued)

(ii) Caffeine produces a similar 'feel-good' factor to theobromine.



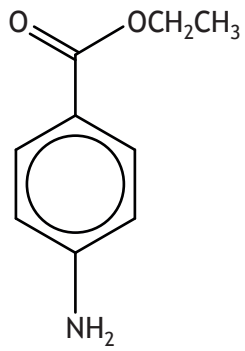
theobromine



caffeine

Using your knowledge of chemistry, suggest why these compounds produce a similar 'feel-good' factor when consumed. **3**

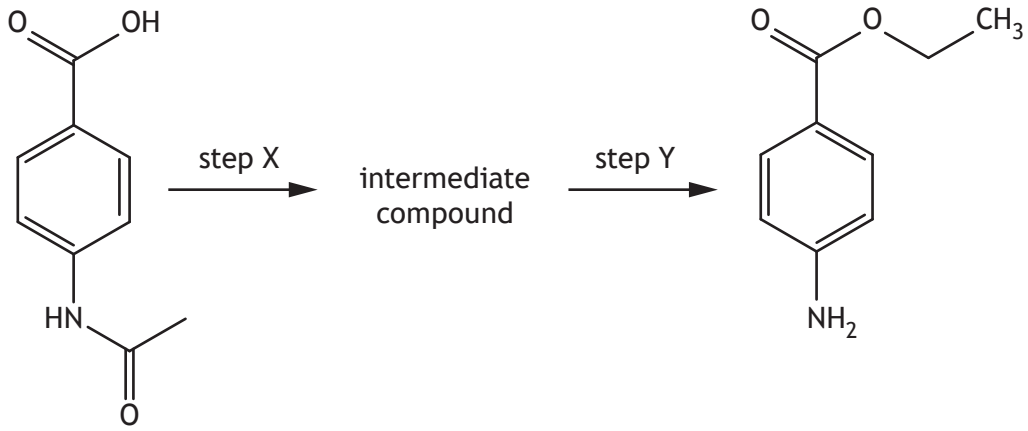
9. Benzocaine is used to relieve pain and itching caused by conditions such as sunburn, insect bites or stings.



benzocaine

A student was carrying out a project to synthesise benzocaine.

(a) Two of the steps in the synthesis of benzocaine are shown in the reaction scheme below.

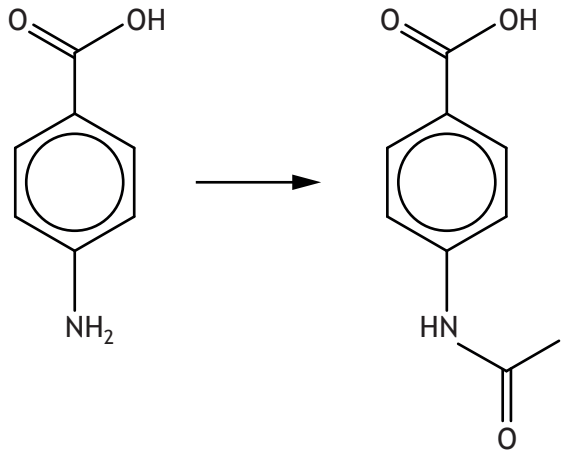


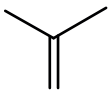
(i) Complete the table by identifying the type of reaction taking place in step X and in step Y. **2**

Step X	
Step Y	

9. (a) (continued)

(ii) The initial step in the synthesis is shown below.





The O group is used to protect the amine group and is removed again to make benzocaine.

Suggest why it is necessary to protect the amine group during this synthesis. **1**

9. (continued)

(b) The benzocaine produced in the reaction was recrystallised from ethanol to remove impurities.

(i) Explain why ethanol is a suitable solvent for this recrystallisation. **1**

(ii) Outline the steps that should be carried out to recrystallise benzocaine from ethanol. **2**

(c) The student analysed the recrystallised benzocaine by determining the melting point and by thin-layer chromatography (TLC).

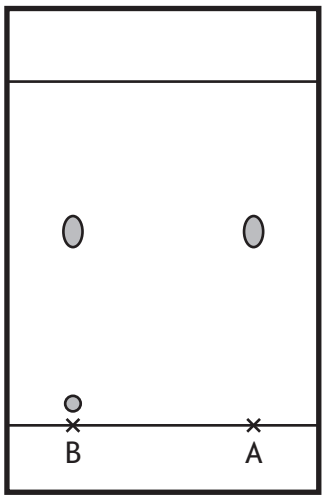
(i) Melting point analysis can be used to determine if the synthesised benzocaine is pure.

(A) State an effect impurities would have on the melting point of the recrystallised benzocaine. **1**

(B) State why impurities lead to this effect on the melting point. **1**

9. (c) (continued)

(ii) TLC was used to confirm the identity of the recrystallised benzocaine. A sample was dissolved in a small volume of solvent and spotted onto a TLC plate. The following chromatogram was obtained.



B = recrystallised benzocaine

(A) State the name of the substance spotted at A on the TLC plate. **1**

(B) Calculate the R_f value of the spot showing the substance present in sample A. **1**

(C) Based on the results obtained in the TLC analysis, explain whether the student's product is pure. **1**

10. A student was researching ways to synthesise ethoxyethane and its isomer 2-methoxypropane and found two different methods.

(a) Method 1 uses an alcohol to synthesise ethoxyethane.

$$2CH_3CH_2OH \xrightarrow{H^+} CH_3CH_2OCH_2CH_3 + H_2O$$

ethanol ethoxyethane

(i) Suggest the role of the H^+ ions in this reaction. **1**

(ii) Suggest why this method would not be suitable to synthesise 2-methoxypropane. **1**

(b) Method 2 uses alkoxide ions and a haloalkane to synthesise ethoxyethane.

$$CH_3CH_2O^- + CH_3CH_2Br \rightarrow CH_3CH_2OCH_2CH_3 + Br^-$$

ethoxide ion bromoethane ethoxyethane

(i) Suggest why this reaction is more likely to follow an S_N2 mechanism rather than an S_N1 mechanism. **1**

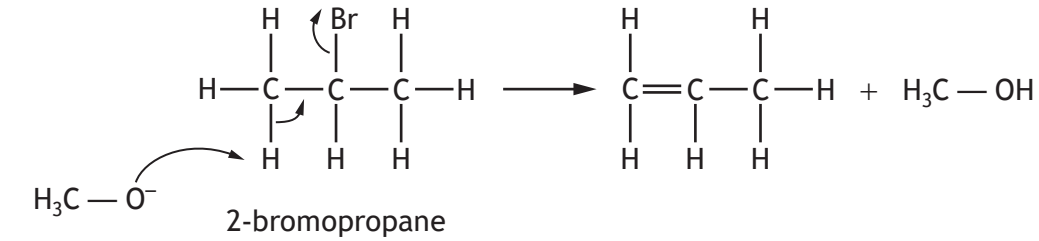
(ii) Using structural formulae and curly arrow notation, outline a possible mechanism for this reaction. **2**

MARKS

DO NOT WRITE IN THIS MARGIN

(iii) Draw the structures of two reactants that would react to make 2-methoxypropane using method 2. **2**

(iv) When the student attempted to make 2-methoxypropane using methoxide ions and 2-bromopropane the major product of the reaction was found to be propene. A possible mechanism for this reaction is shown.



2-bromopropane

methoxide ion

State the role of the methoxide ions in this mechanism. **1**

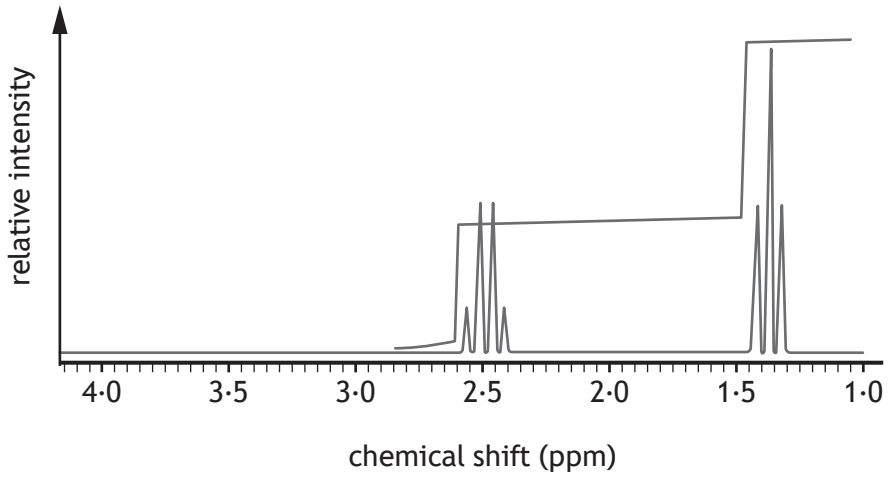
(c) The student analysed a sample of ethoxyethane using elemental microanalysis and high resolution ^{1}H NMR spectroscopy.

(i) 2.50 g of ethoxyethane was burned producing 5.95 g of CO_2 and 3.04 g of H_2O as the only products.

Using the information above, show by calculation that the sample was ethoxyethane. **2**

10. (c) (continued)

(ii) The high resolution ^{1}H NMR spectrum of ethoxyethane is shown.



(A) The two peaks in this spectrum are split into multiplets.

Explain fully why this splitting pattern helps to confirm the sample is ethoxyethane. **2**

(B) Explain why the integration curve also helps to confirm the sample is ethoxyethane. **1**

11. 250 cm^3 of buffer solution was prepared by dissolving a weighed sample of ammonium chloride in 0.96 mol l^{-1} ammonia solution. After preparation the buffer was found to have a pH of 10.23.

(a) Explain fully how this solution would resist a change in pH if a few drops of dilute acid solution were added. **2**

(b) The pH of a basic buffer can be calculated using the pK_a value for the dissociation constant of the conjugate acid.

$$\text{pH} = \text{p}K_a - \log\frac{[\text{conjugate acid}]}{[\text{base}]}$$

(i) Calculate the concentration, in mol l^{-1}, of ammonium ions in the buffer solution using the pK_a value for ammonium ions given in the data booklet. **2**

(ii) As the equilibrium position for ammonia solution lies to the left, the concentration of ammonium ions is assumed to be entirely from the presence of the ammonium chloride salt.

Calculate the mass, in g, of the weighed sample of ammonium chloride that was used to make this buffer solution. **1**

[END OF SPECIMEN QUESTION PAPER]

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

National
Qualifications
SPECIMEN ONLY

S813/77/01 **Chemistry**

Marking Instructions

These marking instructions have been provided to show how Qualifications Scotland would mark this specimen question paper.

Qualifications Scotland
Teisteanasan Alba

General marking principles for Advanced Higher Chemistry

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

(a) Marks for each candidate response must **always** be assigned in line with these general marking principles and the detailed marking instructions for this assessment.

(b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

(c) If a specific candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.

(d) Where a candidate makes an error at an early stage in a multi stage calculation, credit should normally be given for correct follow on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of non-mathematical reasoning. The exception to this rule is where the marking instructions for a numerical question assign separate "concept marks" and an "arithmetic mark". In such situations, the marking instructions will give clear guidance on the assignment of partial marks.

(e) In many cases, marks can still be awarded for inaccurate or unconventional spelling or vocabulary as long as the meaning of the word(s) is conveyed. For example, responses that include 'distilling' for 'distillation', or 'it gets hotter' for 'the temperature rises', should be accepted.

(f) If a correct answer and a wrong answer are present, it should be treated as a cancelling error and no marks should be given. For example, in response to the question, 'State the colour seen when blue Fehling's solution is warmed with an aldehyde', the answer 'red green' gains no marks.
However, if a correct answer and additional information, which does not conflict, are present, the additional information should be ignored, whether correct or not. For example, in response to a question concerned with melting point, 'State why the tube should not be made of copper', the response 'Copper has a low melting point and is coloured grey' would **not** be treated as having a cancelling error.

(g) Full marks are usually awarded for the correct answer to a calculation without working and the partial marks shown in the Detailed Marking Instructions are for use when working is given but the final answer is incorrect. An exception is when candidates are asked to 'Find, by calculation', when full marks cannot be awarded for the correct answer without working.

(h) Significant figures.

This marking instruction only applies to correct final answers. If the data in a question is given to three significant figures, the final answer should also have three significant figures. However one fewer significant figure and up to two more significant figures is acceptable.

For example if a correct final answer is 8.16 J then 8.2 J, 8.158 J and 8.1576 J would also be acceptable. Answers out with this range would not be acceptable and one mark would not be awarded.

The use of a recurrence dot, eg $0.\dot{6}$, would imply an infinite number of significant figures and would therefore not be acceptable.

This marking instruction must only be applied a maximum of once per paper and cannot be applied if instruction **(i)** has already been applied in the paper.

(i) Units

This marking instruction only applies to correct final answers. In most questions units are not required. However, if the candidate writes units then they must be correct. The symbols L and l are both acceptable for litres.
An incorrect unit would not be acceptable and one mark would not be awarded.

This marking instruction must only be applied a maximum of once per paper and cannot be applied if instruction **(h)** has already been applied in the paper.

(j) Intermediate rounding.

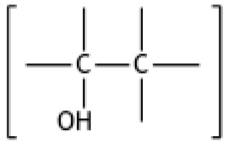
Ideally, calculated intermediate values should not be rounded. However, if the candidate has correctly rounded, the calculated intermediate values can have one significant figure fewer than the data given in the question but no fewer, otherwise full marks may not be awarded and partial marking would apply.
For example, if the data in a question is given to three significant figures, the intermediate value should have no fewer than two significant figures.

(k) If a structural formula is asked for, CH_3 is acceptable as a methyl group, and CH_3CH_2 and C_2H_5 are acceptable as an ethyl group.

If a name is asked for such as 3-methylhexane, then 3, methyl-hexane would be acceptable, ie ignore incorrect use of commas and dashes.

(l) When drawing structural formulae, a mark should only be awarded if the bonds point to the appropriate atoms.

The example below would be incorrect.



Marking instructions for each question

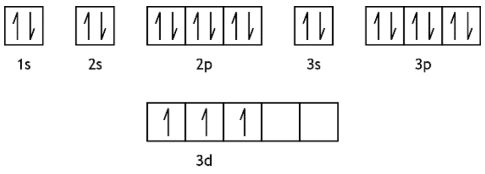
Section 1

Question	Answer	Max mark
1.	B	1
2.	D	1
3.	C	1
4.	C	1
5.	B	1
6.	A	1
7.	C	1
8.	B	1
9.	C	1
10.	A	1
11.	A	1
12.	B	1
13.	D	1
14.	D	1
15.	A	1
16.	D	1
17.	D	1
18.	B	1
19.	C	1
20.	B	1
21.	A	1
22.	C	1
23.	C	1
24.	D	1
25.	C	1

Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)		Lithium	**1**	
	(b)		(Excited) electrons fall to lower energy levels.	**1**	
	(c)		178 (kJ mol^{-1}) Partial marking **1 mark** may be awarded for E = Lhc/(1000)λ. **OR** Correct substitution of values.	**2**	180/178.4/178.45 also acceptable. Units not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
2.	(a)		<table><tr><td>Acid</td><td>HClO(aq)</td></tr><tr><td>Conjugate base</td><td>ClO^-(aq)</td></tr></table> **OR** <table><tr><td>Acid</td><td>H_3O^+(aq)</td></tr><tr><td>Conjugate base</td><td>$H_2O(\ell)$</td></tr></table>	**1**	State symbols not required but if given must be correct. Charges must be shown.
	(b)		$K_a = \dfrac{[H_3O^+(aq)][ClO^-(aq)]}{[HClO(aq)]}$	**1**	State symbols not required but if given must be correct.
	(c)		The H^+ ions from the water (equilibrium) are removed by the ClO^- ions/conjugate base. **(1)** $H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$ **AND** Equilibrium shifts to right. **OR** Produces an excess of OH^- ions. **(1)**	**2**	

Question			Expected response	Max mark	Additional guidance
3.	(a)	(i)	+4, 4, 4+, IV, four	**1**	–4, 4– not acceptable
		(ii)		**1**	Labels are required. Must have one arrow in each of any of the 3d boxes and arrows must be either all pointing up or all pointing down.
		(iii) (A)	Any p orbital 	**1**	Axes not required.
		(B)	Any of 2,1,–1,$+\frac{1}{2}$ 2,1,–1,$-\frac{1}{2}$ 2,1,0,$-\frac{1}{2}$ 2,1,+1,$+\frac{1}{2}$. 2,1,+1,$-\frac{1}{2}$.	**1**	
	(b)	(i)	Green/500-560 nm/complementary colour to purple filter used. **AND** Any mention of colorimeter being zeroed/absorbance measured using blank or solvent only.	**1**	
		(ii)	Dilute the sample. **OR** Prepare new standard solutions of greater concentration.	**1**	

Question			Expected response	Max mark	Additional guidance
3.	(b)	(iii)	This is an open-ended question **1 mark**: The candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) that are relevant to the situation, showing that they have understood at least a little of the chemistry within the context. **2 marks**: The candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) that are relevant to the situation, showing that they understand the context. **3 marks:** The maximum available mark would be awarded to a candidate who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The candidate shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the context. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.	**3**	**Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award zero marks also if the candidate merely restates the chemistry given in the question.

Question			Expected response	Max mark	Additional guidance
4.	(a)		0.0117 moles HCl unreacted.	**1**	0.012/0.01165 are also acceptable answers.
	(b)		106 (%) **(3)** Partial marking Up to **2 marks** may be awarded for any two of the following. No moles HCl reacting (0.02 − 0.0117 =) $8.30 \times 10^{-3.}$. **OR** Correct subtraction of incorrectly calculated moles. **OR** Correct calculation of mass of $CaCO_3$ from an incorrect number of moles. **OR** Correctly calculating a % from an incorrectly calculated mass of calcium carbonate.	**3**	106.4/106.41 are also acceptable answers. Mass $CaCO_3 = (4.15 \times 10^{-3} \times 100.1 =)$ 0.415 g is awarded **2 marks**. Allow follow through from part 4(a).
	(c)		Concentration of NaOH greater than stated on the bottle. **OR** Concentration of HCl less than stated on the bottle. **OR** Mass of egg shell used due to water/moisture/being wet. **(1)** Standardise NaOH **OR** Standardise HCl **OR** Repeat experiment with new mass/sample of dry egg shell. **(1)**	**2**	The mark for the improvement can only be awarded if it matches the reason.

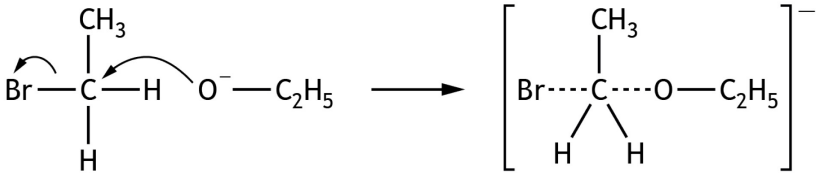
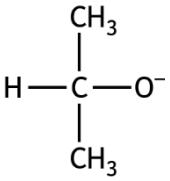
Question			Expected response	Max mark	Additional guidance
5.	(a)		−243 (J K^{-1} mol^{-1})	**1**	−240 also acceptable. Units not required but must be correct if given.
	(b)		−171.6 (kJ mol^{-1}). **AND** Yes/feasible. **OR** −171600 (J mol^{-1}). **AND** Yes/feasible. **(2)**	**2**	Working must be shown. Follow through from 5 (a) applies. Units not required but must be correct if given.
			Partial marking **1 mark** may be awarded for $\Delta G^{o} = \Delta H^{o} - T\Delta S^{o}$ **OR** = (−244) − 298(−0.243) **OR** −171.6 (kJ mol^{-1}) **OR** −171600 (J mol^{-1}) **OR** Incorrect value with correct feasibility for incorrect value.		

Question			Expected response	Max mark	Additional guidance
6.	(a)		first/1st	**1**	
	(b)		Rate = $k[NO(g)]^2[H_2(g)]$	**1**	Must be lowercase k R or r in place of rate is not acceptable. Square brackets are required State symbols not required but if given must be correct.
	(c)		750 **(1)** $mol^{-2}\ l^2\ s^{-1}$ **(1)**	**2**	
7.	(a)		Diamminedichloridoplatinum(II)	**1**	Must be spelled exactly as shown.
	(b)		85.7 (%) **(2)** Partial marking **1 mark** may be awarded for Theoretical yield of asplatin 7.424 (g). **OR** A correctly calculated % yield from an incorrectly calculated theoretical yield of asplatin.	**2**	86/85.66/85.663 are also acceptable answers.
	(c)	(i)	4	**1**	
		(ii)	Lone/non-bonding pairs of electrons.	**1**	

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	2-methylbutanal	**1**	
		(ii)	Rotate by same amount/angle in opposite/different directions.	**1**	
		(iii)	3-methylbutanal **(1)** Height ratios show that peak at 0.9 due to 6 methyl protons. **OR** Only compound with only 4 proton environments. **(1)**	**2**	
	(b)	(i)	$C_6H_8N_2$	**1**	C, H and N can be in any order.
		(ii) (A)	One s orbital and two p orbitals combine to make three degenerate sp^2 hybrid orbitals.	**1**	
		(B)	End-on overlap of (atomic/hybrid) orbitals.	**1**	
	(c)	(i)	1140 g **OR** 1.14 kg	**1**	1100/1140.1 g are also acceptable answers. 1.1/1.140/1.1401 kg are also acceptable answers. Unit is required.

Question			Expected response	Max mark	Additional guidance
8.	(c)	(ii)	This is an open-ended question **1 mark**: The candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) that are relevant to the situation, showing that they have understood at least a little of the chemistry within the context. **2 marks**: The candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) that are relevant to the situation, showing that they understand the context. **3 marks:** The maximum available mark would be awarded to a candidate who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The candidate shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the context. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.	**3**	**Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award zero marks also if the candidate merely restates the chemistry given in the question.

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	<table><tr><td>Step 1</td><td>condensation</td></tr><tr><td>Step 2</td><td>hydrolysis</td></tr></table>	**2**	Any order.
		(ii)	Nitrogen of amine group could also react. **OR** Nitrogen of amine group is a nucleophile.	**1**	
	(b)	(i)	Benzocaine is completely soluble in ethanol at high temperatures but only slightly soluble/insoluble in ethanol at low temperatures.	**1**	
		(ii)	• minimum/small (volume) • hot solvent/hot ethanol • cool • filter	**2**	All four points for **2 marks**. Two or three points for **1 mark**. Hot filtration is not required. Cooling must happen before final filtering. If there is no mention of dissolving the benzocaine then a maximum of **1 mark** can be awarded.
	(c)	(i) (A)	Lower melting point. **OR** Wider melting point range.	**1**	
		(B)	Disruption in intermolecular bonding.	**1**	
		(ii) (A)	Pure benzocaine	**1**	
		(B)	$R_f = 0.53–0.6$	**1**	Only one single value is acceptable and must be within the range given.
		(C)	Impure **AND** extra/impurity spot (for product). **OR** Two/multiple spots (for product).	**1**	

Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	Catalyst	**1**	
		(ii)	Only works for symmetrical ether. **OR** Mix of products produced.	**1**	
	(b)	(i)	Less stable carbocation would form.	**1**	
		(ii)	 Correct curly arrows **(1)** Transition state **(1)**	**2**	Transition state must have square brackets with the negative charge outside.
		(iii)	 **(1)** $CH_3Br/CH_3Cl/CH_3I$ **(1)**	**2**	Answers relating to propan-2-ol alkoxide are not acceptable. Any correct structural formulae are acceptable.
		(iv)	Base	**1**	
	(c)	(i)	Mass of C 1.623 g H 0.338 g O 2.50 – 1.623 – 0.338 = 0.539 g All three masses **(1)** Correct mole ratio calculated. **(1)**	**2**	
		(ii) (A)	Peak at 1.4 is a triplet and so is a proton environment next to a carbon atom with two protons on it. **(1)** Peak at 2.5 is a quartet and so is a proton environment next to a carbon atom with three protons on it. **(1)**	**2**	
		(B)	Ratio 2:3 which agrees with 4 ($2CH_2$) :6 ($2CH_3$).	**1**	

Question			Expected response	Max mark	Additional guidance
11.	(a)		OH^- ions would react with added H^+ ions **(1)** Ammonia equilibrium will shift to right to replace OH^- ions removed. **(1)**	**2**	
	(b)	(i)	0.10 (mol l^{-1}) **(2)** Partial marking **1 mark** may be awarded for Correct substitution of values into the expression including the pK_a of ammonia. **OR** $0.1047 = \frac{\left[NH_4^+\right]}{0.96}$ **(1)**	**2**	0.1/0.102/0.1015 are also acceptable answers. Units not required but must be correct if given.
		(ii)	1.3 (g)	**1**	1.31/1.311/1.3108 are also acceptable answers. Units not required but must be correct if given.

[END OF SPECIMEN MARKING INSTRUCTIONS]

Published: August 2026

Change since last published:

The duration of the paper has been shortened and the number of marks reduced. Some questions have been removed from the previous specimen question paper, some have been edited or updated, and some have been replaced.