

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

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Pearson Edexcel International Advanced Level

Monday 2 June 2025

Morning (Time: 1 hour 45 minutes)

Paper
reference

WCH15/01A

Chemistry

International Advanced Level

**UNIT 5: Transition Metals and Organic
Nitrogen Chemistry**

You must have:

Scientific calculator, Data Booklet, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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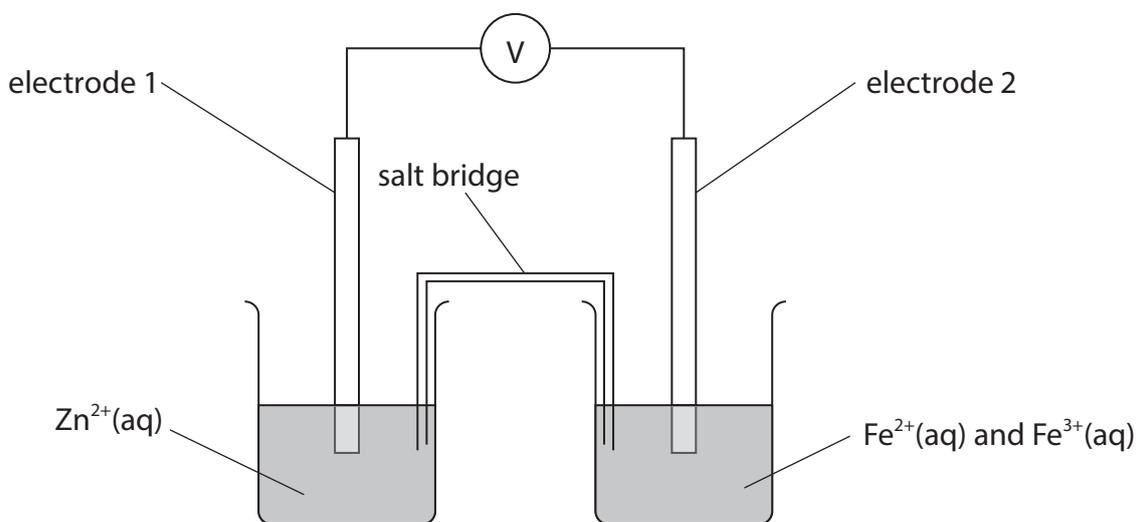
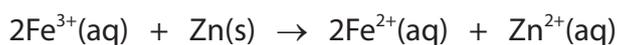
SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross . If you change your mind, put a line through the box and then mark your new answer with a cross .

- 1 The apparatus shown may be used to measure the electrode potential for the reaction between iron(III) ions and zinc metal.



- (a) Which electrodes are used for this cell?

(1)

	Electrode 1	Electrode 2
<input type="checkbox"/> A	iron	zinc
<input type="checkbox"/> B	platinum	platinum
<input type="checkbox"/> C	zinc	iron
<input type="checkbox"/> D	zinc	platinum



- (b) The solution for the right-hand half-cell is prepared by adding suitable amounts of iron(II) sulfate and iron(III) sulfate to distilled water to make 1.00 dm^3 of solution.

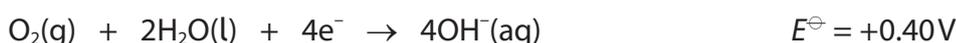
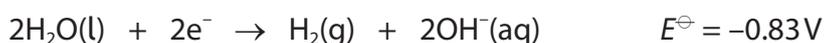
What mass of iron(III) sulfate, $\text{Fe}_2(\text{SO}_4)_3 \cdot \text{H}_2\text{O}$, must be used to measure the **standard** electrode potential for this cell?

(1)

- A 55.80 g
 B 208.95 g
 C 399.90 g
 D 417.90 g

(Total for Question 1 = 2 marks)

- 2 The half-equations for the hydrogen-oxygen fuel cell in **alkaline** solution are shown.



- (a) What is the overall cell reaction?

(1)

- A $\text{H}_2(\text{g}) + 6\text{OH}^-(\text{aq}) \rightarrow 4\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$
 B $\text{H}_2(\text{g}) + 6\text{OH}^-(\text{aq}) \rightarrow 4\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) + 6\text{e}^-$
 C $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$
 D $2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$

- (b) What is the standard emf, E_{cell}^\ominus , of this fuel cell?

(1)

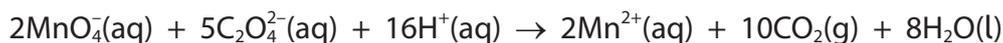
- A +2.06V
 B +1.23V
 C +0.43V
 D -0.43V

(Total for Question 2 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.



3 Manganate(VII) ions, MnO_4^- , react with ethanedioate ions, $\text{C}_2\text{O}_4^{2-}$, in acidic solution.



(a) What is the **change** in oxidation number of a carbon atom when this reaction occurs?

(1)

- A -1
- B +1
- C +3
- D +4

(b) 25.0 cm^3 of a $0.0200\text{ mol dm}^{-3}$ solution of ethanedioate ions is titrated with an acidified solution containing $0.0400\text{ mol dm}^{-3}$ manganate(VII) ions.

What volume, in cm^3 , of this solution of manganate(VII) ions is needed for complete reaction?

(1)

- A 5.00
- B 10.0
- C 12.5
- D 31.3

(Total for Question 3 = 2 marks)

4 The standard emf, E_{cell}^\ominus , of a reaction is positive.

Which **must** be correct?

- A the entropy change of the system, $\Delta S_{\text{system}}^\ominus$, is positive
- B the entropy change of the surroundings, $\Delta S_{\text{surroundings}}^\ominus$, is positive
- C both the entropy changes of the system, $\Delta S_{\text{system}}^\ominus$, **and** surroundings, $\Delta S_{\text{surroundings}}^\ominus$, are positive
- D the total entropy change, $\Delta S_{\text{total}}^\ominus$, is positive

(Total for Question 4 = 1 mark)

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5 The aqueous solution of a transition metal ion is colourless.

Which is the electronic configuration of this ion?

- A [Ar] 3d⁸
- B [Ar] 3d¹⁰
- C [Ar] 3d⁵4s¹
- D [Ar] 3d¹⁰4s²

(Total for Question 5 = 1 mark)

6 Excess aqueous silver nitrate is added to a solution containing 0.100 mol of chromium(III) chloride, CrCl₃·6H₂O.

A precipitate, AgCl, appears immediately, which after drying, is found to have a mass of 14.35 g.

What is the formula of the complex ion in the solution?

- A [Cr(H₂O)₆]³⁺
- B [CrCl(H₂O)₅]²⁺
- C [CrCl₂(H₂O)₄]⁺
- D [CrCl₃(H₂O)₃]

(Total for Question 6 = 1 mark)

7 This question is about transition metal complexes.

(a) Which complex has a tetrahedral structure?

(1)

- A [CrCl₄]⁻
- B [Cu(NH₃)₄(H₂O)₂]²⁺
- C [Pt(NH₃)₂Cl₂]
- D [TiCl₆]²⁻

(b) Which complex contains a metal in the +1 oxidation state?

(1)

- A [CuCl₂]⁻
- B [CrCl₄]⁻
- C [Pt(NH₃)₂Cl₂]
- D [Ni(CO)₄]

(Total for Question 7 = 2 marks)



- 8 When EDTA^{4-} is added to an aqueous solution of iron(III) ions, the EDTA complex is formed.

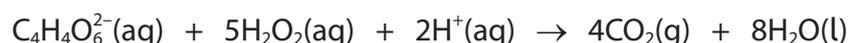
Which is the **best** explanation for this?

- A iron(III) ions form stronger bonds with EDTA^{4-} ions than with water
- B iron(III) ions form more bonds with EDTA^{4-} ions than with water
- C the formation of the EDTA complex produces more particles in solution
- D water forms stronger hydrogen bonds than EDTA^{4-}

(Total for Question 8 = 1 mark)

- 9 An acidified solution, containing tartrate ions, $\text{C}_4\text{H}_4\text{O}_6^{2-}$, is mixed with hydrogen peroxide solution.

When pink cobalt(II) chloride solution is added to the mixture, there is effervescence as carbon dioxide is evolved and the solution turns green.



After a few seconds, the effervescence stops and the solution turns back to pink.

What is the role of **cobalt(II) ions** in this reaction?

- A a dehydrating agent
- B an oxidising agent
- C a reducing agent
- D an oxidising agent and a reducing agent

(Total for Question 9 = 1 mark)

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10 Benzene is nitrated using a mixture of concentrated nitric and sulfuric acids.

In this reaction, the sulfuric acid

- A dissolves both benzene and nitric acid
- B forms an addition compound with benzene
- C protonates the nitric acid
- D protonates the benzene

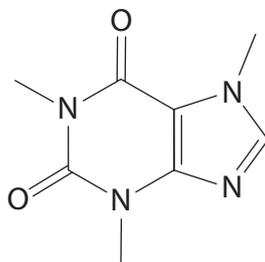
(Total for Question 10 = 1 mark)

11 Which is the **best** technique to show that the carbon-carbon bonds in benzene are all the same length?

- A infrared spectroscopy
- B mass spectrometry
- C high resolution proton NMR spectroscopy
- D X-ray diffraction

(Total for Question 11 = 1 mark)

12 The structure of caffeine, $C_8H_{10}O_2N_4$, is shown.



Which functional group is present?

- A aldehyde
- B amide
- C ketone
- D nitrile

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 The reaction between chlorine and phenol is faster than that between chlorine and benzene.

Which is the **best** explanation for this?

- A the carbon-oxygen bond is weaker than the carbon-hydrogen bonds
- B oxygen is more electronegative than carbon
- C the phenol ring has greater electron density than the benzene ring
- D phenol is more acidic than benzene

(Total for Question 13 = 1 mark)

14 Poly(ethenol) is used to make hospital laundry bags for soiled or contaminated linen.

This is because poly(ethenol) is

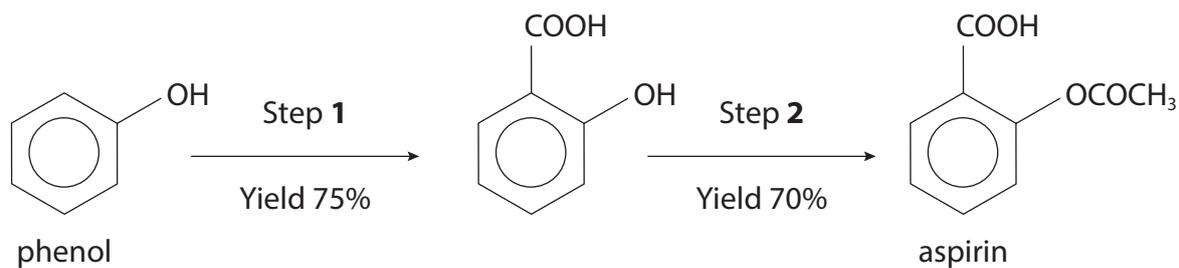
- A a bactericide
- B broken down by detergent
- C flexible
- D soluble in water

(Total for Question 14 = 1 mark)

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15 A reaction scheme to produce aspirin from phenol is shown.



(a) Which reagents are used in Step 2?

(1)

- A chloroethane and aluminium(III) chloride
- B ethanoic anhydride and sulfuric acid
- C ethanol and sulfuric acid
- D potassium dichromate(VI) and sulfuric acid

(b) What mass of aspirin would be produced from 47.0 g of phenol in this reaction scheme?

[Data: M_r phenol = 94 M_r aspirin = 180]

(1)

- A 47.3 g
- B 65.3 g
- C 90.0 g
- D 94.6 g

(Total for Question 15 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

16 This question is about manganese compounds.

(a) Manganese(II) ions in solution, $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$, are a pale pink colour.

(i) Draw the shape of this complex ion.

(1)

(ii) Describe the bonding between the manganese(II) ion and the ligands.

(2)

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(iii) Explain why $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ ions are coloured.

(3)

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(b) Explain why aqueous solutions of some complex ions are acidic by comparing the data in the table.

(3)

Complex ion formula	pH of a solution of concentration of 1 mol dm^{-3}
$[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$	5.3
$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$	4.7
$[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$	1.5

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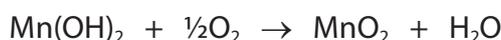
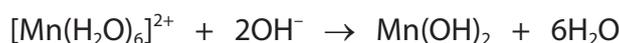
- (c) The concentration of dissolved oxygen in water is measured as part of the assessment of the level of pollution in rivers.

Good quality river water has a value range between 5 ppm and 8 ppm of dissolved oxygen.

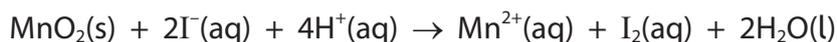
The oxidation of $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ ions is used to measure the amount of dissolved oxygen.

The procedure was devised in 1888 by a Hungarian chemist, Lajos Winkler.

- Step 1** A 50 cm^3 sample of river water is placed in a container. Aqueous solutions of manganese(II) sulfate and potassium hydroxide are then added. The container is sealed and shaken.



- Step 2** The mixture is acidified with sulfuric acid and then excess aqueous potassium iodide is added.



- Step 3** The whole of the mixture is titrated against a solution of sodium thiosulfate with a concentration of $0.00284\text{ mol dm}^{-3}$ using a starch indicator.



A mean titre of 12.20 cm^3 was recorded.

- (i) State the changes that would be observed in Step 1.

(2)

- (ii) Calculate the moles of manganese(IV) oxide in the 50 cm^3 sample.

(2)



- (iii) Calculate the concentration of dissolved oxygen, in ppm, in the sample collected.

[Assume the density of water = 1.0 g cm^{-3}]

(4)

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P 7 8 2 1 3 A 0 1 3 2 8

(d) Nitrate(III) ions, NO_2^- , are often present in wastewater effluents.

These may be reduced to nitrogen(II) oxide, NO, in the acidic conditions of Step 2.

(i) Suggest the **half-equation** for the reduction of NO_2^- to NO under acidic conditions. State symbols are not required. (1)

(ii) Derive the equation for the reduction of nitrate(III) ions by **iodide ions**, using your answer to (d)(i). State symbols are not required. (1)

(iii) Deduce the effect, if any, on the value of dissolved oxygen obtained in (c)(iii) if the nitrate(III) ions are not removed prior to Step 2. No calculation is required. (2)

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(Total for Question 16 = 21 marks)



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P 7 8 2 1 3 A 0 1 5 2 8

17 This question is about primary amines.

(a) Explain why ethylamine is fully miscible with water.

(3)

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*(b) Amines are derived from ammonia, which is a weak base.

Explain the differences in the strengths of three bases: ammonia, methylamine and phenylamine.

In your answer, include an equation showing how one of these bases acts as a Brønsted–Lowry base when reacting with water in aqueous solution.

The pH of the aqueous solutions of these bases are shown in the table.

Name	Formula	pH of 0.1 mol dm ⁻³ solution
ammonia	NH ₃	11.13
methylamine	CH ₃ NH ₂	11.82
phenylamine	C ₆ H ₅ NH ₂	8.81

(6)

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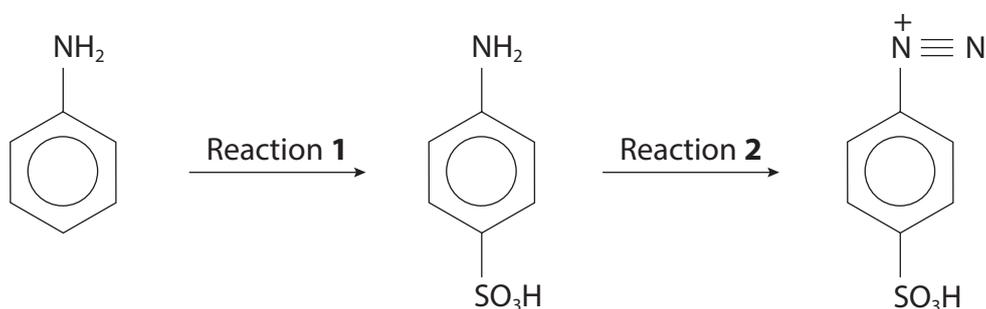
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P 7 8 2 1 3 A 0 1 7 2 8

- (c) Phenylamine is a starting material in the synthesis of methyl orange, an indicator used in acid-base titrations.

The first two reactions in this synthesis are shown.



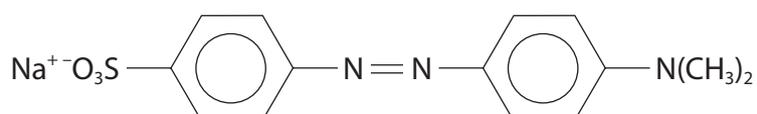
- (i) Identify, by name or formula, the reagent used in Reaction 1.

(1)

- (ii) State the reagents and conditions for Reaction 2.

(2)

- (d) The diazonium ion, produced in Reaction 2, is converted into methyl orange.



- (i) Draw the structure of the reagent which is added to the diazonium ion in this reaction.
Ignore the conversion to the sodium salt.

(1)

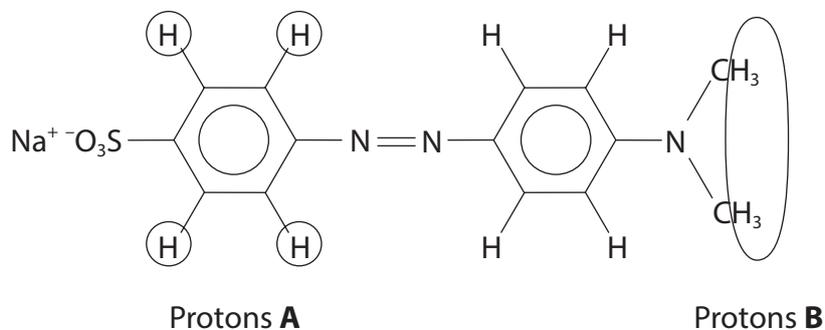


- (ii) The high resolution proton NMR spectrum of methyl orange has several peaks, some of which are very close together.

Predict the chemical shift and the relative intensity of Protons **A** circled on the left and Protons **B** circled on the right.

Include the splitting pattern of the peak for Protons **B**.

(3)



	Chemical shift / ppm	Relative intensity	Splitting pattern
Protons A			X
Protons B			

(Total for Question 17 = 16 marks)

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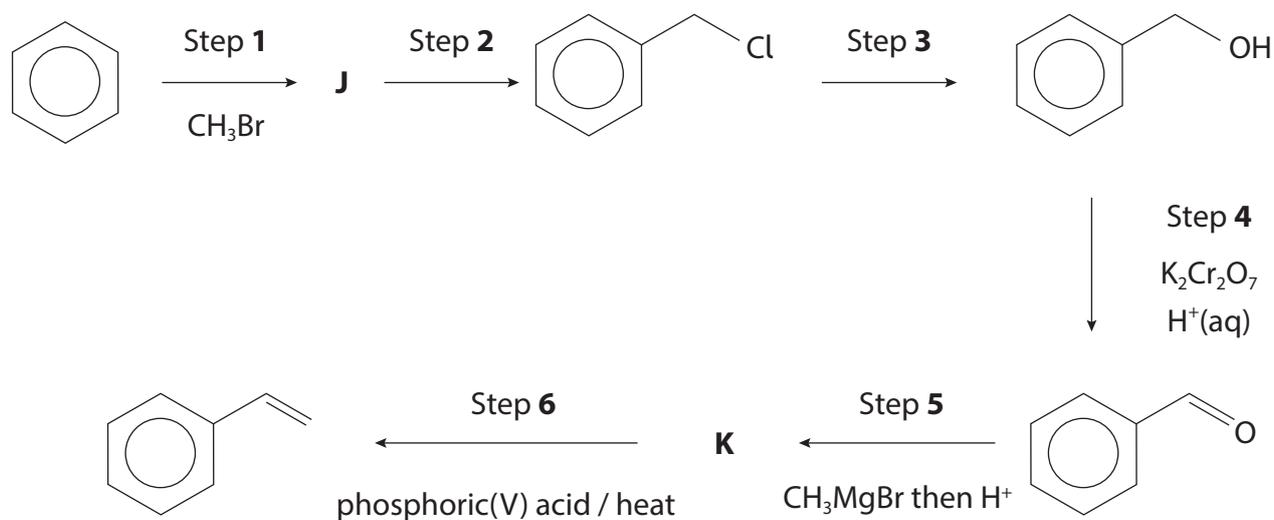
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P 7 8 2 1 3 A 0 1 9 2 8

18 Poly(phenylethene), polystyrene, is used for packaging.

A possible route for the synthesis of phenylethene from benzene is shown.



(a) Draw the mechanism for the reaction in Step 1 to produce **J**, including the formation of the electrophile.

(4)

(b) State the reagent and conditions used for the reaction in Step 3.

(2)

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(g) Draw the structure of poly(phenylethene) showing two repeat units.

(1)

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 51 MARKS

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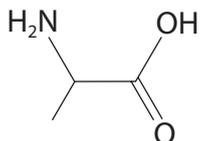
SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

19 This question is about amino acids.

(a) Alanine is a naturally occurring amino acid.

(i) Give the IUPAC name for alanine.



(1)

(ii) Explain why alanine has a much higher melting temperature than butanoic acid, which has a similar relative molecular mass.

Detailed descriptions of the bonding involved are **not** required.

(3)

Molecule	M_r	Melting temperature / °C
alanine	89	258
butanoic acid	88	-5.1

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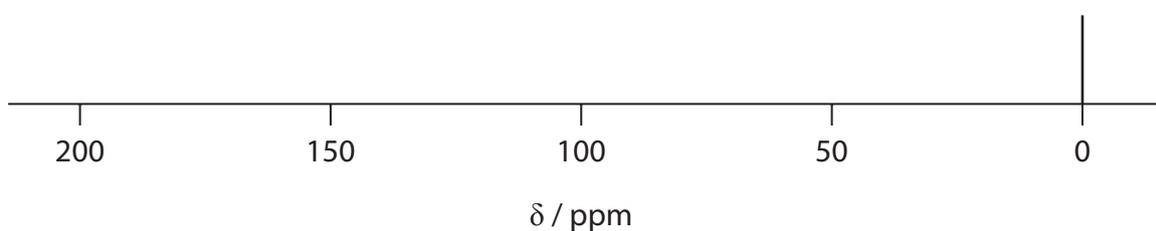
(iii) Carbon-13 NMR spectra usually have a peak at a chemical shift of 0.

Identify the compound responsible for this peak.

(1)

(iv) Complete the carbon-13 NMR spectrum of alanine showing the chemical shift values for each peak and the carbon atoms responsible for the peaks.

(3)



(v) Alanine exists as two optical isomers.

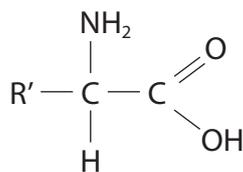
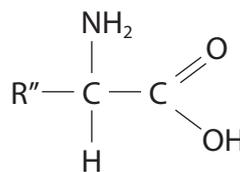
Explain how this type of isomerism occurs, stating how the isomers may be distinguished.

(3)



- (b) Two amino acids, **F** and **G**, combine in a condensation reaction to form a dipeptide, **E**.

R' and R'' are different and may be a hydrogen atom or alkyl groups.

**F****G**

- (i) Draw a possible structure of **E**.

(2)

- (ii) Determine the **molecular** formula of **E**, using the data shown and the information in (b).

(3)

% carbon	% hydrogen	% nitrogen	% oxygen
51.1	8.51	15.1	



- (c) **E** was hydrolysed by heating under reflux with hydrochloric acid.
F and **G** were produced and were analysed using mass spectrometry.

The m/z values for the molecular ions of **F** and **G** are shown.

Amino acid	m/z value
F	75
G	131

- (i) **F** is not optically active.

Suggest a structure for **F**.

(1)

- (ii) **G** has two chiral centres.

Suggest a structure for **G**.

(2)

(Total for Question 19 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1 2 3 4 5 6 7 0 (8)

1.0
H
hydrogen
1

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
6.9 Li lithium 3	9.0 Be beryllium 4	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	4.0 He helium 2
23.0 Na sodium 11	24.3 Mg magnesium 12	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

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